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Assessment of the 4VsW Cod Stock Complex

by

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Abstract

Research vessel survey population estimates and Canadian tonnage class 5 average catch per unit of effort during the months of January to April were used to fine tune ages 5 and older VPA mean numbers and biomass. A fully recruited 1980 fishing mortality of $F = 0.225$ was considered to best represent the age 5 and older stock status. Year-class size at ages 4 and 3 in 1980 were adjusted by regression with an index of year-class size from R.V. surveys while year-class size at age 2 was estimated from a relationship between year-class size at age 1 and the age 7 and older biomass during the year of spawning. The 1982 $F_{0.1}$ catch is estimated to be 53,700 mt.

Résumé

Les estimations de populations dérivées des levées de navires de recherche et les prises par unité d'effort moyennes des bateaux canadiens appartenant à la classe de tonnage 5 durant les mois de janvier à avril ont été utilisés pour ajuster les nombres moyens et les biomasses de 5 ans et plus de l'APV. Une mortalité par pêche en 1980 de 0.225 sur les âge pleinement recrutés a semblé donner la meilleure représentation de l'état du stock de 5 ans et plus. Les nombres de poissons de 3 et 4 ans en 1980 ont été estimés par régression avec un indice dérivé des levées des navires de recherche alors que le nombre de poissons de 2 ans a été estimé à l'aide d'une relation entre la taille des classes d'âge à 1 an et la biomasse des poissons de 7 ans et plus durant l'année de ponte. La capture au niveau $F_{0,1}$ en 1982 est estimé à 53,700 tm.

Introduction

This stock complex had been under quota management since 1973 when ICNAF set the first TAC at 60,500 mt. Assessments of the stock status at the time (Halliday, 1972) indicated that the fishing mortalities were slightly above F_{max}, that incoming year-classes generally appeared to be below average and that a 60,000 mt TAC for 1973 was "higher than that desirable for this stock" (Halliday, 1972 p.6). This statement appears to have been appropriate and the TAC was undercaught in 1973-1974 and 1975 (60,000 mt for 1974 and 1975).

The stock complex was assessed again in 1975 (Halliday, 1975) using newly recalculated removals at age for Spain and the USSR which indicated recruitment to the fishery at a much younger age than was previously assumed based on the sampling of Canadian catches. The calculations showed that a 60,000 mt TAC in 1976 would generate fishing mortalities substantially above the estimated F_{max} and that the 1976 F_{max} yield would be between 28,000 and 31,000 mt while the $F_{0.1}$ catch would have been between 17,000 and 19,000 mt. The 1976 TAC was set at 30,000 mt and again undercaught.

The 1976 assessment of 4VsW cod indicated that:

"since 1971, fishing mortality rates have exceeded F_{max} = 0.35. However the observed levels of fishing mortality were not sufficient to explain the rapid decline in stock size in recent years, the major cause being the recruitment to the fishery of the poor 1971 to 1973 year-classes. In view of the large silver hake fishery conducted in this area with small meshed trawls during the period when the cod stocks declined, the Subcommittee examined the consequences of relatively small by-catches of young cod (ages 1 and 2) in the silver hake fishery on the subsequent recruitment of cod. It was estimated that by-catches of about 4,000 mt annually, equally divided between ages 1 and 2 fish, explained the reduced recruitment of cod observed in recent years, and that by-catches of 10,000 mt of age 1 fish could virtually eliminate the cod stock." (ICNAF Redbook 1976, p.87).

Canada extended its jurisdiction over fisheries to 200 miles as of January 1, 1977 and CAFSAC (Canadian Atlantic Fisheries Scientific Advisory Committee) was created soon afterwards to, among other things, provide scientific advice to the Atlantic Fisheries Management Committee on the management of all stocks of interest or potential interest to Atlantic coast fishermen. The CAFSAC 1977 Groundfish Subcommittee Report (Appendix I of Advisory Document 77/3) states that:

"Reasons for the decline of this cod stock are not yet fully known. Two possibilities were considered. First, the silver hake fishery in 4VWX might take young cod as by-catch. Second, silver hake may predate on young cod. The correlations between cod numbers at age 1 and effort in the silver hake fishery that was shown in the 1976 assessment of this stock was not as strong when new data were added. No significant relation was found between cod numbers at age 1 and silver hake biomass" (p.34).

