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The 1984 assessment of 4VsW cod: a completely revised procedure

by

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Abstract

Provisional statistics indicate that only 82% of the 64,000 t TAC was caught in 1983. Several year-classes were well represented in the catch with the 1977, 1978, and 1979 year-classes each contributing more than 20% of the total. A new standardized commercial catch rate series was developed to take into account the uncertainties associated with the Canadian offshore otter-trawler fleet data for the periods 1968-1973 and 1978-1979. The new series shows high catch rates since 1980 and an increasing trend between 1981 and 1983. The research vessel surveys indicate that the recruiting year-classes are from strong to very strong and that the abundance of the fully-recruited age groups is stable. A sequence of flat-topped and dome-shaped partial recruitment vectors was used to compute non-small-mesh mid-year fishable biomasses from cohort analysis runs. Calibration of the cohort analysis, performed only with the new standardized commercial catch rate, indicated a fishing mortality of 0.35 for the fully-recruited ages (6+). If the 55,000 t TAC is taken in 1984, the projected $F_{0.1}$ catch for 1985 is 52,000 t.

Résumé

Selon les statistiques provisoires, les prises en 1983 ont totalisé seulement 82% du TPA de 64,000 tonnes. Plusieurs classes d'âge y étaient bien représentées, en particulier celles de 1977, 1978 et 1979 qui chacune contribuèrent plus de 20% du total. Une nouvelle série standardisée de taux de capture commerciaux fut développée afin de tenir compte de l'imprécision des données en provenance des grands chalutiers canadiens pour les périodes 1968-1973 et 1978-1979. Cette nouvelle série montre que les taux sont élevés depuis 1980 et même à la hausse depuis 1981. Selon les levées des navires de recherche, l'abondance des classes d'âge qui rejoignent présentement le stock exploité varie de grande à très grande alors que celle des groupes plus âgés serait stable. Une séquence de vecteurs de recrutement partiel en tranchet et en forme de dôme fut utilisée pour calculer, à partir des résultats d'analyse de cohortes, des biomasses exploitables de milieu d'année pour les pêcheries autres que celle utilisant les chaluts à petites mailles. La calibration de l'analyse de cohortes, effectuée uniquement à l'aide des taux de capture commerciaux standardisés, indique que le taux de mortalité par pêche subi par les âges pleinement recrutés (6+) en 1983 fut de 0.35. Si le TPA de 55,000 tonnes est atteint en 1984, les prises au niveau $F_{0.1}$ pour 1985 sont évaluées à 52,000 tonnes.

Introduction

Concluding their analysis of the status of the cod stock complex in NAFO Division 4VsW, Gagné et al. (MS 1983) stated that this complex had recovered from low levels in the 1970s. Nevertheless, the calculated $F_{0.1}$ catch for 1984 was 53,000 t and as a result Fisheries and Oceans reduced the TAC by 14%, from 64,000 t in 1983 to 55,000 t in 1984. CAFSAC (Advisory Document 83/19) attributed this reduction to errors in the fisheries statistics used to perform the 1982 assessment (Maguire et al. MS 1982); clearly, the reduction did not reflect a deterioration of the status of the Scotian Shelf cod stock complex, one of the major groundfish resources in Atlantic Canada. Unfortunately, it was widely perceived as such within and outside the Department.

At its 1984 meeting, the Groundfish Subcommittee requested that the procedure followed in the two preceding assessments be modified in several major ways. This document, in addition to describing the overall 1984 assessment, details and discusses these modifications. It also evaluates last year's conclusion on the status of the stock complex. Finally, it briefly comments on the biological advice provided in recent years and on the use of that advice by the managers of the fishery.

Nominal Catches

The overall catch of cod in 4VsW was down 3,400 t in 1983 from 1982 (Table 1) and for the first time since 1976, the TAC was not taken. In 1983, Portugal became the first foreign nation since extension of jurisdiction in 1977 to receive a directed allocation for cod on the Scotian Shelf; it caught 80% of the 1,500 t allocated. By-catches of cod by other foreign nations were up slightly from 1982 but remained below the average level since 1977.

Canadian landings in 1983 were 4,800 t less than in 1982. Again catches in 4Vs exceeded those in 4W continuing a trend which began in 1980 (Table 2). However, the 1983 4Vs catches were 6,900 t less than in 1982 while those in 4W increased by 3,500 t. Similarly, landings from trawlers fell by 5,500 t in 4Vs but increased by 4,700 t in 4W. This was mainly due to the exploitation of different fishing grounds by the spring fishery; in 1982, it was concentrated north of the Gully in 4Vs but was more active south of Sable Island in 4W in 1983. Overall trawler catch dropped by 850 t.

With a reduction of 4,000 t in their reported landings, the longliners suffered the largest overall decrease in 1983, 64% of which was experienced in 4Vs. Catches by other Canadian gears were back to the 1980 level, a decrease of about 20% from the high values of 1981 and 1982.

Age Composition of the Commercial Catch

Sampling of the Fishery

The cod fishery in 4VsW was again well sampled in 1983 with a total of 178 samples collected. In general, the sampling followed properly the activities of the major gears as shown in Table 3 (see also Appendix 1). With 74% of the Canadian catch, the otter trawls received 64% of the samples. Each quarter of that fishery was well covered although a few more samples in the second and third quarters in 4Vs would have resulted in a more even distribution of the catch to sample ratios. The "line" fishery (longline and handline) landed 18% of the Canadian catch and received 25% of the samples. The second quarter in 4Vs and especially the fourth quarter in 4W should have been covered more intensively. Thirteen percent of the samples were collected from the Scottish and Danish seine catches which represented 5% of the total domestic removal. Of all the major gears, the seines were the most intensively sampled. Finally, 3% of the sampling effort was devoted to the gillnet fishery in 4W which landed only 1% of the total catch. Even though the overall coverage of the fishery could have benefited from some adjustments, the sampling of the major gears was adequate.

Construction of the Age-Length Keys

Of the 178 samples collected in 1983, only 85 had been entirely processed at assessment time. The otoliths of the 93 remaining samples had yet to be read. Samples length frequencies which were not aged were not used in the age-length keys. If the sampling of the fishery was adequate, the coverage obtained from the processed samples was much less so. Indeed only 25 samples were available for the second half of the year and only six for the last quarter. In the next section, we use the 1982 data to illustrate how such a situation may impact the results of the analysis.

We summarize in Table 4 the data used to generate each key. As in last year's assessment, at least 20 otoliths were read in each sample used. The 55 otter trawl samples were grouped on a quarterly basis. The longline and the seine samples, 18 and 11 respectively, were divided in two half-year periods. The a and b coefficients required for the length-weight relationships were obtained from the 1983 summer research survey data. Depending on the origin of the majority of the catch apportioned to each key, the divisional or the combined coefficients were used (Table 4a).

Age-length keys were also generated for the catch of the three major foreign countries that caught cod in 4VsW in 1983. Fishing for cod in 4Vs, a Portuguese trawler fleet caught 961 t in April-May and 257 t between October and December. We determined the length composition of their catch from length frequencies collected by the International Observer Program which had full coverage of the fleet activities. We compared the length frequencies of the Portuguese catch to those of the Canadian trawler fleet fishing in 4Vs at the same time. The frequencies for the April-May period were different and a separate key was produced. The frequencies for the

October-December period were very similar and the Portuguese catch of 257 t was lumped with the Canadian trawler catch and used with key 4 of Table 4a.

The small-mesh fishery, pursued by Cuba and the Soviet Union at the edge of the shelf in 4W, had a cod by-catch of 226 t in 1983. As in the past, we used length frequencies collected by the International Observer Program and length-weight coefficients from the summer research survey to construct a separate key for that fishery. In the 1983 assessment, the small-mesh key was not included in the calculations of the mean weights at age and the numbers at age generated from it were merely added to the catch numbers. This year we used all the keys to estimate the mean weights at age. In this way we obtained a value for age one which came from the small-mesh key.

The ten keys were used to generate the age composition of 97% of the total catch. Those estimates were bumped up to 100%. The resulting removals at age, mean weights at age and catch biomasses at age are presented in Tables 5 to 9.

Each of the 1977, 1978 and 1979 year-classes contributed more than 20% to the total numbers caught; together, they add up to 77%. Over three million fish i.e. - 11% of the total, came from the 1980 year-class. This is the second largest proportion of age 3 fish in the catch since 1977, closely behind the 1978 year-class in 1981.

The mean weights-at-age show slight or no variations for ages 1 to 5 between 1982 and 1983. With the exception of age 7, the weights for ages 6 to 11 are lower in 1983 than in 1982.

Update of the 1982 Catches At Age

The otoliths of 42 samples collected in 1982 were not read in time for the 1983 assessment. Processing of these samples was completed in 1983 and they were available for the present assessment. The new samples were distributed as follows:

Quarter	Otter Trawl	Lines	Seines
1	16	3	
2	4		
3	1		3
4	11		4
Total	32	3	7

We used 38 of those samples to update three otter trawl keys as well as the unique key for the seines. The longliner keys were not modified since the three additional samples had been collected in March, at a time when the longliner catches were very low. Details on the construction of these keys are presented in Table 4b. The 1982 data included in Tables 7 to 9 incorporate these updated numbers.

We compare in Figure 1 the 1982 removals at age as calculated for the 1983 assessment (Gagné et al. MS 1983) and the updated values. The differences are small, the updated curve showing 36% more age 3, 16% more age 4, and 11%, 15%, and 15% less age 6 to 8 fish respectively.

The age composition of the commercial catch is of paramount importance in stock assessment since the estimate of population size is derived from it. We therefore decided to repeat the 1983 assessment following the procedure adopted by the Subcommittee but with the updated catch-at-age matrix. A new estimate of population size was calculated assuming a fully-recruited fishing mortality of 0.25. The partial recruitment for ages 1 to 3 was readjusted so that the size at age 1 of the year-classes 1979 to 1981 be approximately equal to the long-term geometric mean of 107 million fish. The partial recruitment at age 4 was not modified since a variety of calibration exercises have all indicated a value around 0.56 (see section on partial recruitment further in this document).

In Figure 2, we compare the updated 1982 population numbers with those of last year's assessment. Again differences are small. However, the updated numbers-at-age 3 and 4 are higher than estimated last year.

We also recalculated the projected age composition of the 1983 catch using the actual total of 52,332 t. Two runs were made, one with the parameters as evaluated last year, the other with the updated 1982 catch and population numbers, weights at age and partial recruitment. The input parameters are presented in Table 10 and the results summarized in Figure 3. The observed catch numbers at age 3 and particularly at age 4 are higher than all the predicted values, the update resulting in estimates virtually identical to the original values for those ages. However, the update produced a higher population number at age 4 which resulted in higher projected catches at age 5, in close agreement with the observed data. In conclusion, increasing the number of samples used to calculate the age composition of the 1982 catch by 60% resulted in a marginal improvement of the agreement between projected and observed 1983 catch-at-age.

The reason for the important discrepancies observed at age 3 and 4 between the projected and the observed catch can be found elsewhere. In the last two assessments (Maguire et al. MS 1982; Gagné et al. MS 1983), population sizes and projected catch numbers have been estimated assuming that the 1979 and 1980 year-classes were of average size. Gagné et al. (MS 1983) noted that the limited evidence available to them suggested that these two year-classes were better than average. We shall demonstrate later that the 1979 year-class (age 4 in 1983) now appears to be the largest observed since 1958. As for the 1980 year-class, it is now believed to be at least equal to the 1979 year-class at age 3 and might be even larger. CAFSAC apparently very much underestimated the size of these year-classes in its 1983 assessment and consequently their importance in the catch of that year. Interpreting these results requires caution

however since only 48% of the samples collected could be used to determine the 1983 removals at age.

Stock Size Indices

Commercial Catch-Per-Unit of Effort

As in 1983, the multiplicative catch rate standardization model (Gavaris 1980) was used to generate a commercial catch rate series. Data from Spanish pair trawlers, TC 4 and TC 5, Canadian (M&Q) longliners, TC 2-4 combined, side draggers TC 4 and stern draggers TC 5 were used for the period 1968-1983. Semi-annual values of total catch and effort were entered as observations.

The resulting catch rate series is presented in Figure 4. The 1983 value is above the 1982 and is virtually equal to 1979, being the highest values in the series. This catch rate is almost identical to that used last year (Gagné et al. MS 1983).

Previous assessments noted the possibility of substantial misreporting of catch and effort by the Canadian offshore trawler fleet in 1978 and 1979. This prompted the rejection of a commercial catch rate series as a method of tuning the Sequential Population Analysis (SPA) and the sole use of research survey results (Gray MS 1979; Maguire MS 1980; Maguire MS 1981). Since it is not possible to correct these data for misreporting it was decided to remove the 1978 and 1979 values for side and stern otter trawlers. Furthermore data from Canadian (M & Q) otter trawlers between 1968 and 1973 did not seem to be indicative of fishable biomass. While the catch rate series for Canadian (M & Q) longliners and Spanish pair trawlers were declining, the two otter trawler series were either level (stern, TC 5) or increasing (side, TC 4) (Figure 5). The results from previous SPA runs indicated a decreasing trend in fishable biomass over the same time period. The replacement of the Western IIA trawl with the more efficient Engel high lift trawl in 1974-75 and the opportunistic nature of the Canadian offshore fishery during this time period (Gray MS 1979) may be partly responsible for this discrepancy. Consequently it was decided to remove the data for Canadian (M & Q) side and stern otter trawlers for 1968 to 1973 from the analysis. The standardized catch rate series obtained using Spanish pair-trawlers TC 4 and TC 5 separately (1968-76), Canadian longliners TC 2-4 combined (1968-83) and Canadian (M & Q) side otter trawlers TC 4 and stern otter trawlers TC 5 (1974-77, 1980-83) is given in Figure 6.

The 1978 and 1979 points are substantially lower than in the former series. While both series show a decline from 1968 to 1975 followed by an increase to current high levels, the relative heights of the two peaks differ. In the initial series the catch rate in 1969 was 64% of the 1982 level while in the second series the 1969 catch rate is 88% of the 1983 level. The authors and the Groundfish Subcommittee consider the later

series to be consistent with both the general consensus regarding data quality and the trend in fishable biomass during the 1968-1975 time period. Consequently only this series is used hereafter.

Groundfish Research Surveys

For the first time in the summer of 1983, the main vessel to conduct the groundfish survey in 4VsW was the Alfred Needler, the new research trawler of the Scotia-Fundy Region. Comparative fishing experiments have been conducted between the Needler and her predecessor the Lady Hammond but their analysis is not completed yet. Both vessels fished together for parts of the 1983 summer survey, but as shown in Table 11, the insufficient coverage of 4VsW by the Hammond compels us to use the Needler's data for this assessment.

Results of preliminary analyses of the comparative fishing experiments between the Needler and the Hammond were presented at the May meeting of the Groundfish Subcommittee (Fanning, pers. comm.). Using these results and others presented last year on connecting the Hammond and the A.T. Cameron data (Koeller and Smith MS 1983), the Subcommittee investigated the problem of amalgamating data from three different research vessels into a coherent time series. It was agreed that for cod, the series for the Cameron and the Hammond should remain unadjusted and that the numbers caught by the Needler should be increased by a factor of 1.39. Although this is a temporary measure which may be modified as more conclusive information becomes available, we adhere to it for the analyses presented here unless otherwise indicated.

As was the case last year, the survey gear encountered unusually high concentrations of cod in several strata of 4W (Table 12). In three of the four strata where that occurred, large sets were experienced by both the Needler and the Hammond which were then fishing close to each other (Table 13). The high numbers caught were the results of heavy concentrations of cod between ages 1 and 4 and especially ages 2 and 3. The population estimates (Table 14 and 15) consequently indicate that the 1979 and 1980 year-classes are very strong, particularly in 4W, and that the 1981 and 1982 year-classes may be above average. A rare sequence of strong year-classes seems to be recruiting to the 4VsW cod population. As for the older ages, the survey data suggest a situation stabilized at a level higher than prior to 1978 (Figure 7). Population estimates from the Hammond for 1980 and 1981 are included in Table 15b for comparison.

In 1979 a spring groundfish survey was initiated using the Lady Hammond on the Scotian Shelf. We now have four years of data available which we present in Tables 16 to 18. In the spring of 1982, large numbers of cod were caught in those strata 55, 56 and 59 where very big sets were recorded in the following summer survey. However no such unusually large set was brought in in the spring (Table 16).

For no obvious reason, the spring cruises have consistently caught less 2 to 4 year-old cod than the summer ones. However these age groups follow the same annual trends in both series (Figure 8). The spring survey data indeed agree with the summer survey in indicating the presence in the 4VsW cod population of very strong 1979 and 1980 year-classes, surrounded by strong ones for 1978 and 1981.

Fall groundfish surveys also began in 1979. However the data on 4VsW cod are too sparse to warrant a meaningful analysis.

Estimation of Stock Size

Sequential Population Analysis (SPA)

We followed the procedure used in the previous assessment of 4VsW cod (Gagné et al. MS 1983) to perform our initial sequential population analysis. Cohort runs (Pope 1972) were carried out with fully recruited fishing mortalities (F) ranging from 0.15 to 0.40 in 0.025 increments. We used the final partial recruitment vector from the 1983 assessment as our input partial recruitment for the most recent year (PR82 in Table 19). Starting F for the oldest age class (age 16+) was set at 0.250 and iterations were continued until the differences between F at age 16 and the mean F for the fully recruited ages 7 to 10 were 0.001 or less. Technically the oldest age class should include only catch at age from a specific year-class (i.e. age 16 rather than 16+) however to be consistent with previous assessments we chose the method described. Although not analysed it is unlikely that this will have a noticable effect on the assessment. The instantaneous rate of natural mortality (M) was assumed to be constant at 0.2.

The resulting population number and F matrices were used to calculate the mean population numbers as in Ricker (1975 p.12). For the purpose of this assessment, we assumed that mean population numbers was equal to mid-year population numbers.

Fishable biomasses were calculated as follows: F values were weighted by population numbers and averaged across fully recruited ages 6 to 10 unless indicated otherwise. The F matrix was divided by these mean Fs to produce a matrix of annual partial recruitment vectors. The yearly estimates of population biomass at age were then multiplied by these partial recruitment vectors and the products summed over ages to obtain the estimates of fishable biomass for each year. A matrix of partial recruitment vectors is presented in Table 20.

The analysis of that matrix led the Subcommittee to the following conclusions:

1) 4VsW cod appears not to be fully recruited to the commercial fishery until age 6, not age 5 as assumed in previous assessments.

2) The general shape of the partial recruitment changed during the period 1968-1983; it was flat-topped from 1968 to 1976, dome-shaped between 1977 and 1981 and flat-topped again in 1982-83.

These had to be considered in calculating fishable biomasses for SPA calibration purposes.

In recent assessments of 4VsW cod, cohort runs were initiated with the final partial recruitment vector from the previous year's analysis. Even though this is a legitimate and accepted procedure it was decided that a second series of cohort runs be done with a new starting partial recruitment vector. Mean values were calculated using the vectors of Table 20 for the period 1977 to 1981. In agreement with the preceding analysis, full recruitment was assumed for ages 6 and older. The resulting vector appears as PRAV in Table 19. Before this vector could be used to initiate cohort analysis runs, it was decided to change the values for ages 1 to 3 as follows, assuming a fully recruited fishing mortality of 0.2: the values for ages 1 and 2 were adjusted to make the size of the 1981 and 1982 year-classes approximately equal to the long-term geometric mean at age 1 (107×10^6 from the results of the 1983 assessment, 1958-1980). The 1980 year-class (age 3) was made equal to the largest observed since 1968 i.e. the 1979 year-class. This partial recruitment vector is presented as PRSUB in Table 19.

Calculation of Partial F Matrices

The small mesh fishery in 4VsW is not cod directed. Consequently there is no catch rate information available to incorporate in the commercial catch rate standardization process. To improve the calibration of the SPA results with the standardized catch rate, it was decided to remove the influence of that fishery's catches from the estimates of fishable biomasses.

From their analyses of the cod catches in the small mesh fishery, Maguire et al. (MS 1982) concluded that the removals at age calculated by Gray (MS 1979) for the period 1966-78 were probably as accurate as possible. They were therefore used in the last two assessments. Maguire et al. (MS 1982) also provided estimates for 1979 to 1981. Gagné et al. (MS 1983) revised the 1980 and 1981 estimates from more recent statistics and provided one for 1982. An estimate for 1983 is presented in Table 6 of this document. From these various sources, we constructed a catch-at-age matrix for the small mesh fishery for the period 1968 to 1983 (Table 21). We then subtracted these numbers from the catch-at-age matrix for the entire fishery. Dividing the resulting array by the total catch-at-age matrix gave us the proportion of the total fishing mortality generated by all the gears combined except the small-mesh gear (Table 22). A partial F matrix representing all the non-small-mesh gears can be obtained by multiplying a total F matrix by these proportions.

In order to calculate biomasses exploitable by the non-small-mesh gears, we needed a partial recruitment matrix derived from a partial F matrix. From the second series of cohort runs, we took the F matrix generated for a fully recruited F of 0.25 and multiplied it by the matrix of proportions described above (Table 22). From that matrix of partial Fs (Table 23) we produced a partial recruitment matrix by following the procedure outlined earlier. The mean weighted Fs were calculated on ages 7 to 10.

Calculation of Partial Fishable Biomasses

As indicated before, the analysis of Table 20 revealed that vectors of different shapes were required to describe the overall availability of the fish to the commercial gears during different periods. From the partial recruitment matrix just described (Table 23), partial recruitment vectors were derived for the periods 1968-76 and 1977-81.

The individual vectors of the first period were averaged across the years and these averages deemed to be representative of that period. Ages 6 and older were assumed to be fully recruited.

The recruitment pattern for the 1977 to 1981 period appeared to be domed-shaped and thus required a different procedure. The annual vectors were averaged and the mean of the averages for the fully recruited ages 6 and 7 calculated. The inverse of that mean (1/1.12 = 0.89) was then multiplied by the mean PR for ages 1 to 5 as well as 8 and 9. This procedure is not sensitive to the value of input terminal fishing mortality. For instance a terminal F value of 0.35 would have generated partial recruitment values of 0.35 and 0.78 for ages 4 and 5 respectively rather than 0.34 and 0.79 as obtained with a teminal F of 0.25. Recruitment was set at 0.45 for ages 10 and older.

For the 1982-83 period we used the starting partial recruitment vector of the second series of cohort runs (PRSUB).

These three vectors (Table 19) were then deployed into a partial recruitment matrix to be used as a constant in the calculation of fishable biomasses. That matrix is characterized by the alternation of flat-topped and dome-shaped partial recruitment patterns and is free from the influence of the small mesh fishery.

Mid-year fishable biomasses were calculated by multiplying the product of that matrix and the mean weights-at-age of Table 8 by the mid-year population numbers derived from the second series of cohort runs.

Calibration of SPA

a) WITH COMMERCIAL CATCH RATE

Gagné *et al.* (MS 1983) used estimates of the beginning-of-the-year fishable biomass to calibrate the SPA results against a standardized

commercial catch rate. However more of the total annual catch of 4VsW cod is taken during the spring to fall period than during other times of the year. The commercial catch and effort statistics are therefore likely to be more representative of the mid-year period. Mid-year estimates of fishable biomass should then be the appropriate representation of population size to calibrate against the standardized commercial catch rate. The results of such calibration runs are presented in Table 24 and Figure 9.

The criteria used by Gagné et al. (MS 1983) to identify the best relationship were the coefficient of determination, the intercept and the ratio between the predicted and the cohort analysis values for the two most recent years. From the statistical point of view, the coefficient of correlation and not its squared value is the proper index to consider in analyses like this one. Using either one however will lead to the same conclusions. Mohn (1983) evaluated various ways of calibrating cohort analyses and concluded that the use of the intercept as a tuning criterion should be discouraged. We therefore adopted the following criteria to select the best relationship: the maximization of the correlation coefficient (r) and the minimization of the residuals for 1981-1983.

Table 24 shows that r is highest (0.92) at fully recruited F values ranging from 0.3 to 0.375 although there was little difference for F_t = 0.275 to F_t = 0.4. The residuals for 1981-1983 are collectively minimized when the mean of the ratios between the predicted and observed values is closest to 1.0. This is obtained for F_t = 0.35. This value of 0.35 is also in the middle of the range of terminal Fs suggested by the correlation coefficient. The calibration with the commercial catch rate therefore indicates a fully-recruited fishing mortality for 1983 of 0.35.

b) WITH RESEARCH SURVEY ABUNDANCE ESTIMATES

We attempted to calibrate the mid-year population estimates of the fully-recruited ages from the second series of cohort runs with those of the research vessel surveys. The survey data were not corrected for the unusually large sets since the influence of these sets is negligible for age 6 and older (Table 13). As indicated by the analysis of the comparative fishing experiment results summarized earlier, we used the unadjusted survey 6+ estimates for 1982 and the 1983 data were first multiplied by 1.39 as in Table 15a.

We summarize the results of the calibration runs in Table 25. Using the same criteria as earlier with the commercial catch rate we see that r values of 0.87 and 0.88 are obtained for terminal F ranging from 0.125 to 0.200. The mean residuals for the 1981-83 period are minimized for F_t between 0.25 and 0.30.

The two criteria therefore indicate different ranges of F values. Similar situations occur when other sets of criteria are considered e.g. r and 1983 residuals, r and mean residuals for 1982-83, etc.. Even though

the relationships between the two variables are very good as evidenced by the r values, we were unable to discriminate amongst them. The Subcommittee therefore concluded that research survey population estimates could not be used to evaluate the 1983 fully-recruited fishing mortality. As for last year, terminal F was estimated on the basis of the commercial data only. The value of F_t = 0.35 was therefore adopted.

F on Partially Recruited Ages

For the 1982 and 1983 assessments of 4VsW cod, Maguire et al. (MS 1982) and Gagné et al. (MS 1983) used an index of year-class size derived from the commercial catch rate data to evaluate the partially-recruited F at age 4. Following the same procedure with the new standardized catch rate calculated for the present assessment produces very good relationships for ages 4 and 5 (r values around 0.9).

The Subcommittee recognized the potential of that approach which utilizes the most recent information from the fishery to estimate parameters for the most recent year. Partial recruitment values however should remain stable over periods of time when no major changes occur in a fishery. On that basis, the Subcommittee requested that the final partial recruitment be calculated as for the second series of cohort runs, assuming a terminal F of 0.35. Averages for the period 1977 to 1981 were therefore used rather than estimates from calibration runs to set the partial recruitment for ages 4 and 5. The resulting vector is PRFIN of Table 19. The corresponding population numbers, fishing mortalities and population biomasses are presented in Tables 26 to 28. Based on these results, it now appears that the 1979 year-class is the largest observed since the 1965 year-class. The 1980 year-class may be even more abundant as the partial recruitment at age 3 had to be reduced to an unusually low level just to make this year-class equal to the largest previously observed at that age i.e. the 1979 year-class.

We discuss in Appendix 2 the effect of using average partial recruitment values for ages 4 and 5 rather than calibrated ones on the results of this assessment.

Catch Projections

Table 29 presents the input vectors used for catch projections. The population numbers at ages 1 and 2 were set to make the size of the corresponding year-classes at age 1 equal to the long-term geometric mean of 107 million fish. The numbers for the other ages are as in Table 26. The 1983 catches at age are from Table 7.

In the two preceding assessments of 4VsW cod, the most recent weights at age were used for catch projections. Our data (Table 8) indicate that the mean weight of a cod (age 1+) in 4VsW increased from 1975 to 1980. For the last three years, it has been fluctuating around 5.5 kilograms with the

1983 value being lower than that of 1982. It is possible that these fluctuations are not real but only result from the uncertainty associated with the available sampling data. For that reason it was decided to use the averages for these three years instead of the most recent weights at age as in previous assessments.

The partial recruitment vector used is the vector of means (PRAV of Table 19) from which we derived PRFIN, the vector used to estimate the fishable biomasses for 1982 and 1983. $F_{0.1}$ was set to 0.2, the accepted value for cod stocks in the Northwest Atlantic.

The results of these projections are summarized in Table 30. If the TAC of 55,000 tons is taken in 1984, the projected 1985 catch resulting from fishing at $F_{0.1}$ would be 52,000 tons. Fishing at $F_{0.1}$ in 1984 would drastically reduce the catch to 42,000 tons and marginally increase the 1985 $F_{0.1}$ catch to 54,000 tons.

Discussion and Conclusion

The results of our analysis corroborate last year's conclusion that the 4VsW cod stock complex is currently quite large. The fishery is supported by a good array of year-classes. The research vessel surveys indicate that the current abundance exceeds the highest levels observed in the 1970s. The 1979 and 1980 year-classes are reaching the ages of recruitment to the fishery and they both appear to be larger than the largest ones observed in 25 years. In 1982 and 1983, the research surveys have caught unprecedented quantities of ages 1 and 2 cod which suggests that the in-coming year-classes too will be much above average. The surveys also indicate that the abundance of the fully-recruited age-groups is remaining stable in spite of an increasing harvest. All these signs agree in identifying a large population.

Yet, the TAC dropped by 9,000 t between 1983 and 1984 and no increase can be anticipated for 1985. This contradiction can be explained by problems encountered in assessing the status of the stock complex. Errors in catch-per-unit-effort statistics of the Scotia-Fundy Region were responsible for overestimating the 1983 optimal yield (Gagné et al. MS 1983).

Table 31 compares the mean fully recruited Fs (ages 6-16) for the years 1977 to 1982 from the current analysis to the estimates produced by the corresponding annual assessments. For instance, it now appears that fully-recruited F in 1977 was 0.27 while Gray (MS 1978) estimated it to be 0.15. Table 31 demonstrates that CAFSAC has consistently underestimated the fishing mortality applied to the stock complex by an average of 54%. This realization was responsible for the dramatic increase in the estimated fully-recruited F between 1982 and 1983. It does not represent a real increase in F but only reflects CAFSAC's new perception of the reality. Had the stock complex not been much larger than a few years ago, this would have generated an equally dramatic reduction in the proposed catch levels.

With the current status of the stock however, it is likely to translate into stable TACs for 1984 and 1985.

Our analysis therefore indicates that fully-recruited fishing mortalities have been well in excess of $F_{0.1}$ since 1977, even exceeding F_{MAX}=0.3 in all but one year. Concurrently fishable biomass has doubled undoubtedly due to the succession of good to very good year-classes. Thus exploitation rates in excess of $F_{0.1}$ for this time period have not prevented the rebuilding of the stock. In fact the actual exploitation levels may have been appropriate to take advantage of the yield potential of these good year-classes while they were of optimal age.

It must be cautioned however that since 1977, restrictions imposed by Fisheries and Oceans were aimed at keeping fishing mortality rates at or below $F_{0.1}$. In spite of these efforts, the resulting F values have always been near or above F_{MAX}.

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Table 1. 4VsW cod nominal catches by country and NAFO Divisions.

YEAR	CANADA	FRANCE	PORTUGAL	SPAIN	USSR	OTHERS	TOTAL	SUBDIV. 4Vs	DIV. 4W	TAC
1958	17938	4577	1095	14857	-	124	38591	23790	14801	-
1959	20069	16378	8384	19999	-	1196	66026	47063	18963	-
1960	18389	1018	1720	29391	-	126	50645	27689	22956	-
1961	19697	3252	2321	40884	113	42	66309	34237	32072	-
1962	17579	2645	341	42146	2383	60	65154	26350	38804	-
1963	13144	72	617	44528	9505	307	68173	27566	40607	-
1964	14330	1010	-	39690	7133	1094	63257	25496	37761	-
1965	23104	536	88	39280	7856	124	70988	36713	34275	-
1966	17690	1494	-	43157	5473	356	68170	27163	41007	-
1967	18464	77	102	33934	1068	512	54157	26607	27550	-
1968	24888	225	-	50418	4865	29	80425	48781	31644	-
1969	14188	217	-	32305	2783	664	50157	22309	27848	-
1970	11818	420	296	41926	2521	446	57427	28632	28795	-
1971	17064	4	18	30864	4506	107	52563	24128	28435	-
1972	19987	495	856	28542	4646	7119	61645	36533	25112	-
1973	15929	922	849	30883	2918	2569	54070	23401	30669	60500
1974	10700	34	1464	27384	3096	1060	43739	19610	24130	60000
1975	9939	1867	546	15611	3042	1512	32517	11694	20823	60000
1976	9567	697	-	11090	1018	2035	24407	11553	12854	30000
1977	9890	68	-	-	97	335	10390	2873	7517	7000
1978	24642	437	-	57	218	51	25405	10357	15048	7000[1]
1979	39219	18	-	2	683	108	40030	15393	24637	30000
1980	48821	17	5	5	338	66	49252	31378	17874	45000
1981	53053	-	-	-	630	35	53718	32107	21611	50000
1982	55675[2]	-	-	-	45[3]	34[3]	55754	40112	15642	55600
1983	50885[2]	-	1218[3]	-	166[3]	63[3]	52332	33171	19161	64000

[1] By-catch only

[2] Final Maritimes, preliminary Newfoundland

[3] Preliminary NAFO

Table 2. Division 4VsW cod: Canadian nominal catches by otter trawls[1] and other gear.

Year	Division 4VS		Division 4W		Totals		Totals[4]
	Trawls	Other Gear	Trawls	Other Gear	Trawls	Other Gear	
1958[2]	4258	2092	4892	5731	9150	7823	16973
1959	4181	1286	7294	7308	11475	8594	20069
1960	1924	750	10228	5488	12152	6238	18390
1961	1135	136	12895	5531	14030	5667	19697
1962	1495	93	11762	4229	13257	4322	17579
1963	1258	34	7779	4063	9037	4097	13134
1964	2059	41	7324	4906	9383	4947	14330
1965	7366	106	10293	5338	17659	5444	23103
1966	6375	156	6614	4545	12989	4701	17690
1967	6729	132	6463	5140	13192	5272	18464
1968	9501	66	8367	6954	17868	7020	24888
1969	3539	51	4424	6174	7963	6225	14188
1970	3054	22	3596	5146	6650	5168	11818
1971	5826	41	4745	6452	10571	6493	17064
1972	9856	119	4732	5280	14588	5399	19987
1973	6397	77	4723	4731	11120	4808	15928
1974	4640	60	1343	4658	5983	4718	10701
1975	1815	72	3556	4496	5371	4568	9939
1976	3496	301	934	4836	4430	5137	9567
1977	2751	54	1873	5212	4624	5266	9890
1978	9561	313	8037	6731	17598	7044	24642
1979	14853	524	13784	10058	28637	10582	39219
1980	28941	2437	6298	11145	35239	13582	48821
1981	27662	4445	9148	11798	36810	16243	53053
1982[3]	32274	7838	6352	9211	38626	17049	55675
1983[3]	26752	5201	11021	7911	37773	13112	50885

[1] Total of OTB1, OTB2, OTM, OTB, and BPT

[2] Does not include catch reported only as 4V which is included in Table 1.

[3] Final Maritimes, Preliminary Newfoundland.

[4] Totals may differ from Table 1 due to rounding error.

Table 3. Quarterly distribution of catch to sample ratios for the major Canadian gears in the 1983 4VsW cod fishery.

	Otter Trawls	Lines	Seines	Gillnets
4Vs-Q_1	4650/ 19 = 245	44/ 0	0/ 0	0/0
Q_2	7237/ 10 = 724	2140/ 3 = 713	253/ 3 = 84	0/0
Q_3	5522/ 9 = 614	1660/ 8 = 208	157/ 0	0/0
Q_4	9343/ 27 = 346	629/ 5 = 126	261/ 0	0/0
Total	26752/ 65 = 412	4473/16 = 280	671/ 3 = 224	0/0
4W-Q_1	3519/ 15 = 235	197/ 0	78/ 0	71/0
Q_2	6689/ 12 = 557	1695/11 = 154	785/ 6 = 131	116/0
Q_3	311/ 3 = 104	1436/ 7 = 205	690/ 8 = 86	299/5 = 60
Q_4	502/ 3 = 167	1125/ 1 = 1125	385/ 6 = 64	105/0
Total	11021/ 33 = 334	4453/19 = 234	1938/20 = 97	591/5 = 118
4VsW-Q_1	8169/ 38 = 215	241/ 0	78/ 0	71/0
Q_2	13926/ 31 = 449	3835/14 = 274	1038/ 9 = 115	116/0
Q_3	5833/ 14 = 417	3096/16 = 194	847/ 8 = 106	299/5 = 60
Q_4	9845/ 31 = 318	1754/ 6 = 292	646/ 6 = 108	105/0
Total	37773/114 = 331	8926/36 = 248	2609/23 = 113	591/5 = 118
			Overall Total	49899/178 = 280

Note: The numbers of samples for 4VsW do not agree with the totals of 4Vs + 4W because several samples were assigned to 4VsW and not to a specific Division.

Table 4. Data used to generate the age-length keys for 4VsW cod in 1983 and to revise those for 1982.

a) 1983

Key	Gear	Period Covered	No. of Samples	Length-Weight Coefficients a	Length-Weight Coefficients b	NAFO Division	Catch (t)
1	Otter-trawls	January-March	33	.0103	2.971	4VsW	8169
2	Otter-trawls	April-June	12	.0103	2.971	4VsW	13926
3	Otter-trawls	July-September	5	.0096	2.986	4Vs	5833
4	Otter-trawls	October-December	5	.0096	2.986	4Vs	10102
5	Long-lines	January-June	8	.0103	2.971	4VsW	4076
6	Long-lines	July-December	10	.0103	2.971	4VsW	4850
7	Seines	January-June	6	.0105	2.972	4W	1116
8	Seines	July-December	5	.0105	2.972	4W	1493
9	USSR + Cuba	April-September	49	.0105	2.972	4W	226
10	Portugal	April-May	65	.0096	2.986	4Vs	961
						TOTAL:	50752

b) 1982

Key	Gear	Period Covered	No. of Samples	Length-Weight Coefficients a	Length-Weight Coefficients b	NAFO Division	Catch (t)
1	Otter-trawls	January-March	24	.010	2.985	4VsW	13123
2	Otter-trawls	April-June	22	.010	2.985	4VsW	13197
4	Otter-trawls	October-December	15	.010	2.985	4VsW	8905
7	Seines	January-December	13	.010	2.985	4VsW	2796

a) Age composition (%) for each key.