The Subcommittee recommended that the 1978 catch be kept to the lowest possible level and and that under no circumstances should the catch be allowed to surpass 7,000 mt (Ibid. p.34).

For the first time since the stock had been under quota management, the 1977 catch exceeded the TAC and the Canadian catch showed a slight increase over 1976.

In the 1978 assessment it was found that:

"research survey estimates showed an overall increase in numbers in 1977. However, the age distribution showed lower than usual percentages of one and two year olds. Hence it was assumed that the change in numbers was due to a change in availability and that the data emphasized the lowered recruitment. A CPUE index was developed using data up to 1976 for Spanish pair trawls combined with data to the present for Canadian otter trawls. The CPUE showed an increase in 1977 but, due to the extreme change in the fishery, it was felt that this figure was not comparable to past values" (CAFSAC Advisory Document 78/2, Appendix 3, p. 96).

All indications were that recruitment had seriously dropped and although the Subcommittee felt that it would be optimal to close the fishery, it recommended that under no circumstances should the catch be allowed to exceed 7,000 mt.

It now appears that the stock had started to recover in 1977 and that the 1978 TAC was probably below the optimal level. This led to misreporting of catch location by Canadian fishermen to comply with the existing TAC's. When appropriate corrections were made to catch locations, the 1978 catch was estimated to be 25,405 mt, substantially above the 7,000 mt TAC.

In the 1979 analysis more weight was given to research survey population estimates since the Canadian commercial catch rates were believed to be unreliable due to misreporting while the Spanish catch rate series had ended in 1976. Closer examination of the Spanish data showed "consistency in apportionment of catches to ICNAF Divisions which suggests arbitrary assignment of catches which were initially reported in too little detail "(CAFSAC Advisory Document 79/7, App. I, p.38). However the Spanish catch trends in 4VsW agreed well with R.V. surveys data and other countries CPUE so the Subcommittee did not see any "reason to disbelieve that the catch rate trends of Spanish pair trawlers in Division 4VsW are an accurate reflection of their fishing success "(Ibid p.38). There was also suspicion, but no evidence, that discarding of small cod may have occurred in the Spanish fishery.

Data from the International Observers Program indicated that by-catches of cod in the small mesh fisheries had been underestimated and corrections were made to the removals at age matrix. The results of the assessment indicated an $F_{0.1}$ catch of 42,000 mt in 1979 and 44,000 mt in 1980. However there were considerable uncertainties in the assessment (variability of R.V. survey estimate, 1978 catches etc.) and, in order to further speed up the recovery of the stock, TAC's of 30,000 mt and 45,000 mt were set for 1979 and 1980 respectively. The catch exceeded those values by 10,000 mt in 1979 and by 4,000 mt in 1980.

There is no indication of substantial misreporting in both 1979 and 1980 and the Canadian catch rates will thus be used in the following analysis in conjunction with research vessel survey data.

Nominal catches:

Table 1 shows the 4VsW cod nominal catches by country and NAFO Divisions and Figure 1 shows the total nominal catches since 1958. Until 1976, Spain was the main harvester of that stock complex, catching on the average 33,000 mt a year or 58% of the total nominal catches. Canada followed with 16,500 mt caught annually or 30% of the total. The USSR (3,300 mt or 6%), France (1,900 mt or 3%) and Portugal (1,000 mt or 2%) followed. The average yearly catch by other countries was 1,000 mt annually or 2% of the total. The maximum catch was reported in 1968 (80,425 mt) and the lowest one in 1977 (10,390 mt). The 1958 to 1972 average is close to 61,000 mt. As indicated in the introduction the low catches between 1973 and 1977 are believed to be due to decreased recruitment following by-catches of young cod in the silver hake fishery and the pre-1972 average catch is thought to be more representative of expected yields from that stocks complex.