	OTB				LL		SNU		COMM	PORT
AGE	Q1	Q2	Q3	Q4	Q1-2	Q3-4	Q1-2	Q3-4	Q2-3	Q2
1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.87	0.00
3.00	5.05	11.29	6.53	21.79	0.14	0.74	1.61	20.28	22.10	13.88
4.00	27.11	29.20	31.55	39.67	3.49	11.92	35.11	39.37	41.34	27.18
5.00	25.45	29.01	32.72	21.12	10.28	27.40	25.06	36.28	25.32	32.95
6.00	26.49	23.62	17.79	10.84	35.26	26.53	28.52	3.20	8.24	17.84
7.00	7.17	4.94	6.21	3.57	15.73	11.50	5.77	0.44	1.23	5.07
8.00	5.34	1.02	2.96	0.79	16.97	8.86	3.61	0.00	0.67	1.32
9.00	2.64	0.65	1.54	1.18	10.63	4.91	0.32	0.42	0.17	0.77
10.00	0.37	0.09	0.46	0.61	3.41	3.04	0.00	0.00	0.00	0.17
11.00	0.21	0.08	0.22	0.36	2.10	2.50	0.00	0.00	0.00	0.18
12.00	0.07	0.09	0.01	0.06	0.67	1.09	0.00	0.00	0.00	0.11
13.00	0.04	0.01	0.00	0.00	0.39	0.70	0.00	0.00	0.00	0.00
14.00	0.02	0.00	0.00	0.00	0.68	0.24	0.00	0.00	0.00	0.00
15.00	0.02	0.00	0.00	0.00	0.17	0.09	0.00	0.00	0.00	0.00
16.00	0.00	0.00	0.00	0.00	0.09	0.49	0.00	0.00	0.00	0.00

b) Weights at age.

	OTB				LL		SNU		COMM	PORT
AGE	Q1	Q2	Q3	Q4	Q1-2	Q3-4	Q1-2	Q3-4	Q2-3	Q2
1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00
2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.00
3.00	0.56	0.76	0.87	0.87	0.55	0.70	0.82	0.92	0.72	0.67
4.00	0.96	1.03	1.09	1.18	1.10	1.03	1.08	1.21	1.05	1.09
5.00	1.24	1.56	1.65	1.76	1.42	1.56	1.42	1.61	1.41	1.57
6.00	1.87	2.19	2.26	2.13	2.08	2.14	2.02	1.93	1.90	2.47
7.00	2.61	3.41	3.60	3.43	2.71	3.01	2.48	2.54	2.11	3.64
8.00	2.59	4.29	4.55	4.49	3.30	4.36	2.22	0.00	2.14	4.72
9.00	3.12	4.70	4.83	5.51	4.42	4.80	3.38	2.47	2.45	5.23
10.00	5.95	7.16	4.82	5.75	5.07	6.35	0.00	0.00	0.00	7.57
11.00	6.60	7.56	7.50	6.14	6.49	7.70	0.00	0.00	0.00	6.96
12.00	10.24	6.56	9.83	10.19	9.95	9.20	0.00	0.00	0.00	6.56
13.00	11.53	12.61	0.00	0.00	10.39	10.44	0.00	0.00	0.00	0.00
14.00	11.49	14.74	0.00	0.00	11.32	12.66	0.00	0.00	0.00	0.00
15.00	10.16	0.00	0.00	0.00	12.78	14.23	0.00	0.00	0.00	0.00
16.00	14.30	12.03	0.00	0.00	14.74	12.16	0.00	0.00	0.00	0.00

c) Catches at age.

	OTB				LL		SNU		COMM	PORT
AGE	Q1	Q2	Q3	Q4	Q1-2	Q3-4	Q1-2	Q3-4	Q2-3	Q2
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	2	0
3	264	970	210	1425	2	13	12	227	43	79
4	1417	2509	1013	2594	49	210	252	441	81	156
5	1330	2492	1051	1381	144	483	180	406	50	189
6	1384	2029	571	709	495	468	204	36	16	102
7	375	424	199	233	221	203	41	5	2	29
8	279	88	95	52	238	156	26	0	1	8
9	138	56	49	77	149	87	2	5	0	4
10	19	8	15	40	48	54	0	0	0	1
11	11	7	7	24	29	44	0	0	0	1
12	4	8	0	4	9	19	0	0	0	1
13	2	1	0	0	5	12	0	0	0	0
14	1	0	0	0	10	4	0	0	0	0
15	1	0	0	0	2	2	0	0	0	0
16	0	0	0	0	1	9	0	0	0	0
TOTAL :	5225	8591	3211	6538	1404	1763	717	1120	195	570

Table 5. Age-length key data used to calculate the 1983 catches-at-age. (COMM: USSR + Cuba; PORT: Portugal).

Table 6. 4VsW cod catch at age in the 1978-1983 silver hake fishery.

	YEAR					
AGE	1978	1979	1980	1981	1982	1983*
1	28669	12344	31016	2996	4624	59
2	62548	45994	25245	62732	1389	1701
3	151536	105752	83462	301853	11651	43208
4	177662	213731	72590	280809	16255	80825
5	27051	181317	91791	40672	10223	49504
6	3162	42341	45250	24624	2734	16110
7	1026	5085	16605	7924	1166	2405
8	-	466	1070	1337	160	1310
9	-	129	526	-	369	332
TOTAL	451654	607159	367555	722947	48571	195454
NO. MEASURED	890	2504	6508	4730	1519	3385

* Includes Cuban catches.

Table 7.

4VSW COD; REMOVALS AT AGE (000"S). 28/ 4/84

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0	0	0	45	935	3730	2799	3083	2806	548	2495	1426	1293	2311	2383
2	138	0	0	283	5962	23782	17955	19668	17891	4235	16045	9097	8631	15218	17738
3	2854	2499	7016	3443	6026	16949	14731	18721	17493	6267	17413	7684	8886	12582	14227
4	3534	8887	6118	9588	10335	12267	8930	12497	13973	7989	17783	13724	14802	9146	13361
5	2533	8811	6655	9340	6372	10916	11779	5345	10577	9456	15633	10248	13673	8809	9661
6	3726	6490	4525	6676	7887	5423	4696	6130	4461	4338	8297	6073	4539	10262	8780
7	1610	4384	2811	2885	2744	4875	2874	3135	3256	1467	3482	2144	1942	5160	3432
8	1465	1467	1827	1882	2538	2183	2345	4477	1590	1239	895	510	759	1849	1919
9	2014	878	290	1212	686	346	1047	2127	856	664	816	237	236	496	358
10	859	1101	133	169	478	134	312	1583	496	647	361	50	72	114	393
11	543	318	122	147	169	121	145	172	666	325	152	95	137	131	79
12	58	251	75	88	75	50	75	91	24	65	211	58	56	72	2
13	51	27	1	66	68	26	50	96	14	16	33	12	9	98	37
14	11	0	15	3	0	0	0	88	0	5	17	7	12	12	0
15	10	0	0	0	5	0	0	163	2	7	1	2	4	51	1
16	53	21	6	0	0	1	11	7	1	2	10	2	3	17	1
1+	19459	35134	29594	35826	44279	80803	67749	77384	74106	37270	83644	51369	55054	66328	72372
2+	19459	35134	29594	35782	43344	77073	64950	74301	71300	36722	81149	49943	53761	64017	69989
3+	19321	35134	29594	35499	37383	53291	46995	54633	53409	32487	65104	40846	45130	48799	52251
4+	16467	32635	22578	32056	31357	36342	32264	35912	35916	26220	47691	33162	36244	36217	38024
5+	12933	23748	16460	22468	21022	24075	23334	23414	21943	18231	29908	19438	21442	27071	24663
6+	10400	14937	9805	13128	14650	13159	11555	18069	11366	8775	14275	9190	7769	18262	15002

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	1418	1482	1792	728	2	177	12	31	3	5	0
2	12142	8451	9979	4061	24	153	81	152	348	149	2
3	14881	12885	9485	3587	386	1004	1629	2034	3742	2500	3346
4	7507	9947	4341	3713	1073	3650	6164	5119	9724	7664	8992
5	9755	7130	4549	4818	1559	4621	9145	7112	7276	9953	7946
6	3823	2766	2594	2412	871	2441	4871	6147	4852	3449	6202
7	2996	944	2627	1426	501	768	1162	2929	2991	2408	1787
8	3724	1323	612	611	220	213	371	1066	1455	1273	972
9	1166	413	497	184	128	112	76	319	393	674	586
10	273	369	660	49	35	80	23	88	126	304	190
11	299	15	153	22	44	26	10	47	62	156	127
12	3	5	126	107	55	28	5	26	32	67	46
13	7	0	36	1	11	26	4	4	21	57	21
14	5	0	9	4	3	9	1	1	2	51	15
15	5	0	9	1	2	4	0	4	6	19	5
16	20	0	18	1	7	2	0	8	6	24	10
1+	58024	45730	37487	21725	4921	13314	23554	25087	31039	28752	30248
2+	56606	44248	35695	20997	4919	13137	23541	25056	31036	28747	30248
3+	44464	35797	25716	16936	4895	12984	23460	24904	30688	28598	30246
4+	29583	22912	16231	13349	4509	11980	21831	22870	26946	26098	26900
5+	22076	12965	11890	9636	3436	8330	15666	17751	17222	18434	17908
6+	12321	5835	7341	4818	1877	3709	6522	10639	9946	8481	9962

Table 8.

4VSW COD; MEAN WEIGHTS AT AGE (KG). 28/ 4/84

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.020	0.020	0.020	0.020	0.020	0.010
2	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.150	0.160	0.150	0.140	0.150	0.110
3	0.565	0.565	0.565	0.565	0.565	0.565	0.565	0.565	0.450	0.470	0.430	0.420	0.450	0.320
4	0.943	0.943	0.943	0.943	0.943	0.943	0.943	0.943	0.900	0.960	0.870	0.850	0.910	0.640
5	1.465	1.465	1.465	1.465	1.465	1.465	1.465	1.465	1.490	1.590	1.440	1.410	1.500	1.070
6	2.097	2.097	2.097	2.097	2.097	2.097	2.097	2.097	2.180	2.330	2.100	2.070	2.190	1.560
7	2.827	2.827	2.827	2.827	2.827	2.827	2.827	2.827	2.940	3.130	2.820	2.780	2.940	2.090
8	3.671	3.671	3.671	3.671	3.671	3.671	3.671	3.671	3.720	3.960	3.570	3.520	3.730	2.650
9	4.335	4.335	4.335	4.335	4.335	4.335	4.335	4.335	4.500	4.790	4.330	4.260	4.510	3.210
10	5.263	5.263	5.263	5.263	5.263	5.263	5.263	5.263	5.270	5.610	5.060	4.990	5.280	3.750
11	5.956	5.956	5.956	5.956	5.956	5.956	5.956	5.956	6.000	6.390	5.770	5.680	6.020	4.280
12	6.845	6.845	6.845	6.845	6.845	6.845	6.845	6.845	6.690	7.120	6.430	6.340	6.710	4.770
13	7.500	7.500	7.500	7.500	7.500	7.500	7.500	7.500	7.340	7.810	7.050	6.950	7.360	5.230
14	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	7.930	8.440	7.620	7.510	7.950	5.650
15	9.025	9.025	9.025	9.025	9.025	9.025	9.025	9.025	8.470	9.010	8.140	8.020	8.490	6.040
16	10.014	10.014	10.014	10.014	10.014	10.014	10.014	10.014	8.960	9.530	8.610	8.480	8.980	6.380

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.050	0.080	0.130	0.100	0.100	0.100	0.200	0.000	0.000	0.000	0.000	0.120
2	0.180	0.220	0.330	0.270	0.280	0.280	0.620	0.530	0.570	0.616	0.581	0.390
3	0.440	0.450	0.620	0.530	0.570	0.810	0.950	0.760	0.800	0.833	0.805	0.807
4	0.810	0.790	1.020	0.890	0.960	1.090	1.250	1.060	1.150	1.139	1.073	1.082
5	1.290	1.210	1.530	1.340	1.460	1.670	1.680	1.700	1.600	1.693	1.580	1.549
6	1.850	1.720	2.130	1.870	2.030	2.360	2.470	2.390	2.210	2.133	2.393	2.100
7	2.480	2.280	2.820	2.470	2.660	3.170	3.610	3.130	3.080	2.965	2.779	3.103
8	3.140	2.900	3.580	3.120	3.350	4.580	5.230	3.710	4.310	3.941	4.074	3.529
9	3.830	3.540	4.410	3.810	4.070	4.140	5.590	4.770	5.260	5.698	5.492	4.378
10	4.520	4.220	5.280	4.530	4.800	5.330	6.540	6.840	6.920	7.163	7.078	5.763
11	5.200	4.900	6.190	5.270	5.550	4.650	7.920	7.960	7.560	7.673	8.743	6.988
12	5.870	5.590	7.130	6.010	6.290	4.910	9.210	9.410	10.190	9.261	9.097	9.041
13	6.520	6.280	8.090	6.760	7.020	7.140	10.400	10.630	7.920	11.868	11.428	10.626
14	7.140	6.960	9.050	7.510	7.740	8.590	9.750	10.030	8.130	8.654	10.589	11.715
15	7.730	7.620	10.010	8.240	8.430	10.600	8.680	11.450	14.450	9.836	12.484	12.693
16	8.290	8.270	10.960	8.960	9.100	14.940	12.210	12.510	14.030	14.107	13.927	12.489

Table 9.

4VSW COD; CATCH BIOMASS AT AGE (T), 28/ 4/84

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0	0	0	3	54	216	162	179	56	11	50	29	26	23	119
2	38	0	0	78	1645	6564	4956	5428	2684	678	2407	1274	1295	1674	3193
3	1613	1412	3964	1945	3405	9576	8323	10577	7872	2945	7488	3227	3999	4026	6260
4	3333	8380	5769	9041	9746	11568	8421	11785	12576	7669	15471	11665	13470	5853	10822
5	3711	12908	9750	13683	9335	15992	17257	7831	15760	15035	22512	14450	20510	9426	12463
6	7813	13610	9489	14000	16539	11372	9848	12855	9725	10108	17424	12571	9940	16009	16243
7	4551	12394	7947	8156	7757	13782	8125	8863	9573	4592	9819	5960	5709	10784	8511
8	5378	5385	6707	6909	9317	8014	8608	16435	5915	4906	3195	1795	2831	4900	6026
9	8731	3806	1257	5254	2974	1500	4539	9221	3852	3181	3533	1010	1064	1592	1371
10	4521	5795	700	889	2516	705	1642	8331	2614	3630	1827	249	380	428	1776
11	3234	1894	727	876	1007	721	864	1024	3996	2077	877	540	825	561	411
12	397	1718	513	602	513	342	513	623	161	463	1357	368	376	343	12
13	382	203	8	495	510	195	375	720	103	125	233	83	66	513	241
14	88	0	120	24	0	0	0	704	0	42	130	53	95	68	0
15	90	0	0	0	45	0	0	1471	17	63	8	16	34	308	8
16	531	210	60	0	0	10	110	70	9	19	86	17	27	108	8
1+	44411	67715	47010	61955	65363	80556	73742	96117	74911	55543	86415	53306	60647	56616	67464
2+	44411	67715	47010	61952	65309	80340	73580	95938	74854	55532	86365	53278	60621	56593	67345
3+	44373	67715	47010	61874	63663	73776	68624	90510	72171	54855	83959	52004	59327	54919	64152
4+	42761	66303	43046	59929	60259	64200	60301	79932	64299	51909	76471	48777	55328	50893	57892
5+	39428	57922	37277	50887	50513	52632	51880	68148	51723	44240	61000	37112	41858	45039	47070
6+	35717	45014	27527	37205	41178	36641	34624	60317	35964	29205	38488	22662	21349	35614	34607

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	113	193	179	73	0	35	0	0	0	0	0
2	2671	2789	2694	1137	7	95	43	87	214	87	1
3	6696	7989	5027	2045	313	954	1238	1627	3117	2013	2702
4	5931	10146	3863	3564	1170	4562	6534	5887	11076	8221	9734
5	11804	10909	6096	7034	2604	7763	15546	11379	12318	15724	12307
6	6576	5892	4851	4896	2056	6029	11641	13585	10349	8252	13022
7	6831	2662	6489	3793	1588	2772	3637	9021	8868	6691	5546
8	10800	4736	1909	2047	1008	1114	1377	4594	5734	5184	3430
9	4128	1821	1894	749	530	626	362	1678	2239	3700	2564
10	1152	1948	2990	235	187	523	155	609	903	2153	1094
11	1465	93	806	122	205	206	78	355	476	1361	887
12	17	36	757	673	270	258	46	265	296	611	418
13	44	0	243	7	79	270	42	32	249	655	228
14	35	0	68	31	26	88	10	8	17	536	179
15	38	0	74	8	21	35	0	58	59	235	66
16	165	0	161	9	105	24	0	112	85	336	128
1+	58465	49213	38102	26424	10165	25356	40708	49298	56001	55758	52304
2+	58352	49021	37923	26352	10165	25321	40708	49298	56001	55758	52304
3+	55680	46232	35228	25214	10158	25226	40665	49211	55787	55671	52303
4+	48984	38243	30201	23170	9846	24272	39427	47584	52670	53658	49602
5+	43053	28097	26338	19605	8676	19709	32893	41697	41594	45437	39868
6+	31250	17188	20242	12571	6073	11946	17347	30318	29276	29713	27561

Table 10. Variables used to project the 1983 catch composition.

a) Data as in Gagné et al. (MS 1983).

AGE	NB.	CATCH	WEIGHT	PR
1	110336	5	0.066	0.00020
2	90495	41	0.576	0.00200
3	68843	1845	0.743	0.12000
4	55891	6589	1.045	0.55600
5	49191	9903	1.577	1.00000
6	19139	3853	2.389	1.00000
7	14018	2822	2.708	1.00000
8	7396	1489	3.695	1.00000
9	3641	733	5.019	1.00000
10	1455	293	7.037	1.00000
11	710	143	8.796	1.00000
12	313	63	9.107	1.00000
13	323	65	11.397	1.00000
14	283	57	10.914	1.00000
15	99	20	12.514	1.00000
16	114	23	13.878	1.00000

b) Data updated for 1984 assessment.

AGE	NB.	CATCH	WEIGHT	PR
1	105082	5	0.066	0.00021
2	88013	149	0.581	0.00750
3	70295	2500	0.805	0.16000
4	65013	7664	1.073	0.55600
5	49438	9953	1.580	1.00000
6	17132	3449	2.393	1.00000
7	11960	2408	2.779	1.00000
8	6321	1273	4.074	1.00000
9	3346	674	5.492	1.00000
10	1511	304	7.078	1.00000
11	773	156	8.743	1.00000
12	334	67	9.097	1.00000
13	285	57	11.428	1.00000
14	251	51	10.589	1.00000
15	93	19	12.484	1.00000
16	120	24	13.927	1.00000

Table 11. Results of 1983 comparative fishing for 4VsW cod. Stratum totals were calculated assuming a trawl wing spread of 34', the same as that used on the A.T. Cameron. The Needler data were unadjusted.

		ALFRED NEEDLER Stratum Total ('000)			LADY HAMMOND Stratum Total ('000)	
Stratum	# Sets	Number ($x10^{-3}$)	Weight (t)	# Sets	Number ($x10^{-3}$)	Weight (t)
			4Vs			
43	4	11687	18562	1	130558	202977
44	4	16956	23130	3	37695	46847
45	5	2028	5168	1	3252	7928
46	3	463	892	0	-	-
47	4	18286	22802	0	-	-
48	4	415	377	0	-	-
49	2	101	172	0	-	-
50	3	842	495	1	604	443
51	1	307	584	1	29	15
52	2	785	1834	1	2673	6238
			4W			
53	3	0	0	2	27	27
54	3	2115	1818	2	0	0
55	7	137956	62030	6	139739	69668
56	6	22692	10655	6	63106	34752
57	2	2837	1530	0	-	-
58	3	29725	16737	3	31786	21008
59	4	37960	40998	3	9470	7686
60	2	200	267	1	0	0
61	2	57	0	0	-	-
62	4	177	414	4	0	0
63	2	60	0	0	-	-
64	5	1805	1635	2	3900	1774
65	5	188	257	0	-	-
66	3	0	0	0	-	-
TOTAL 4Vs		51867	74017			
4W		235773	136341			
4VsW		287639	210358			

Table 12. Unadjusted results of summer surveys in 4VsW; 1970-81: A.T. Cameron; 1982: Lady Hammond; 1983: Needler

4VS COD; AVERAGE NUMBER PER SET PER STRATUM IN R,V, SURVEYS, 28/ 4/84

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
43	20.37	28.31	17.88	9.14	3.93	14.10	1.17	2.89	4.05	12.32	38.67	39.02	19.83	86.69
44	26.72	110.65	123.97	20.29	13.43	6.36	14.21	46.69	18.79	25.28	23.76	82.59	44.70	42.27
45	0.85	81.84	7.11	25.98	2.05	2.75	3.82	17.95	3.33	3.61	60.16	27.08	43.63	19.41
46	1.54	3.50	2.92	0.78	1.11	1.06	3.68	0.31	0.00	1.90	5.90	12.35	23.98	9.23
47	36.15	1.89	29.99	38.03	20.45	64.06	69.61	54.94	21.49	52.91	76.22	118.88	222.40	110.57
48	33.21	3.61	4.52	12.72	4.31	3.27	12.55	51.22	37.69	50.66	6.46	13.29	68.53	2.80
49	59.68	2.87	0.49	13.13	0.39	0.73	4.83	0.32	0.00	7.11	18.47	0.00	14.58	6.83
50	1.09	1.52	3.38	14.77	24.96	1.29	4.23	4.74	13.61	2.86	0.00	15.71	11.59	21.52
51	0.00	1.17	2.14	0.55	0.92	7.40	0.55	0.00	0.00	5.83	1.03	4.08	10.87	20.42
52	0.00	1.52	1.84	0.38	72.36	17.01	9.04	3.83	1.94	13.07	0.67	8.89	9.14	22.27

4W COD; AVERAGE NUMBER PER SET PER STRATUM IN R,V, SURVEYS, 28/ 4/84

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00	2.76	0.00	0.00
54	0.00	0.00	5.83	2.13	0.73	0.62	10.50	2.57	0.65	14.13	4.51	17.27	12.23	41.48
55	4.60	8.95	21.70	24.25	135.44	38.31	42.50	41.82	45.69	67.53	35.10	55.43	1964.67	636.20
56	15.94	17.34	15.82	42.64	18.08	26.50	38.41	53.30	18.48	190.23	27.61	96.42	44.45	232.52
57	1.52	1.02	1.38	20.07	178.47	1.64	0.00	2.39	659.53	0.00	99.30	0.51	7.29	34.23
58	20.20	18.88	105.00	2811.08	10.54	45.21	37.54	100.55	81.54	63.15	186.90	42.74	23.10	442.08
59	11.36	54.69	3.40	340.64	11.06	7.50	39.15	38.70	9.78	13.22	1.08	19.15	1.37	118.00
60	4.03	1.75	0.00	1.54	0.00	1.25	0.49	0.00	1.19	0.00	1.11	0.49	2.54	1.46
61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.65	0.00	0.00	0.00	0.46	0.49
62	3.89	1.23	2.92	0.00	0.24	2.42	3.56	0.57	0.00	0.73	0.61	0.00	0.55	0.82
63	13.13	13.61	18.69	12.59	42.28	14.32	4.23	43.35	3.28	3.75	2.66	4.25	2.15	1.94
64	31.99	6.26	8.84	89.18	47.35	21.61	29.13	14.33	26.06	37.52	53.92	13.39	32.53	13.62
65	3.92	3.11	0.19	0.32	1.66	1.17	5.88	0.66	7.29	10.05	2.06	0.29	3.16	0.77
66	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00	0.53	0.00	1.03	0.00

Table 13. Age composition of large sets during the 1983 summer comparitive survey (Wingspread = 34; Needler data unadjusted).

Age	A. NEEDLER Stratum 55 Set 24	A. NEEDLER Stratum 55 Set 25	L. HAMMOND Stratum 55 Set 24	L. HAMMOND Stratum 55 Set 25	A. NEEDLER Stratum 56 Set 7	L. HAMMOND Stratum 56 Set 7	A. NEEDLER Stratum 58 Set 5	A. NEEDLER Stratum 58 Set 6	L. HAMMOND Stratum 58 Set 5	L. HAMMOND Stratum 58 Set 6	A. NEEDLER Stratum 59 Set 76
0	0	0	0	0	0	0	0	0	0	0	0
1	1153	9	456	0	8	0	2	2	1	0	0
2	326	382	71	429	225	496	83	162	97	94	16
3	2	1911	0	2229	640	2299	329	501	389	432	153
4	0	420	0	422	107	448	80	87	152	106	146
5	0	131	0	111	26	121	25	20	61	27	78
6	0	20	0	17	1	11	4	2	10	2	22
7	0	2	0	2	0	2	1	0	1	0	3
8	0	0	0	1	0	0	0	0	0	0	2
9	0	0	0	0	0	0	0	0	0	0	1
10	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0
TOTAL	1481	2875	527	3211	1007	3377	524	774	711	661	421

Table 14. Cod population estimates from summer research vessel surveys. 1970-81: A.T. Cameron; 1982: Lady Hammond; 1983: Alfred Needler (X1.39).

a) 4Vs

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	162	0	181	360	1277	171	185	481	200	289	114	330	372	1664
2	11992	1638	5189	4317	3450	2989	5736	4365	3137	3107	1415	8325	21216	2663
3	2219	30138	9550	6266	3503	6881	6643	14393	6964	6152	4150	11568	21602	16084
4	5142	4468	29774	3240	1151	2575	2104	8030	5618	6526	4811	23083	11178	20415
5	2730	12129	4365	4835	1112	1805	2019	6014	1151	6218	11017	9346	6920	15321
6	867	4209	5649	242	1658	465	346	2092	280	3366	8426	5312	6705	10874
7	777	2260	1541	736	151	649	294	523	108	1474	2720	2539	3745	2545
8	278	1062	513	262	340	235	1308	604	67	848	955	933	1719	1615
9	25	70	254	27	159	285	0	244	66	297	260	392	284	436
10	22	70	153	0	46	23	929	0	26	83	265	582	419	309
11	209	0	0	166	43	0	0	161	0	45	93	95	226	89
12	0	0	0	0	0	0	0	0	0	5	0	74	0	40
0+	24423	56044	57169	20451	12890	16078	19564	36907	17617	28410	34226	62579	74386	72055
1+	24423	56044	57169	20451	12890	16078	19564	36907	17617	28410	34226	62579	74386	72055
2+	24261	56044	56988	20091	11613	15907	19379	36426	17417	28121	34112	62249	74014	70391
3+	12269	54406	51799	15774	8163	12918	13643	32061	14280	25014	32697	53924	52798	67728
4+	10050	24268	42249	9508	4660	6037	7000	17668	7316	18862	28547	42356	31196	51644
5+	4908	19800	12475	6268	3509	3462	4896	9638	1698	12336	23736	19273	20018	31229
6+	2178	7671	8110	1433	2397	1657	2877	3624	547	6118	12719	9927	13098	15909

b) 4W (not corrected for unusually large sets)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0	0	0	0	0	0	0	0	174	1017	50	74	9	79
1	1316	1539	6029	15768	3897	3201	2057	327	2833	924	576	4259	2261	53341
2	4396	6042	4485	118463	29511	5423	8330	5780	9928	7505	5649	4445	204812	49897
3	3031	5526	2331	98699	15743	6119	9455	11979	24281	9892	14338	7368	167290	151853
4	2572	3559	1762	56708	4472	3596	8083	9029	28587	10069	5449	7670	54798	46932
5	1012	3674	1447	17689	905	1154	4602	5339	8310	11857	6348	2711	7904	19163
6	361	1566	340	1628	586	210	918	2801	3210	5687	3673	3258	1315	4969
7	755	1199	80	2171	221	218	362	558	781	1222	2074	1865	580	1084
8	188	413	34	639	123	0	0	274	118	161	347	620	131	392
9	79	568	241	404	65	148	0	0	24	114	78	141	129	113
10	227	0	0	514	115	0	0	0	53	0	0	68	0	0
11	0	137	0	0	20	0	38	0	0	0	0	68	0	0
12	101	58	0	0	59	68	0	62	79	0	0	0	0	0
0+	14038	24281	16749	312683	55717	20137	33845	36149	78378	48448	38582	32547	439229	327823
1+	14038	24281	16749	312683	55717	20137	33845	36149	78204	47431	38532	32473	439220	327744
2+	12722	22742	10720	296915	51820	16936	31788	35822	75371	46507	37956	28214	436959	274403
3+	8326	16700	6235	178452	22309	11513	23458	30042	65443	39002	32307	23769	232147	224506
4+	5295	11174	3904	79753	6566	5394	14003	18063	41162	29110	17969	16401	64857	72653
5+	2723	7615	2142	23045	2094	1798	5920	9034	12575	19041	12520	8731	10059	25721
6+	1711	3941	695	5356	1189	644	1318	3695	4265	7184	6172	6020	2155	6558

Table 15. Research vessel population estimates of 4VsW cod.

a) 1970-81: A.T. Cameron; 1982: Lady Hammond; 1983: Alfred Needler (X1.39).

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0	0	0	0	0	0	0	0	174	1017	50	74	9	79
1	1478	1539	6210	16128	5174	3372	2242	808	3033	1213	690	4589	2633	55005
2	16388	7680	9674	122780	32961	8412	14066	10145	13065	10612	7064	12770	226028	52560
3	5250	35664	11881	104965	19246	13000	16098	26372	31245	16044	18488	18936	188892	167937
4	7714	8027	31536	59948	5623	6171	10187	17059	34205	16595	10260	30753	65976	67347
5	3742	15803	5812	22524	2017	2959	6621	11353	9461	18075	17365	12057	14824	34483
6	1228	5775	5989	1870	2244	675	1264	4893	3490	9053	12099	8570	8020	15843
7	1532	3459	1621	2907	372	867	656	1081	889	2696	4794	4404	4325	3629
8	466	1475	547	901	463	235	1308	878	185	1009	1302	1553	1850	2007
9	104	638	495	431	224	433	0	244	90	411	338	533	413	549
10	249	70	153	514	161	23	929	0	79	83	265	650	419	309
11	209	137	0	166	63	0	38	161	0	45	93	163	226	89
12	101	58	0	0	59	68	0	62	79	5	0	74	0	40
0+	38461	80325	73918	333134	68607	36215	53409	73056	95995	76858	72808	95126	513615	399878
1+	38461	80325	73918	333134	68607	36215	53409	73056	95821	75841	72758	95052	513606	399799
2+	36983	78786	67708	317006	63433	32843	51167	72248	92788	74628	72068	90463	510973	344794
3+	20595	71106	58034	194226	30472	24431	37101	62103	79723	64016	65004	77693	284945	292234
4+	15345	35442	46153	89261	11226	11431	21003	35731	48478	47972	46516	58757	96053	124297
5+	7631	27415	14617	29313	5603	5260	10816	18672	14273	31377	36256	28004	30077	56950
6+	3889	11612	8805	6789	3586	2301	4195	7319	4812	13302	18891	15947	15253	22467

b) 1970-79: A.T. Cameron; 1980-82; Lady Hammond; 1983: Alfred Needler (X1.39).

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	0	0	0	0	0	0	0	0	174	1017	0	0	9	79
1	1478	1539	6210	16128	5174	3372	2242	808	3033	1213	581	7518	2633	55005
2	16388	7680	9674	122780	32961	8412	14066	10145	13065	10612	14783	15196	226028	52560
3	5250	35664	11881	104965	19246	13000	16098	26372	31245	16044	44538	25472	188892	167937
4	7714	8027	31536	59948	5623	6171	10187	17059	34205	16595	16544	33630	65976	67347
5	3742	15803	5812	22524	2017	2959	6621	11353	9461	18075	10704	10560	14824	34483
6	1228	5775	5989	1870	2244	675	1264	4893	3490	9053	5074	7219	8020	15843
7	1532	3459	1621	2907	372	867	656	1081	889	2696	2434	3905	4325	3629
8	466	1475	547	901	463	235	1308	878	185	1009	650	1961	1850	2007
9	104	638	495	431	224	433	0	244	90	411	260	543	413	549
10	249	70	153	514	161	23	929	0	79	83	164	353	419	309
11	209	137	0	166	63	0	38	161	0	45	35	152	226	89
12	101	58	0	0	59	68	0	62	79	5	0	39	0	40
0+	38461	80325	73918	333134	68607	36215	53409	73056	95995	76858	95767	106548	513615	399878
1+	38461	80325	73918	333134	68607	36215	53409	73056	95821	75841	95767	106548	513606	399799
2+	36983	78786	67708	317006	63433	32843	51167	72248	92788	74628	95186	99030	510973	344794
3+	20595	71106	58034	194226	30472	24431	37101	62103	79723	64016	80403	83834	284945	292234
4+	15345	35442	46153	89261	11226	11431	21003	35731	48478	47972	35865	58362	96053	124297
5+	7631	27415	14617	29313	5603	5260	10816	18672	14273	31377	19321	24732	30077	56950
6+	3889	11612	8805	6789	3586	2301	4195	7319	4812	13302	8617	14172	15253	22467

Table 16. Mean numbers per tow of 4VsW cod in spring research surveys.

a) 4Vs

13/ 7/84

	1979	1980	1981	1982
43	0.46	0.00	13.32	0.00
44	14.86	15.20	80.69	0.00
45	8.34	0.00	123.03	35.00
46	3.39	17.46	9.69	0.00
47	0.27	2.01	13.68	0.97
48	0.96	0.22	10.69	99.45
49	3.37	3.85	0.00	7.15
50	15.62	54.50	0.00	46.38
51	1.00	1.59	0.00	268.63
52	33.02	76.71	20.59	7.95

b) 4W

13/ 7/84

	1979	1980	1981	1982
53	0.00	0.53	0.00	2.09
54	37.48	16.93	17.65	27.66
55	13.92	23.45	137.94	384.52
56	1.86	3.23	17.96	210.03
57	8.72	0.00	4.39	96.56
58	0.00	0.00	0.00	24.66
59	9.21	60.25	17.37	145.00
60	0.97	1.52	6.32	12.06
61	0.00	0.35	0.00	0.42
62	2.24	0.41	0.23	1.88
63	6.25	3.75	0.00	1.00
64	12.82	16.39	192.98	10.23
65	2.64	5.39	2.27	8.07
66	1.01	0.00	0.00	4.33

Table 17. Population numbers ($x10^{-3}$) estimates of 4Vs and 4W cod from spring research surveys.

A) 4Vs, 28/ 4/84

	1979	1980	1981	1982
0	0	0	0	0
1	478	401	0	119
2	1778	4759	6267	3000
3	614	1679	7631	4309
4	1087	1416	9912	4145
5	2131	1807	8325	6136
6	1265	1229	10397	2275
7	998	716	5411	2350
8	385	119	3067	1445
9	33	44	297	402
10	114	21	354	301
11	121	25	77	119
12	27	5	67	89
0+	9031	12221	51805	24690
1+	9031	12221	51805	24690
2+	8553	11820	51805	24571
3+	6775	7061	45538	21571
4+	6161	5382	37907	17262
5+	5074	3966	27995	13117

B) 4W, 28/ 4/84

	1979	1980	1981	1982
0	0	0	0	0
1	270	2078	23700	7483
2	4322	3025	4653	60851
3	1948	4186	7577	47137
4	628	3368	12461	29860
5	1810	5428	5664	14667
6	1666	7104	6165	3440
7	361	3381	3797	1566
8	438	755	1335	1663
9	154	140	213	403
10	170	52	35	109
11	100	18	0	62
12	36	0	0	0
0+	11903	29535	65600	167241
1+	11903	29535	65600	167241
2+	11633	27457	41900	159758
3+	7311	24432	37247	98907
4+	5363	20246	29670	51770
5+	4735	16878	17209	21910

Table 18. Population numbers ($x10^{-3}$) estimates of 4VsW cod from spring research surveys.

4VSW, 28/ 4/84

	1979	1980	1981	1982
0	0	0	0	0
1	748	2479	23700	7602
2	6100	7784	10920	63851
3	2562	5865	15208	51446
4	1715	4784	22373	34005
5	3941	7235	13989	20803
6	2931	8333	16562	5715
7	1359	4097	9208	3916
8	823	874	4402	3108
9	187	184	510	805
10	284	73	389	410
11	221	43	77	181
12	63	5	67	89
0+	20934	41756	117405	191931
1+	20934	41756	117405	191931
2+	20186	39277	93705	184329
3+	14086	31493	82785	120478
4+	11524	25628	67577	69032
5+	9809	20844	45204	35027

Table 19. Various partial-recruitment vectors used in our Sequential Population Analysis. Details given in text.

PR82: final vector from 1983 assessment; used in first series of SPA runs.

PRAV: mean partial recruitment values for ages 1 to 5, calculated for the period 1977-1981 from Table 20.

PRSUB: vector derived by CAFSAC Groundfish Subcommittee and used in second series of SPA runs.

PRFB's: three vectors used to calculate mid-year fishable biomasses.

PRFIN: vector used to produce the final estimates of population size and fishing mortalities.

				P R F B			
Age	PR82	PRAV	PRSUB	68-76	77-81	82-83	PRFIN
1	0.0002	.001	0.0000031	0.01	0.000	0.000	0.0000018
2	0.0020	.005	0.00011	0.06	0.003	0.000	0.000063
3	0.1200	.077	0.160	0.21	0.070	0.160	0.096
4	0.5560	.337	0.337	0.54	0.340	0.337	0.337
5	1.0	.786	0.786	0.91	0.770	0.786	0.786
6	1.0	1.0	1.0	1.0	1.0	1.0	1.0
7	1.0	1.0	1.0	1.0	1.0	1.0	1.0
8	1.0	1.0	1.0	1.0	0.870	1.0	1.0
9	1.0	1.0	1.0	1.0	0.630	1.0	1.0
10	1.0	1.0	1.0	1.0	0.45	1.0	1.0
11	1.0	1.0	1.0	1.0	0.45	1.0	1.0
12	1.0	1.0	1.0	1.0	0.45	1.0	1.0
13	1.0	1.0	1.0	1.0	0.45	1.0	1.0
14	1.0	1.0	1.0	1.0	0.45	1.0	1.0
15	1.0	1.0	1.0	1.0	0.45	1.0	1.0
16	1.0	1.0	1.0	1.0	0.45	1.0	1.0

Table 20. Matrix of partial recruitment vectors. Population numbers and fishing mortality matrices are from the first series of cohort runs with PR82 and for F_t = 0.2. Weighted F values were calculated on ages 6 to 10.

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	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.034	0.025	0.046	0.043	0.059	0.029	0.045	0.029	0.015	0.000	0.004	0.000	0.000	0.000	0.003	0.000
2	0.198	0.256	0.349	0.391	0.484	0.311	0.405	0.255	0.092	0.002	0.009	0.002	0.004	0.007	0.003	0.002
3	0.226	0.207	0.634	0.389	0.627	0.522	1.011	0.452	0.144	0.031	0.069	0.101	0.052	0.130	0.083	0.120
4	0.426	0.417	1.066	0.548	0.729	0.430	1.234	0.385	0.320	0.160	0.304	0.498	0.344	0.382	0.470	0.556
5	0.777	0.675	1.213	0.581	1.241	0.835	1.453	0.777	0.909	0.556	0.771	1.010	0.727	0.868	0.750	1.000
6	0.921	1.100	0.898	0.951	1.259	0.958	0.897	0.769	1.091	0.878	1.068	1.198	0.995	0.979	0.884	1.000
7	1.306	0.880	1.279	1.033	0.666	0.795	0.963	1.265	1.129	1.378	0.977	0.727	1.122	1.026	1.098	1.000
8	0.925	0.855	1.013	1.495	0.880	1.322	1.480	0.810	0.912	1.034	0.764	0.657	0.912	1.269	0.981	1.000
9	0.957	0.915	1.346	0.605	0.754	0.906	0.666	0.833	0.552	1.044	0.645	0.347	0.737	0.654	1.484	1.000
10	0.739	0.182	0.898	0.635	0.972	0.949	1.198	1.715	0.165	0.467	0.822	0.158	0.470	0.532	1.068	1.000
11	0.632	0.612	1.398	2.306	0.879	1.691	0.177	0.648	0.171	0.583	0.381	0.125	0.361	0.574	1.420	1.000
12	1.086	0.746	1.094	0.748	0.103	0.040	0.137	3.076	1.159	1.978	0.415	0.083	0.363	0.404	1.341	1.000
13	0.379	0.207	0.324	4.203	0.775	0.390	0.000	1.174	0.142	0.687	1.459	0.067	0.069	0.488	1.551	1.000
14	0.795	0.189	0.506	0.322	0.000	0.127	0.000	0.216	0.321	1.947	0.661	0.075	0.017	0.049	3.143	1.000
15	0.146	0.276	0.253	4.554	0.038	8.885	0.000	1.743	0.036	0.673	20.279	0.000	0.330	0.149	0.847	1.000
16	0.982	0.708	1.134	0.942	0.818	0.993	1.077	1.156	0.690	0.981	0.802	0.472	0.810	0.870	1.158	1.000

Table 21. Removals-at-age ($x10^{-3}$) of 4VsW cod by the small mesh fishery.

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	2142	1225	1110	1984	2046	1218	1273	1538	513	1	29	12	31	3	5	0
2	13656	7811	7076	12649	13040	10153	7090	8571	2866	23	63	46	25	63	1	2
3	8838	5055	4579	8184	8437	5187	5877	7105	2376	222	152	106	83	302	12	43
4	1606	921	834	1487	1536	984	1004	1214	406	121	178	214	73	281	16	81
5	534	305	277	495	512	432	146	176	59	26	27	181	92	41	10	50
6	0	0	0	0	0	7	66	80	28	6	3	42	45	25	3	16
7	0	0	0	0	0	23	0	0	0	1	1	5	17	8	1	2
8	0	0	0	0	0	10	4	7	3	0	0	0	1	1	0	1
9	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1+	26776	15317	13876	24800	25570	18017	15460	18691	6251	400	453	606	368	724	48	195
2+	24633	14092	12766	22816	23524	16799	14187	17152	5738	399	424	594	337	721	43	195
3+	10977	6281	5690	10167	10485	6646	7097	8582	2872	376	361	548	312	658	42	193
4+	2140	1226	1110	1983	2047	1458	1220	1476	495	154	209	442	229	356	30	150
5+	534	305	277	495	512	475	216	263	89	33	31	228	156	75	14	69
6+	0	0	0	0	0	43	70	87	30	7	4	47	64	34	4	19

Table 22. Ratios of catch-at-age by gears other than small mesh trawls to the total catch-at-age in the 4VsW cod fishery.

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.30	0.31	0.84	0.03	0.00	0.00	0.00	1.00
2	0.15	0.14	0.18	0.17	0.26	0.16	0.16	0.14	0.29	0.03	0.59	0.43	0.84	0.82	0.99	0.00
3	0.49	0.34	0.48	0.35	0.41	0.65	0.54	0.25	0.34	0.43	0.85	0.93	0.96	0.92	1.00	0.99
4	0.91	0.93	0.94	0.84	0.89	0.87	0.90	0.72	0.89	0.89	0.95	0.97	0.99	0.97	1.00	0.99
5	0.97	0.97	0.98	0.94	0.95	0.96	0.98	0.96	0.99	0.98	0.99	0.98	0.99	0.99	1.00	0.99
6	1.00	1.00	1.00	1.00	1.00	1.00	0.98	0.97	0.99	0.99	1.00	0.99	0.99	0.99	1.00	1.00
7	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 23. Partial recruitment matrix derived from a matrix of partial F values. The original population numbers and F matrices came from a cohort run with PRSUB for input partial recruitment vector and F_t = 0.25. Mean F values calculated on ages 7 to 10.

MATRIX OF PARTIAL-F VALUES, 9/ 7/84

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.004	0.002	0.002	0.004	0.005	0.003	0.003	0.003	0.003	0.000	0.001	0.000	0.000	0.000	0.000	0.000
2	0.026	0.021	0.021	0.042	0.079	0.043	0.032	0.028	0.019	0.000	0.002	0.000	0.001	0.002	0.001	0.000
3	0.099	0.041	0.102	0.086	0.157	0.285	0.266	0.089	0.035	0.003	0.019	0.036	0.025	0.044	0.018	0.039
4	0.342	0.224	0.333	0.291	0.396	0.314	0.536	0.217	0.204	0.036	0.092	0.180	0.162	0.162	0.132	0.083
5	0.663	0.377	0.392	0.347	0.726	0.668	0.689	0.584	0.639	0.139	0.242	0.367	0.337	0.369	0.256	0.195
6	0.814	0.632	0.296	0.600	0.778	0.812	0.422	0.585	0.770	0.223	0.343	0.434	0.463	0.412	0.301	0.249
7	1.158	0.505	0.422	0.652	0.409	0.669	0.476	0.985	0.813	0.354	0.315	0.271	0.513	0.434	0.372	0.250
8	0.817	0.495	0.335	0.942	0.541	1.104	0.729	0.651	0.645	0.270	0.251	0.247	0.432	0.527	0.333	0.250
9	0.847	0.526	0.450	0.381	0.462	0.758	0.321	0.683	0.419	0.265	0.214	0.132	0.347	0.279	0.498	0.250
10	0.653	0.105	0.297	0.408	0.597	0.793	0.580	1.341	0.125	0.129	0.264	0.061	0.224	0.225	0.362	0.250
11	0.559	0.351	0.463	1.458	0.555	1.422	0.085	0.507	0.122	0.159	0.133	0.046	0.172	0.243	0.478	0.250
12	0.959	0.429	0.361	0.475	0.063	0.035	0.066	2.370	0.830	0.505	0.143	0.034	0.166	0.170	0.452	0.250
13	0.336	0.119	0.107	2.648	0.481	0.328	0.000	0.925	0.099	0.177	0.477	0.027	0.034	0.197	0.520	0.250
14	0.704	0.109	0.167	0.203	0.000	0.108	0.000	0.174	0.231	0.478	0.215	0.029	0.008	0.022	1.023	0.250
15	0.129	0.159	0.084	2.871	0.023	7.436	0.000	1.370	0.026	0.173	6.287	0.000	0.156	0.064	0.289	0.250
16	0.869	0.408	0.376	0.596	0.502	0.833	0.527	0.917	0.501	0.255	0.261	0.178	0.380	0.367	0.392	0.250

WEIGHTED F VALUES 9/ 7/84

1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1.003	0.479	0.395	0.676	0.458	0.855	0.544	0.929	0.664	0.298	0.286	0.244	0.466	0.431	0.374	0.250

PARTIAL RECRUITMENT 9/ 7/84

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.004	0.004	0.005	0.006	0.011	0.004	0.006	0.003	0.005	0.000	0.004	0.000	0.000	0.000	0.000	0.000
2	0.026	0.043	0.053	0.062	0.172	0.050	0.059	0.030	0.029	0.000	0.006	0.001	0.003	0.004	0.004	0.000
3	0.098	0.085	0.257	0.127	0.342	0.334	0.490	0.096	0.052	0.011	0.067	0.148	0.053	0.103	0.049	0.158
4	0.341	0.467	0.843	0.430	0.864	0.367	0.986	0.233	0.307	0.120	0.323	0.739	0.347	0.375	0.353	0.334
5	0.661	0.785	0.993	0.513	1.584	0.781	1.267	0.628	0.962	0.467	0.846	1.505	0.723	0.857	0.684	0.782
6	0.811	1.318	0.751	0.888	1.697	0.949	0.776	0.629	1.159	0.746	1.201	1.779	0.993	0.957	0.804	0.998
7	1.154	1.054	1.068	0.965	0.892	0.782	0.875	1.060	1.224	1.188	1.103	1.112	1.100	1.009	0.994	1.000
8	0.815	1.033	0.848	1.394	1.180	1.291	1.342	0.701	0.970	0.903	0.877	1.013	0.926	1.224	0.891	1.000
9	0.844	1.097	1.139	0.565	1.009	0.886	0.590	0.735	0.631	0.889	0.748	0.542	0.745	0.648	1.331	1.001
10	0.651	0.219	0.751	0.603	1.303	0.927	1.066	1.443	0.189	0.432	0.924	0.248	0.479	0.522	0.968	1.001
11	0.557	0.733	1.174	2.157	1.212	1.662	0.156	0.545	0.184	0.531	0.467	0.190	0.370	0.564	1.276	1.001
12	0.956	0.895	0.914	0.704	0.138	0.041	0.122	2.549	1.250	1.693	0.502	0.137	0.357	0.395	1.208	1.001
13	0.335	0.247	0.271	3.919	1.050	0.384	0.000	0.995	0.149	0.594	1.670	0.110	0.074	0.457	1.390	1.001
14	0.702	0.228	0.423	0.301	0.000	0.126	0.000	0.187	0.349	1.602	0.754	0.117	0.018	0.050	2.733	1.001
15	0.129	0.332	0.212	4.248	0.051	8.693	0.000	1.473	0.039	0.581	22.004	0.000	0.335	0.150	0.772	1.001
16	0.866	0.851	0.951	0.882	1.096	0.974	0.969	0.986	0.755	0.854	0.913	0.730	0.815	0.851	1.046	1.001

Table 24. Results of calibration of mid-year fishable biomass from cohort analysis against the standardized commercial catch rate.

Year	Standard CPUE	Fishable Biomass	Predicted	P/FB	Fishable Biomass	Predicted	P/FB	Fishable Biomass	Predicted	P/FB
			F_t = 0.15			F_t = 0.2			F_t = 0.275	
1976	0.56	48187	27542	0.57	45665	35883	0.79	43600	42709	0.98
1977	0.64	52201	48485	0.93	49030	51974	1.06	46439	54830	1.18
1978	0.81	88394	92440	1.05	82514	85747	1.04	77709	80268	1.03
1979	0.87	111643	107953	0.97	102513	97666	0.95	95048	89246	0.94
1980	1.16	130601	181901	1.39	115326	154483	1.34	102823	132043	1.28
1981	1.13	161422	173627	1.08	134723	148126	1.10	112858	127254	1.13
1982	1.22	258415	196897	0.76	202972	166006	0.82	157574	140722	0.89
1983	1.31	348690	220685	0.63	261517	184283	0.70	190194	154488	0.81
r			0.80			0.86			0.91	
Res. 81-83			0.82			0.87			0.94	
			F_t = 0.3			F_t = 0.325			F_t = 0.35	
1976	0.56	43141	44227	1.02	42753	45511	1.06	42420	46613	1.10
1977	0.64	45864	55465	1.21	45378	56003	1.23	44962	56464	1.26
1978	0.81	76643	79051	1.03	75742	78021	1.03	74970	77139	1.03
1979	0.87	93391	87375	0.94	91991	85792	0.93	90791	84436	0.93
1980	1.16	100046	127055	1.27	97697	122835	1.26	95685	119218	1.25
1981	1.13	107997	122616	1.14	103886	118690	1.14	100362	115326	1.15
1982	1.22	147481	135102	0.92	138939	130347	0.94	131617	126272	0.96
1983	1.31	174345	147866	0.85	160934	142263	0.88	149438	137461	0.92
r			0.92			0.92			0.92	
Res. 81-83			0.97			0.99			1.01	
			F_t = 0.375			F_t = 0.4				
1976	0.56	42132	47567	1.13	41881	48403	1.16			
1977	0.64	44602	56864	1.28	44287	57214	1.29			
1978	0.81	74302	76374	1.03	73718	75706	1.03			
1979	0.87	89753	83260	0.93	88845	82232	0.93			
1980	1.16	93943	116084	1.24	92419	113342	1.23			
1981	1.13	97310	112411	1.16	94640	109861	1.16			
1982	1.22	125271	122740	0.98	119719	119651	1.00			
1983	1.31	139476	133299	0.96	130759	129658	0.99			
r			0.92			0.90				
Res. 81-83			1.03			1.05				

Table 25. Results of calibration of mid-year 6+ population numbers against summer survey 6+ population estimates.

Year	Survey 6+	Cohort 6+	Pred.	P/C	Cohort 6+	Pred.	P/C	Cohort 6+	Pred.	P/C
			F_t=0.1			F_t=0.125			F_t=0.150	
1976	4195	8697	8694	1.00	8164	9511	1.16	7808	10055	1.29
1977	7319	9607	19158	1.99	8872	17835	2.01	8382	16952	2.02
1978	4812	15669	10760	0.69	14377	11155	0.78	13515	11417	0.84
1979	13302	24286	39199	1.61	22378	33777	1.51	21105	30160	1.43
1980	18891	34737	57920	1.67	31019	48669	1.57	28536	42499	1.49
1981	15947	42139	48058	1.14	36195	40824	1.13	32227	36000	1.12
1982	15253	52564	45734	0.87	43341	38975	0.90	37187	34468	0.93
1983	22467	99621	69897	0.70	79697	58196	0.73	66414	50393	0.76
r			0.86			0.87			0.88	
Res. 81-83			0.90			0.92			0.93	
			F_t=0.175			F_t=0.2			F_t=0.225	
1976	4195	7553	10443	1.38	7361	10734	1.46	7212	10960	1.52
1977	7319	8032	16320	2.03	7770	15846	2.04	7566	15478	2.05
1978	4812	12899	11604	0.90	12437	11744	0.94	12078	11853	0.98
1979	13302	20195	27576	1.36	19513	25637	1.31	18983	24129	1.27
1980	18891	26761	38091	1.42	25429	34784	1.37	24392	32211	1.32
1981	15947	29389	32552	1.11	27259	29966	1.10	25601	27954	1.09
1982	15253	32789	31247	0.95	29489	28830	0.98	26920	26950	1.00
1983	22467	56926	44818	0.79	49811	40635	0.82	44276	37381	0.84
r			0.88			0.87			0.86	
Res. 81-83			0.95			0.96			0.98	
			F_t=0.25			F_t=0.275			F_t=0.3	
1976	4195	7093	11142	1.57	6995	11290	1.61	6914	11413	1.65
1977	7319	7403	15183	2.05	7270	14941	2.06	7159	14740	2.06
1978	4812	11791	11940	1.01	11556	12011	1.04	11361	12070	1.06
1979	13302	18559	22922	1.24	18212	21934	1.20	17923	21111	1.18
1980	18891	23562	30152	1.28	82883	28467	1.24	22317	27063	1.21
1981	15947	24273	26344	1.08	23187	25026	1.08	22281	23928	1.07
1982	15253	24863	25446	1.02	23180	24215	1.04	21776	23189	1.06
1983	22467	39849	34777	0.87	36226	32647	0.90	33207	30871	0.93
r			0.85			0.83			0.80	
Res. 81-83			0.99			1.01			1.02	

Table 26. 4VsW cod population numbers (000's) with Ft = 0.35 and partial recruitment of PRFIN in Table 19.

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	105357	94741	107711	93138	140224	155364	151974	152023	167093	134924	92243	108457	95022	95348
2	92283	86259	77567	88186	76215	113960	123827	121893	121677	134265	109971	73265	87507	76628
3	68833	75430	70623	63507	71945	57005	71784	85134	82001	83432	106095	75518	51753	63835
4	38779	53774	59496	51473	48879	53451	31335	45443	52762	51308	62638	71107	54876	34331
5	23191	28552	35985	43175	33467	30668	32662	17575	25897	30555	34779	35193	45800	31536
6	17918	16695	15404	23440	26898	21635	15232	16083	9552	11633	16460	14329	19541	25126
7	5761	11299	7797	8517	13150	14886	12806	8222	7621	3784	5599	5969	6237	11892
8	4326	3260	5284	3840	4363	8284	7776	7884	3895	3294	1771	1433	2947	3349
9	4313	2216	1341	2673	1441	1276	4807	4245	2404	1750	1575	640	712	1726
10	1756	1709	1020	836	1092	559	731	2988	1551	1194	832	552	310	369
11	969	661	403	715	531	461	336	316	1014	821	392	354	406	188
12	125	302	253	220	452	282	268	144	103	228	378	183	204	209
13	56	50	20	139	100	302	186	152	36	63	128	119	98	117
14	45	0	17	15	54	21	224	107	37	17	37	75	86	72
15	63	27	0	0	10	45	17	183	8	31	9	15	55	60
16	131	43	22	0	0	4	37	14	3	5	19	7	10	41
1+	363908	375017	382942	379874	418822	458201	454001	462407	475655	457302	432925	387216	365564	344825
2+	258551	280276	275231	286736	278598	302837	302028	310383	308562	322378	340682	278759	270542	249478
3+	166268	194017	197664	198550	202383	188877	178201	188491	186885	188113	230711	205494	183035	172850
4+	97434	118587	127041	135043	130439	131872	106417	103356	104884	104681	124617	129976	131282	109015
5+	58655	64813	67546	83571	81559	78421	75082	57914	52122	53373	61979	58868	76405	74683
6+	35464	36261	31561	40395	48092	47753	42420	40339	26224	22818	27200	23676	30606	43148

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	73368	63966	74404	83860	70450	63502	110345	102577	166796	166785	107199	105919
2	75973	57913	51088	59576	67038	57020	51989	90183	83971	136533	136549	87763
3	48968	46151	36428	34180	39747	51211	46663	42427	73762	68612	111469	111662
4	40879	27218	24321	18166	19402	29297	41579	37296	33262	58551	52789	89001
5	19833	21379	15492	10912	10945	12525	23015	30739	24957	22601	39139	36285
6	17848	7496	8677	6232	4818	4602	8844	14662	16893	13998	11920	23038
7	11286	6669	2678	4602	2755	1762	2979	5032	7597	8269	7070	6639
8	5067	6135	2749	1338	1390	966	989	1744	3069	3570	4063	3610
9	1069	2412	1653	1053	542	586	591	617	1093	1548	1606	2175
10	964	551	920	980	413	277	364	383	437	606	912	705
11	199	434	204	419	205	294	195	225	293	278	382	471
12	36	92	85	154	205	148	201	136	176	197	171	172
13	106	27	72	65	12	71	71	139	107	120	133	80
14	7	53	16	59	21	9	48	35	110	84	79	57
15	48	6	39	13	40	13	4	31	28	89	67	19
16	3	38	0	32	3	32	9	0	26	19	68	38
1+	295653	240540	218825	221641	217985	222314	287888	326227	412575	481860	473617	467635
2+	222285	176574	144422	137781	147535	158812	177543	223650	245779	315075	366418	361715
3+	146312	118661	93334	78205	80497	101791	125553	133467	161808	178542	229869	273953
4+	97344	72510	56906	44025	40750	50580	78891	91040	88046	109929	118400	162291
5+	56465	45292	32585	25859	21348	21284	37312	53745	54784	51379	65611	73290
6+	36632	23912	17093	14947	10403	8758	14297	23005	29827	28778	26472	37005

Table 27. 4VsW cod; fishing mortality rates with Ft = 0.35 and partial recruitment of PRFIN in Table 19.

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	0.000	0.000	0.000	0.001	0.007	0.027	0.021	0.023	0.019	0.004	0.030	0.015	0.015	0.027	0.037	0.025	0.022
2	0.002	0.000	0.000	0.004	0.090	0.262	0.175	0.196	0.177	0.035	0.176	0.148	0.115	0.248	0.298	0.264	0.202
3	0.047	0.037	0.116	0.062	0.097	0.398	0.257	0.278	0.269	0.087	0.200	0.119	0.210	0.246	0.387	0.441	0.496
4	0.106	0.202	0.121	0.230	0.266	0.293	0.378	0.362	0.346	0.189	0.377	0.240	0.354	0.349	0.448	0.364	0.601
5	0.129	0.417	0.229	0.273	0.236	0.500	0.508	0.410	0.600	0.419	0.687	0.388	0.400	0.369	0.773	0.702	0.711
6	0.261	0.561	0.393	0.378	0.392	0.324	0.417	0.547	0.726	0.531	0.814	0.632	0.297	0.600	0.785	0.829	0.434
7	0.369	0.560	0.508	0.469	0.262	0.449	0.285	0.547	0.639	0.559	1.163	0.506	0.422	0.653	0.410	0.686	0.494
8	0.469	0.688	0.481	0.780	1.030	0.344	0.405	0.988	0.600	0.537	0.818	0.500	0.335	0.942	0.542	1.111	0.759
9	0.726	0.576	0.273	0.695	0.747	0.356	0.275	0.807	0.500	0.544	0.850	0.526	0.456	0.382	0.462	0.764	0.323
10	0.778	1.244	0.156	0.253	0.661	0.308	0.638	0.881	0.436	0.914	0.653	0.106	0.297	0.417	0.599	0.793	0.586
11	0.966	0.759	0.407	0.258	0.433	0.342	0.647	0.918	1.294	0.575	0.560	0.351	0.466	1.463	0.577	1.433	0.085
12	0.717	2.517	0.396	0.585	0.203	0.218	0.370	1.195	0.296	0.379	0.959	0.430	0.361	0.480	0.064	0.037	0.067
13	8.897	0.906	0.057	0.740	1.385	0.100	0.353	1.201	0.567	0.330	0.336	0.119	0.107	2.648	0.489	0.332	0.000
14	0.315	0.192	8.176	0.242	0.000	0.000	0.000	2.410	0.000	0.404	0.706	0.109	0.167	0.204	0.000	0.110	0.000
15	0.192	0.000	0.300	0.341	0.815	0.000	0.000	4.053	0.330	0.292	0.130	0.160	0.084	2.872	0.023	7.455	0.000
16	0.585	0.767	0.355	0.549	0.675	0.364	0.401	0.806	0.544	0.639	0.871	0.409	0.378	0.599	0.503	0.839	0.540
1+	0.070	0.129	0.097	0.122	0.135	0.230	0.192	0.224	0.206	0.104	0.265	0.169	0.192	0.257	0.340	0.344	0.292

	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.024	0.011	0.000	0.002	0.000	0.000	0.000	0.000	0.000
2	0.205	0.069	0.000	0.003	0.001	0.002	0.003	0.001	0.000
3	0.366	0.105	0.008	0.024	0.043	0.031	0.062	0.025	0.034
4	0.307	0.238	0.041	0.102	0.202	0.186	0.203	0.175	0.118
5	0.618	0.666	0.148	0.251	0.399	0.378	0.440	0.330	0.275
6	0.616	0.806	0.235	0.364	0.457	0.514	0.483	0.385	0.350
7	0.997	0.849	0.377	0.335	0.295	0.555	0.510	0.472	0.350
8	0.704	0.665	0.290	0.272	0.268	0.484	0.599	0.425	0.350
9	0.737	0.470	0.277	0.235	0.146	0.390	0.329	0.623	0.350
10	1.365	0.141	0.150	0.279	0.067	0.252	0.261	0.460	0.350
11	0.516	0.126	0.181	0.159	0.049	0.195	0.283	0.598	0.350
12	2.370	0.861	0.530	0.168	0.041	0.179	0.197	0.568	0.350
13	0.950	0.099	0.188	0.516	0.032	0.042	0.215	0.649	0.350
14	0.184	0.242	0.478	0.232	0.032	0.010	0.027	1.219	0.350
15	1.403	0.028	0.183	6.365	0.000	0.174	0.077	0.370	0.350
16	0.951	0.531	0.274	0.280	0.194	0.420	0.425	0.495	0.350
1+	0.231	0.134	0.027	0.057	0.094	0.080	0.084	0.078	0.080

Table 28. 4VsW cod population biomass (tons).with Ft = 0.35 and partial recruitment of PRFIN in Table 19.

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	6111	5495	6247	5402	8133	9011	8814	8817	3342	2698	1845	2169	1900	953
2	25470	23808	21409	24339	21035	31453	34176	33642	18252	21482	16496	10257	13126	8429
3	38891	42618	39902	35881	40649	32208	40558	48101	36900	39213	45621	31718	23289	20427
4	36569	50708	56104	48539	46093	50404	29549	42853	47486	49256	54495	60441	49937	21972
5	33975	41829	52718	63252	49029	44928	47850	25747	38587	48582	50081	49622	68699	33743
6	37575	35010	32302	49154	56405	45368	31941	33727	20824	27104	34566	29661	42794	39196
7	16285	31942	22041	24079	37176	42082	36203	23242	22406	11845	15789	16594	18336	24853
8	15879	11966	19397	14096	16017	30410	28547	28943	14488	13043	6322	5045	10992	8875
9	18699	9606	5815	11587	6246	5530	20838	18402	10819	8382	6822	2727	3211	5541
10	9244	8996	5367	4399	5746	2942	3849	15727	8173	6697	4209	2752	1635	1385
11	5769	3935	2401	4256	3165	2748	2004	1885	6085	5246	2262	2013	2446	806
12	858	2066	1733	1504	3094	1931	1836	987	692	1622	2431	1163	1371	995
13	423	376	150	1046	752	2267	1393	1138	262	492	900	824	719	610
14	360	0	133	123	436	164	1791	855	296	140	283	561	686	406
15	571	243	0	0	89	402	152	1655	67	276	74	120	465	361
16	1309	428	221	0	0	36	366	138	23	44	161	55	94	263
1+	247987	269025	265940	287657	294066	301885	289867	285859	228703	236122	242356	215722	239700	168816
2+	241877	263530	259693	282255	285933	292874	281053	277041	225361	233424	240511	213553	237800	167862
3+	216406	239723	238284	257916	264898	261421	246877	243399	207110	211941	224016	203296	224674	159433
4+	177516	197105	198382	222035	224249	229213	206319	195298	170210	172728	178395	171579	201385	139006
5+	140947	146396	142278	173496	178156	178809	176770	152446	122723	123472	123900	111137	151447	117034
6+	106971	104567	89560	110244	129127	133881	128920	126698	84136	74890	73818	61515	82748	83291

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	3668	5117	9673	8386	7045	6350	22069	0	0	0	0	12710
2	13675	12741	16859	16085	18771	15966	32233	47797	47864	84104	79373	34227
3	21546	20768	22586	18116	22656	41481	44330	32244	59010	57154	89766	90162
4	33112	21502	24807	16168	18626	31933	51974	39533	38251	66689	56620	96336
5	25584	25869	23702	14622	15980	20917	38665	52257	39932	38263	61835	56203
6	33019	12893	18483	11654	9780	10860	21845	35042	37333	29858	28519	48372
7	27989	15204	7552	11366	7329	5585	10756	15751	23399	24516	19648	20600
8	15910	17790	9841	4176	4658	4422	5173	6472	13226	14068	16554	12740
9	4094	8539	7290	4014	2206	2424	3306	2944	5747	8820	8820	9523
10	4359	2326	4857	4438	1981	1478	2378	2619	3022	4340	6453	4065
11	1036	2126	1264	2209	1137	1365	1547	1793	2215	2132	3340	3293
12	210	512	604	923	1288	726	1847	1283	1789	1828	1559	1554
13	689	172	585	438	83	506	741	1476	849	1427	1516	845
14	48	369	146	445	159	75	469	349	896	728	841	665
15	371	42	390	109	340	140	38	357	399	878	838	244
16	23	317	0	286	24	480	110	0	358	268	942	474
1+	185333	146289	148637	113434	112062	144709	237482	239919	274289	335074	376624	392015
2+	181665	141172	138965	105047	105017	138358	215413	239919	274289	335074	376624	379304
3+	167990	128431	122106	88962	86247	122393	183179	192122	226425	250970	297251	345077
4+	146444	107663	99520	70847	63591	80912	138850	159878	167416	193816	207485	254915
5+	113332	86161	74713	54679	44965	48978	86876	120344	129165	127126	150865	158579
6+	87748	60292	51011	40057	28985	28061	48211	68088	89233	88863	89031	102376

Table 29. Input vectors used for projections.

AGE	NB.	CATCH	WEIGHT	PR
1	107000	0	0.120	0.00100
2	88000	2	0.529	0.00500
3	111662	3346	0.815	0.07700
4	89001	8992	1.098	0.33700
5	36285	7946	1.607	0.78600
6	23038	6202	2.208	1.00000
7	6639	1787	2.949	1.00000
8	3610	972	3.848	1.00000
9	2175	586	5.189	1.00000
10	705	190	6.668	1.00000
11	471	127	7.801	1.00000
12	172	46	9.133	1.00000
13	80	21	11.307	1.00000
14	57	15	10.319	1.00000
15	19	5	11.671	1.00000
16	38	10	13.508	1.00000

Table 30. Results of projections for 4VsW cod with input parameters specified in Table 29.

a) Catch of 55,000 tons in 1984 and fishing at $F_{0.1}$ = 0.2 in 1985.

CATCH NUMBERS

	1983	1984	1985
1	0	26	19
2	2	107	79
3	3346	1343	992
4	8992	6931	3417
5	7946	11256	8682
6	6202	4858	7070
7	1787	2862	2325
8	972	825	1370
9	586	448	395
10	190	270	215
11	127	88	129
12	46	59	42
13	21	21	28
14	15	10	10
15	5	7	5
16	10	2	3
1+	30248	29112	24782
2+	30248	29086	24762
3+	30246	28979	24683
4+	26900	27636	23691

CATCH BIOMASS

	1983	1984	1985
1	0	3	2
2	1	57	42
3	2728	1095	809
4	9874	7611	3752
5	12771	18091	13955
6	13697	10727	15613
7	5270	8439	6856
8	3740	3173	5270
9	3039	2327	2048
10	1266	1802	1431
11	990	684	1009
12	423	535	383
13	242	241	317
14	158	102	105
15	60	82	55
16	138	32	46
1+	54396	55000	51694
2+	54396	54997	51692
3+	54395	54940	51650
4+	51668	53845	50841

FISHING MORTALITY

	1983	1984	1985
1	0.000	0.000	0.000
2	0.000	0.001	0.001
3	0.034	0.021	0.015
4	0.118	0.091	0.067
5	0.275	0.212	0.157
6	0.350	0.270	0.200
7	0.350	0.270	0.200
8	0.350	0.270	0.200
9	0.350	0.270	0.200
10	0.350	0.270	0.200
11	0.350	0.270	0.200
12	0.350	0.270	0.200
13	0.350	0.270	0.200
14	0.350	0.270	0.200
15	0.350	0.270	0.200
16	0.350	0.270	0.200
1+	0.079	0.076	0.064

b) Fishing at $F_{0.1}$ in 1984 and 1985.

CATCH NUMBERS

	1983	1984	1985
1	0	19	19
2	2	79	79
3	3346	998	993
4	8992	5196	3435
5	7946	8561	8889
6	6202	3719	7469
7	1787	2191	2493
8	972	631	1469
9	586	343	423
10	190	207	230
11	127	67	139
12	46	45	45
13	21	16	30
14	15	8	11
15	5	5	5
16	10	2	4
1+	30248	22089	25733
2+	30248	22069	25713
3+	30246	21990	25634
4+	26900	20992	24641

CATCH BIOMASS

	1983	1984	1985
1	0	2	2
2	1	42	42
3	2728	814	809
4	9874	5705	3772
5	12771	13759	14287
6	13697	8214	16494
7	5270	6461	7352
8	3740	2429	5651
9	3039	1782	2196
10	1266	1379	1535
11	990	523	1082
12	423	409	411
13	242	185	340
14	158	78	113
15	60	63	59
16	138	25	49
1+	54396	41871	54194
2+	54396	41869	54192
3+	54395	41827	54150
4+	51668	41013	53340

FISHING MORTALITY

	1983	1984	1985
1	0.000	0.000	0.000
2	0.000	0.001	0.001
3	0.034	0.015	0.015
4	0.118	0.067	0.067
5	0.275	0.157	0.157
6	0.350	0.200	0.200
7	0.350	0.200	0.200
8	0.350	0.200	0.200
9	0.350	0.200	0.200
10	0.350	0.200	0.200
11	0.350	0.200	0.200
12	0.350	0.200	0.200
13	0.350	0.200	0.200
14	0.350	0.200	0.200
15	0.350	0.200	0.200
16	0.350	0.200	0.200
1+	0.079	0.056	0.066

Table 31. Comparison of estimates of fully-recruited fishing mortalities (ages 6-16) from annual assessments of 4VsW cod and from the present analysis.

	1977	1978	1979	1980	1981	1982
F_t from previous assessments	.15	.18	.30	.225	.225	.25
Mean F from current SPA	.27	.34	.39	.51	.49	.43

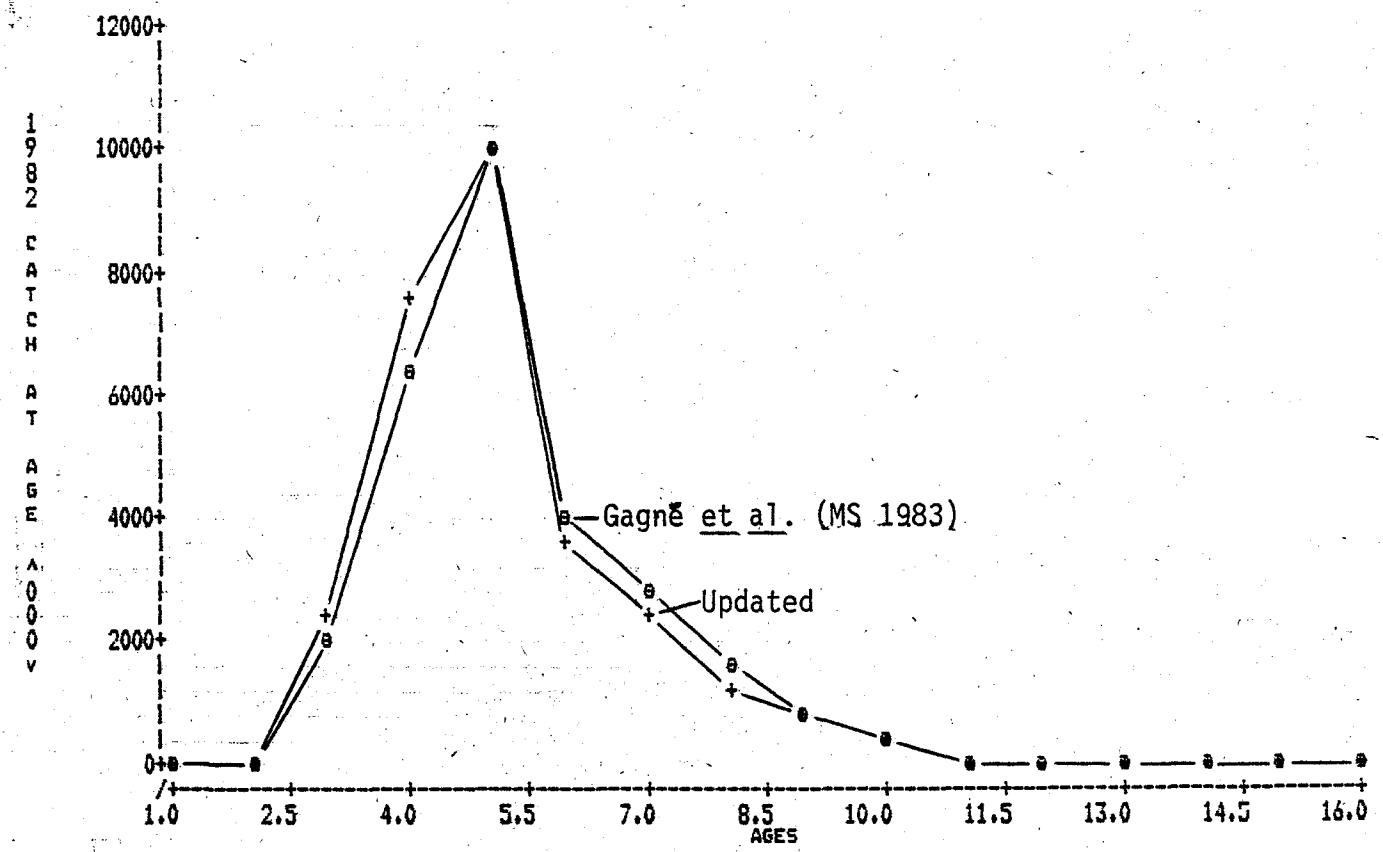


Figure 1. Comparison of two estimates of the age composition of the 1982 catch.

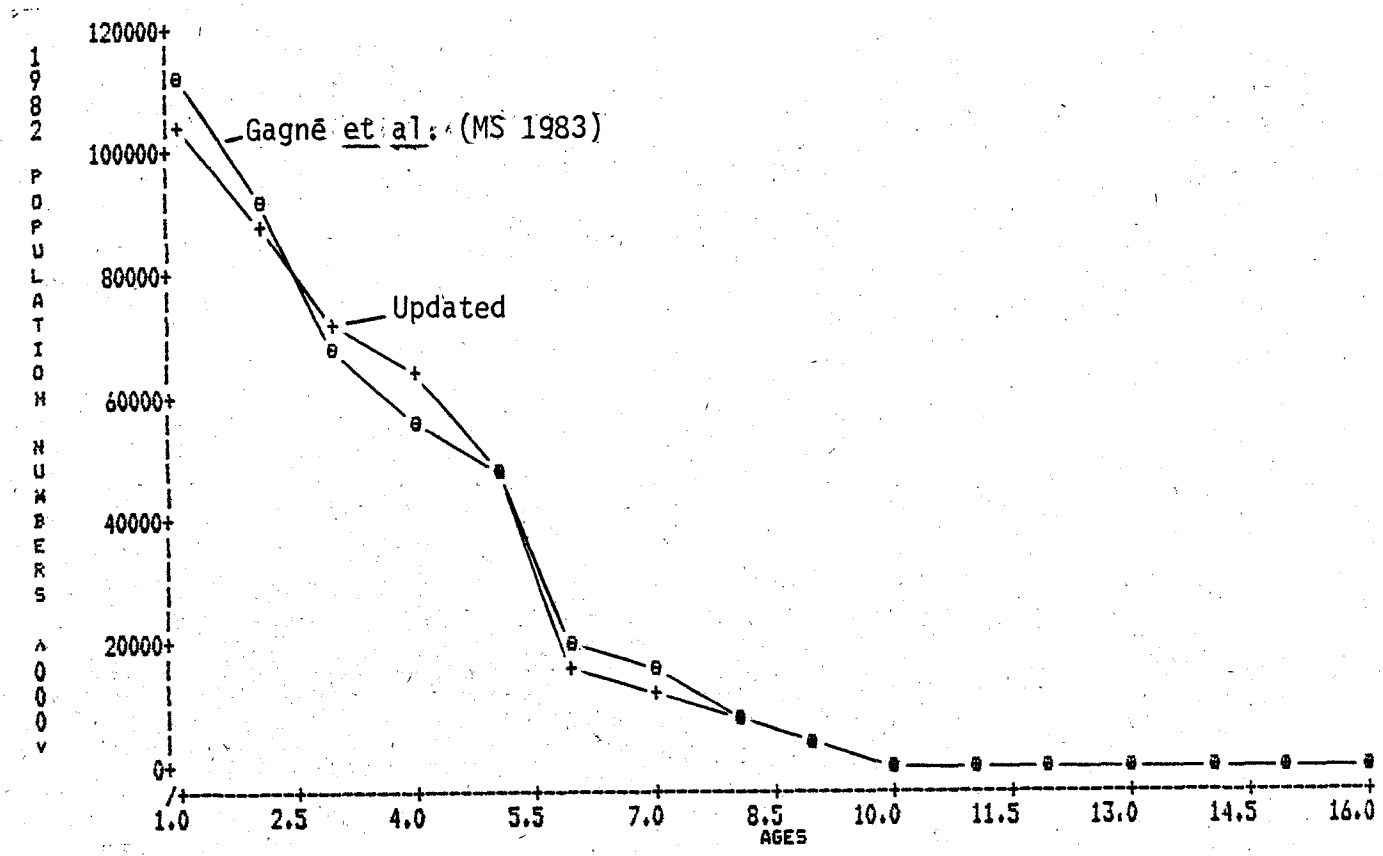


Figure 2. Comparison of two estimates of the 1982 population size-at-age.

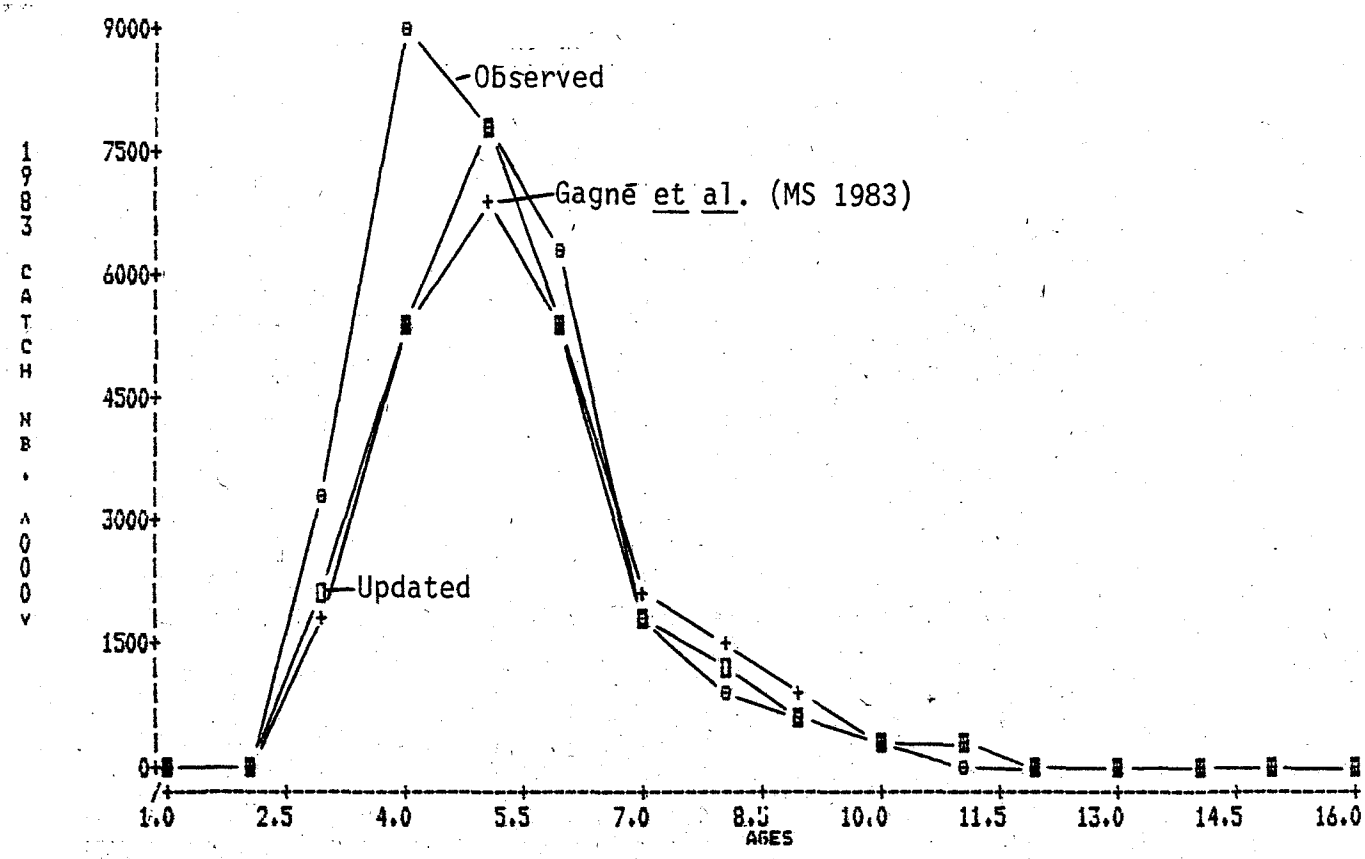
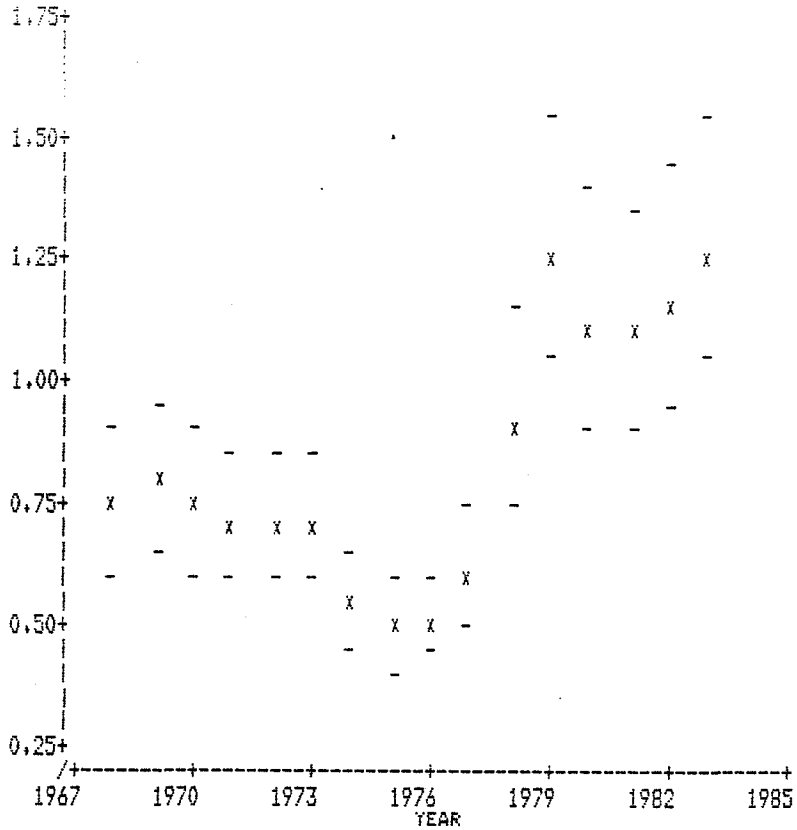


Figure 3. Comparison of the observed 1983 removals at age with the projected ones derived from the 1982 data.



YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	S.E.	EFFORT
1968	80425	0.705	0.745	0.083	107966
1969	50157	0.688	0.793	0.095	63277
1970	57427	0.717	0.740	0.083	77559
1971	52563	0.641	0.689	0.077	76317
1972	61645	0.512	0.706	0.074	87256
1973	54070	0.625	0.697	0.077	77548
1974	43739	0.668	0.552	0.058	79228
1975	32517	0.491	0.488	0.053	66677
1976	24407	0.575	0.511	0.054	47756
1977	10390	0.339	0.615	0.081	16897
1978	25405	0.555	0.919	0.114	27636
1979	40030	0.546	1.257	0.156	31846
1980	49252	0.488	1.116	0.139	44146
1981	53718	0.500	1.085	0.135	49507
1982	55754	0.476	1.172	0.146	47582
1983	52332	0.541	1.260	0.156	41549

AVERAGE C.V. FOR THE MEAN:0.117

Figure 4. Results of commercial catch rate standardization using all data.

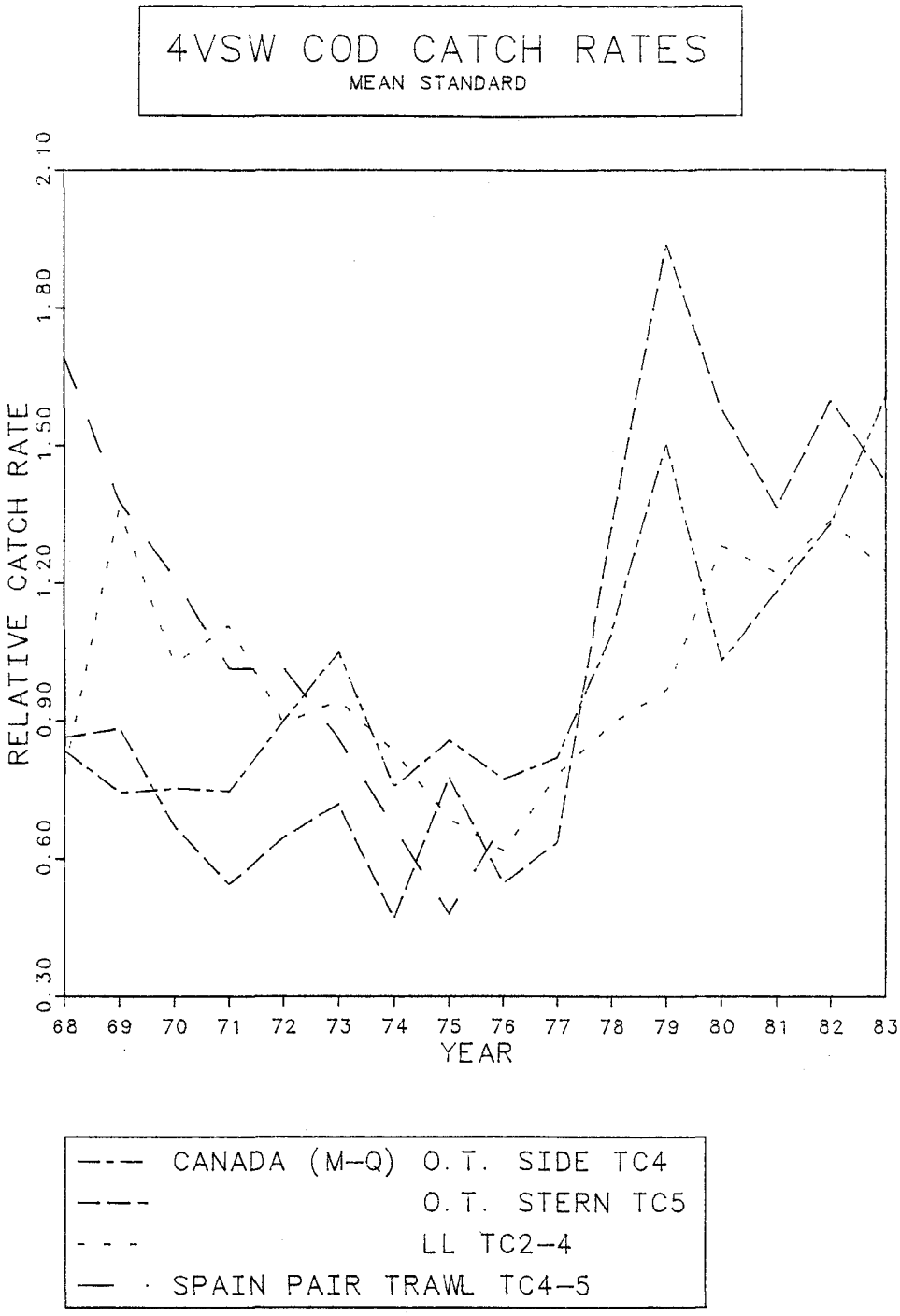
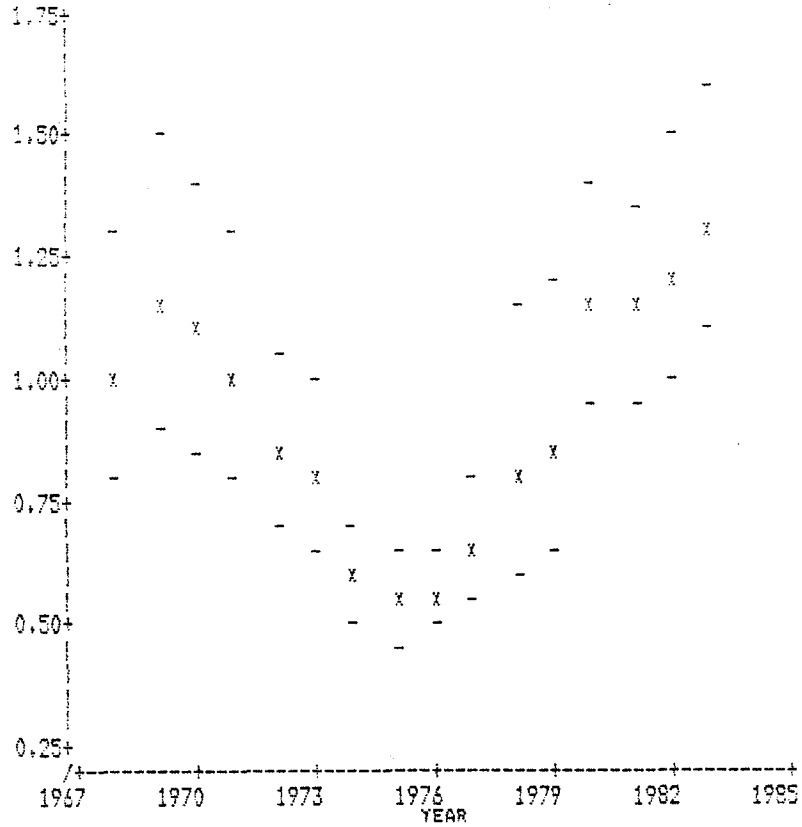


Figure 5. Comparison of four catch rate series used in the standardization of the commercial catch and effort data. Annual values were standardized to the mean of the specific series.



YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	S.E.	EFFORT
1968	80425	0.628	0.990	0.149	81236
1969	50157	0.638	1.155	0.174	43444
1970	57427	0.673	1.089	0.164	52712
1971	52563	0.564	1.006	0.151	52247
1972	61645	0.416	0.851	0.113	72411
1973	54070	0.542	0.803	0.106	67334
1974	43739	0.668	0.606	0.062	72185
1975	32517	0.491	0.527	0.055	61714
1976	24407	0.575	0.561	0.057	43511
1977	10390	0.339	0.642	0.078	16177
1978	25405	0.056	0.812	0.157	31273
1979	40030	0.054	0.872	0.168	45890
1980	49252	0.488	1.158	0.134	42523
1981	53718	0.500	1.126	0.130	47484
1982	55754	0.476	1.218	0.140	45833
1983	52332	0.541	1.308	0.151	40021

AVERAGE C.V. FOR THE MEAN:0.134

Figure 6. Resulting standardized commercial catch rate for 4VsW cod after the removal of the 1968-1973 and 1978-1979 data for Canadian offshore otter trawlers.

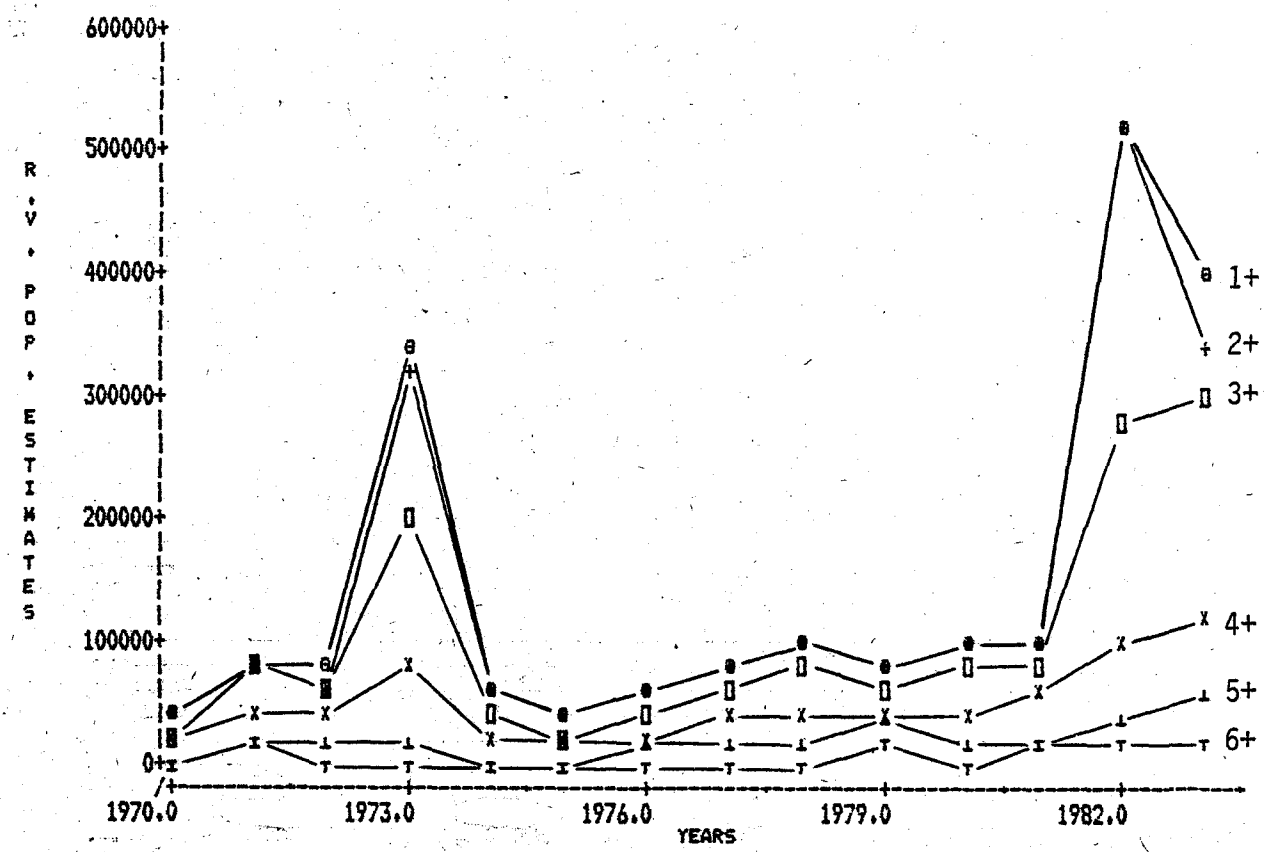


Figure 7. Research survey population estimates of 4VsW cod.

1970-79: A.T. Cameron

1980-82: Lady Hammond

1983: Alfred Needler (X1.39)

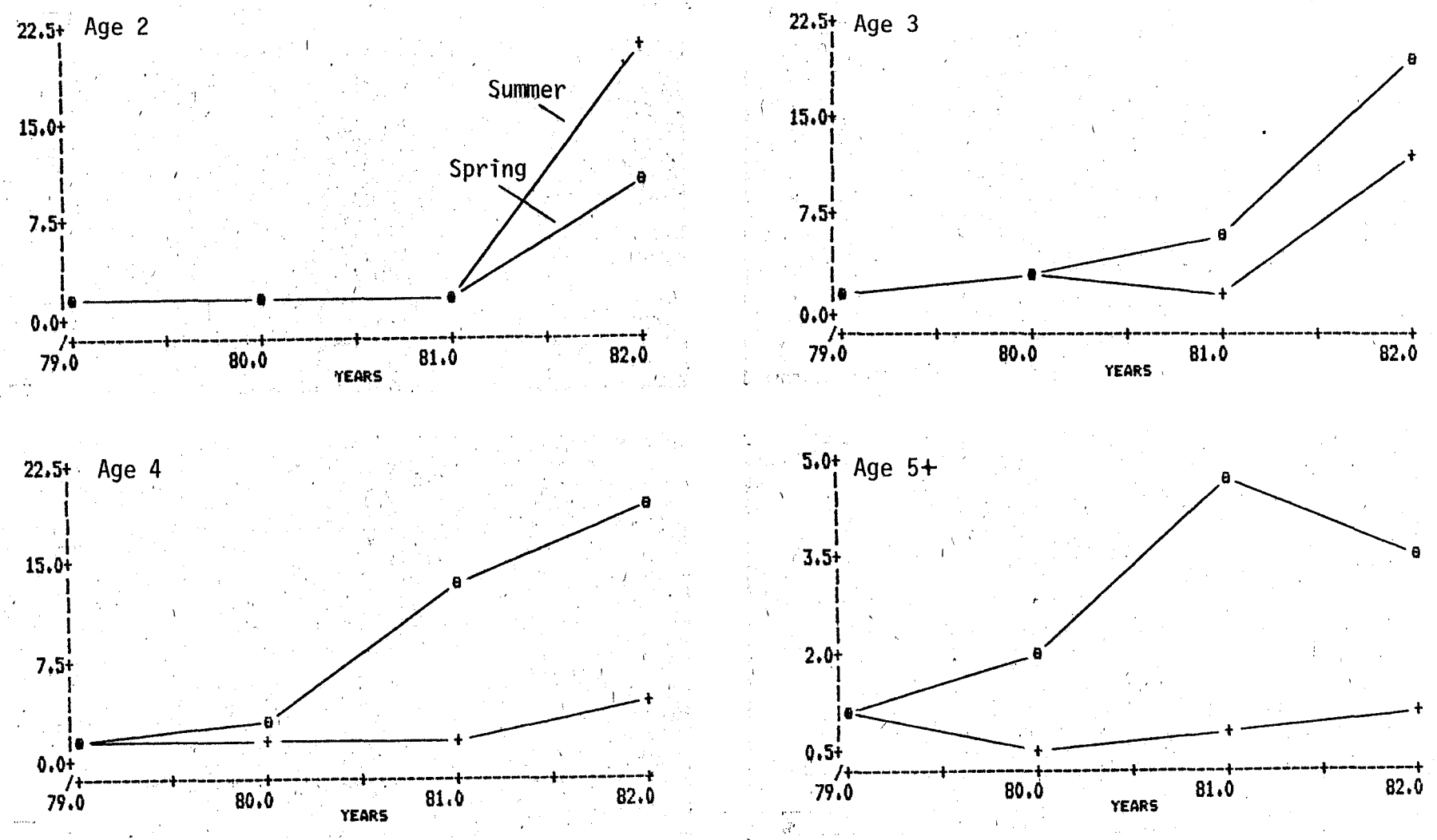


Figure 8. Annual variations in research survey population estimates of 4VsW cod. Each series is standardized to its first value. Spring survey: Lady Hammond; summer survey: 1979: A.T. Cameron; 1980-82: Lady Hammond.

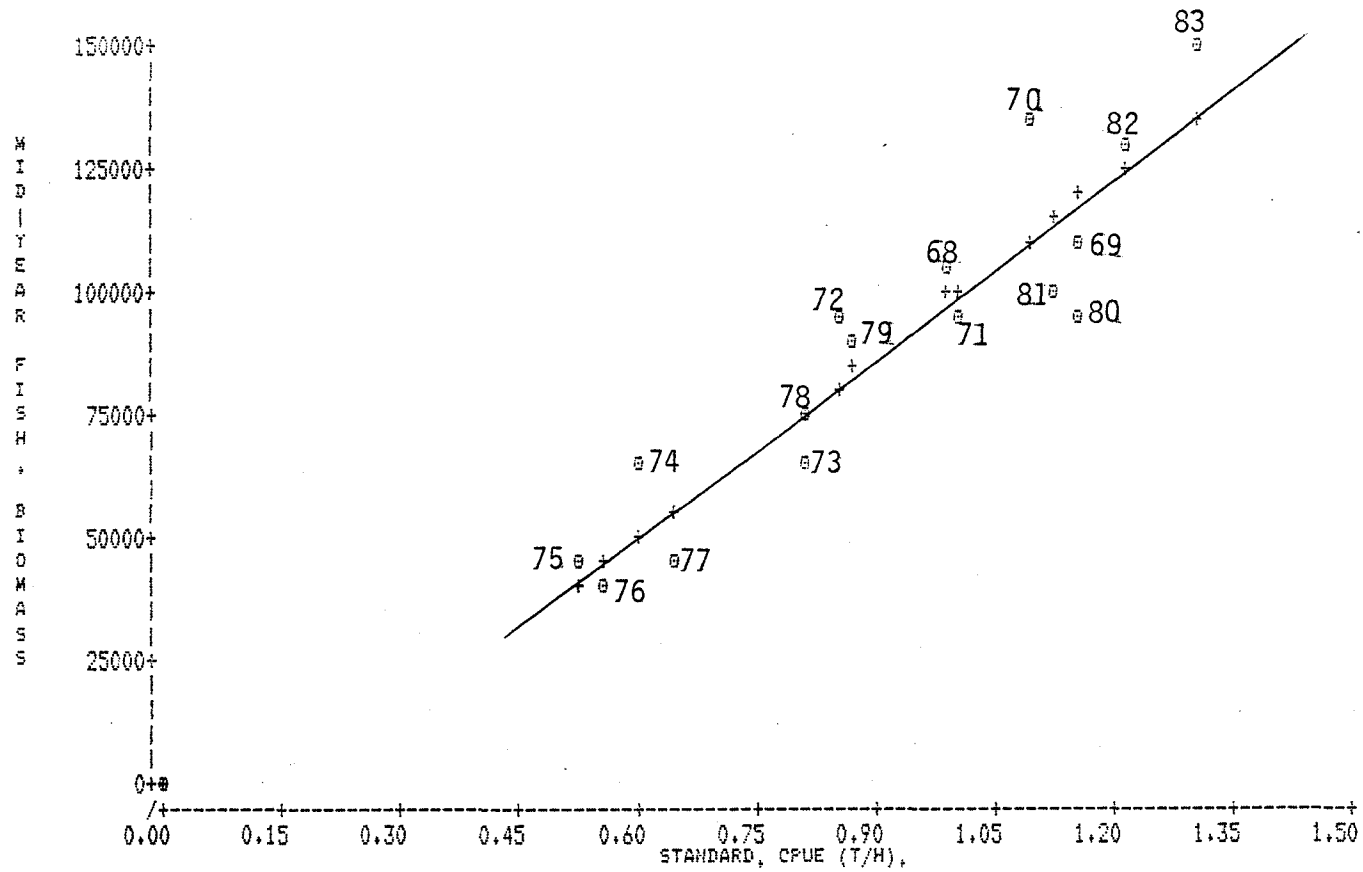


Figure 9. Relationship between mid-year fishable biomass and the standardized commercial catch rate for F_t = 0.35.

Appendix 1.

Canadian commercial samples for cod caught in 4Vs and 4W for 1979, 1980, 1981, and 1982[a].

Year	Div.	Gear	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total	Yearly Total All Gears
1979	4Vs	OTB-1	-	-	-	-	262/43	335/37	169/67	-	-	612/103	616/99	272/41	2266/390	
		OTB-2	-	-	-	-	391/40	-	-	-	-	360/35	626/110	-	1377/185	
	4W	OTB-1	224/45	-	-	-	1015/129	319/49	645/74	616/71	-	765/93	-	-	3584/461	
		OTB-2	-	-	-	-	677/69	-	-	-	-	-	-	265/39	942/108	
		SN4	-	-	-	-	-	-	221/32	1164/129	491/58	-	-	787/107	2663/326	
		LL	-	-	-	360/53	219/50	870/153	822/129	570/70	306/42	-	278/62	223/52	3648/611	
		LHP	-	-	-	-	-	-	225/34	-	-	-	-	-	225/34	
	4VsW	OTB-1	-	-	-	-	298/38	-	-	-	-	-	-	-	298/38	
		OTB-2	-	-	-	-	805/96	-	-	-	-	304/58	-	-	1109/154	16112/2307
1980	4Vs	OTB-1	-	-	3335/238	666/101	-	-	267/45	338/38	-	1756/274	283/34	-	6645/730	
		OTB-2	-	-	956/149	579/106	-	-	213/33	345/64	296/36	1735/281	1691/316	-	5815/985	
		OTB	-	-	-	-	200/43	-	-	-	-	-	-	-	200/43	
	4W	OTB-1	-	333/61	279/49	301/54	-	232/53	-	222/38	-	-	-	-	1367/255	
		OTB-2	-	556/105	319/46	-	-	-	-	154/43	-	-	-	573/91	1602/285	
		SN4	-	-	-	-	-	-	-	642/104	-	254/36	-	-	896/140	
		LL	-	-	-	255/56	-	-	380/60	208/48	286/58	-	-	-	1129/222	
	4VsW	OTB-1	-	-	-	301/59	-	-	-	-	-	309/42	-	-	610/101	
		OTB-2	-	-	-	-	-	-	-	-	-	-	259/58	355/56	614/114	18878/2875
1981	4Vs	OTB-1	-	-	983/139	-	352/44	481/70	2108/334	310/46	-	-	286/60	630/119	5150/812	
		OTB-2	-	-	1411/209	662/124	-	315/67	1000/137	-	233/41	1177/215	860/144	535/115	6193/1052	
		SNU	-	-	-	-	-	-	253/24	-	-	-	-	-	253/24	
		LL	-	-	-	-	-	-	308/64	-	-	-	-	-	308/64	
	4W	OTB-1	298/56	-	607/108	246/38	-	-	246/29	-	-	193/31	-	-	1590/262	
		OTB-2	-	-	-	567/109	-	-	233/37	-	-	338/36	-	-	1138/182	
		SNU	-	-	-	-	-	-	-	-	228/28	505/74	-	-	733/102	
		LL	-	-	-	-	-	430/51	611/87	1022/177	-	345/39	-	-	2408/354	
		LHP	-	-	-	-	-	-	425/83	-	-	-	-	-	425/83	
	4VsW	OTB-2	-	-	629/122	605/124	-	-	-	-	-	-	-	-	1234/246	19432/3181

Appendix 1. (Continued)

Year	Div.	Gear	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total	Yearly Total All Gears
1982	4Vs	OTB-1	-	-	2984/472	822/144	578/107	574/72	-	248/36	-	-	840/176	208/48	6254/1055	
		OTB-2	-	1370/209	2052/230	845/138	958/142	820/99	472/70	-	312/46	317/49	620/123	1276/51	9042/1157	
		SNU	-	-	-	-	-	-	460/56	-	-	-	-	-	460/56	
		LL	-	-	-	-	544/121	2094/503	684/128	-	206/58	-	-	-	3528/810	
	4W	OTB-1	-	-	-	424/93	-	-	514/56	-	-	-	-	-	938/149	
		OTB-2	257/48	-	723/151	234/56	281/31	-	-	-	296/27	186/21	813/101	-	2790/435	
		SNU	-	-	-	-	-	1495/187	-	-	734/80	-	839/102	-	3068/369	
		LL	-	-	-	336/72	427/78	1414/312	203/46	205/38	186/47	-	-	-	2771/593	
		LHP	-	-	-	-	-	121/32	-	-	-	-	-	-	121/32	
	4VsW	OTB-1	-	-	-	-	-	-	-	-	-	-	280/52	-	280/52	
		OTB-2	-	-	-	302/65	949/170	-	295/47	272/24	-	-	634/122	-	2452/428	31704/5136
1983[b]	4Vs	OTB-1	245/54	721/102	886/147	-	-	628/81	293/33	-	-	-	-	-	2773/417	
		OTB-2	1052/192	501/76	1515/256	316/50	610/92	1214/191	831/139	319/54	-	721/104	615/54	-	7694/1208	
		SNU	-	-	-	-	-	-	-	-	-	-	-	-	-	
		LL	-	-	-	300/64	603/111	-	1200/190	733/128	-	-	-	-	2836/493	
	4W	OTB-1	-	-	1214/192	-	-	-	-	-	-	-	326/27	-	1540/219	
		OTB-2	515/94	219/23	1365/217	249/31	-	-	-	-	-	212/24	-	-	2560/389	
		SNU	-	-	-	646/91	-	667/87	-	1052/127	-	-	-	-	2365/305	
		LL	-	-	-	242/39	271/44	967/150	-	858/144	555/111	-	-	-	2893/488	
	4VsW	OTB-1	-	-	592/62	-	-	-	-	-	-	-	-	-	592/62	
		OTB-2	538/101	-	-	498/113	-	-	-	-	-	-	-	-	1036/214	24289/3795

[a] The first number is the number of fish measured and the second, the number of fish aged.

[b] Only samples completed by April/84 are included for 1983.

Appendix 2: Partial recruitment values for ages 4 and 5; effect of using averages rather than values indicated by a calibration procedure.

Partial recruitment values based on averages would smooth out trends that may have developed in recent years which can then proceed unnoticed. This procedure however is much less sensitive to spurious changes that may result from erroneous catch and effort statistics. Erratic variations do not seem to be a problem in the present case since calibration based on the regression of SPA numbers against a variety of standardized catch rates over the last three years all suggest a partial recruitment around 0.55 at age 4. When we used this procedure for age 5 with the two stndardized effort series described in this document, we obtained estimates around 0.9 in both cases. This procedure therefore appears to be fairly robust when used with our data set and has indicated a stable partial recruitment at age 4 for the last three years.

For both ages 4 and 5, the estimates derived from the calibration procedure (PRCAL in Table A.2.1) are higher than those based on averages. In the previous two assessments, the population size and the catch projections were calculated with the same partial recruitment values. Had we done this in the current analysis, the 1983 population estimates for ages 4 and 5 would have been 38% and 11% lower (Table A.2.1).

Larger partial recruitment values increase the projected catches over the short run. However, as shown in the table, that increase would have been insufficient to offset the reduction in population size, resulting in a projected 1985 $F_{0.1}$ catch biomass 6% less than that using PRFIN, assuming a 1984 catch of 55,000 tons.

Unfortunately, it remains unknown which partial recruitment series is better. A good knowledge of the recent trends in partial recruitment would certainly be very useful in analyzing the dynamics of the partially-recruited year-classes as well as the behaviour of the fisheries exploiting them. Such information can certainly not be obtained by averaging over passed periods of time.

Table A.2.1. Effects of using calibrated values (PRCAL) rather than averages (PRFIN) for the partial recruitment at ages 4 and 5. (F_t = 0.35; PRFIN and PRCAL used in cohort runs and projections; other input values as in Table 30.)

Partial Recruitment	PRFIN	PRCAL
age 4	.34	.56
age 5	.79	.90

			Differences	
1983 Population Numbers			Number	Percent
age 4	89001	55562	33439	38
age 5	36285	32275	4010	11
age 1+	468291	430842	37449	8
Projected 1+ Catch (t)				
1984	55000	55000	0	0
1985	51638	48393	3245	6