Since 1977 the fishery has been almost solely Canadian and the catch by other countries amounted to only 386 mt of 49,164 mt caught in 1980. The total nominal catch has steadily increased from 10,390 mt in 1976 to close to 50,000 mt in 1980. On the average, since 1958, 48% of the total has been caught in 4Vs and 52% in 4W. The catches in 4Vs did not show any trend until 1973 when they started to decline; this trend continued up to 1977 when the stocks started to increase again. The catches in 4W increased steadily from 1958 to 1963 then declined to 1967 with a hump in 1966 and remained relatively stable up to 1974 when the decline observed in 4Vs became apparent in 4W with a lag time of one year. The trend afterwards is the same as in 4Vs except that there is a decrease from 1979 to 1980. From 1974 to 1979 the catches in 4W have consistently been higher than those in 4Vs.

For the Canadian fishery, trawlers have generally caught the major portion of the catch (Table 2). Except for a few years, between 1958 and 1961, and in 1978 trawlers took in excess of 90% of the 4Vs catch while in 4W the catch was almost equally divided between trawlers and other gears. Of the 48,778 mt caught by Canada in 1980, 72% (35,084 mt) were caught by trawlers, 19% (9,139 mt) by longliners and 8% (3,763 mt) by Danish and Scottish seines. Various other gears caught 2% (792 mt) of the total 1980 provisional nominal catches.

Removals at age:

Data collected by international observers on USSR vessels fishing for silver hake and squid on the Scotian Shelf showed that the USSR was underestimating the by-catches of cod in those fisheries by an average ratio of 2.66 for 1977-1978 (Gray, 1979). As mentioned earlier, this led in the 1979 assessment (Gray, 1979) to a correction of the catch at age used in previous years to account for suspected under-reporting for years prior to 1977. Provisional data were used for these calculations and the average by-catch ratio has been recalculated with final data.

In 1977, the by-catch ratio of cod by USSR vessels with observers on board was 0.006 in the silver hake fishery and 0.002 in the squid fishery. For that year, the USSR reported a total nominal catch of 97 mt of cod in Divisions 4Vs and 4W. If it is assumed that the by-catch ratios calculated from boats with

observers are the same on boats without observers and given the reported silver
hake nominal catches of 27,351 mt and the squid catches of 18,812 mt, it is
calculated that the USSR caught 202 mt in 1977, giving an under-reporting factor
of 2.1. The by-catch ratios for 1978 were 0.0043 for silver hake and 0.0044 for
squid for boats with observers. Given the reported nominal catches of silver
hake (42,202 mt) and squid (12,434), it was calculated that the USSR caught 236
mt of cod compared with the reported nominal catches of 218 mt. The 1978 under-
reporting factor would thus have been 1.1 and the average factor for 1977-78
would be 1.6. It is not known at this time, and will probably never be known,
what was the real under-reporting factor of cod catches by the USSR for years
prior to 1977 and it is not known either if a factor of 1.6 would be more
appropriate than the previously used factor of 2.66. However given the results
of the calculations, a new catch at age matrix was calculated using the former
value (Table 4). It should be noted that other corrections could happen in the
future after a planned in depth study of the international observers data base
has been done.

When Halliday (1975) recalculated the USSR catch at age he assumed that the
average weight of the fish in the catch was 0.415 kg and that, for years prior
to 1973, the age distribution of the catch was:

Age	1	2	3	4	5
Proportion	.08	.51	.33	.06	.02

From 1973 onwards USSR length frequencies were aged with Canadian summer R.V.
surveys age-length keys.

From Halliday's (1975) and Gray's (1979) data, both the USSR uncorrected
and other countries (without USSR) catch at age were recalculated. The USSR
data were then multiplied by 1.66 and added up to matrix without USSR catch at
age to obtain the new removals at age matrix shown in Table 4.

Table 3, shows the Canadian samples collected for that stock complex since
1979. The 1980 catch at age was obtained by constructing quarterly age-length
keys from otter trawl samples and applying them to the quarterly nominal
catches. A total of 52 otter trawl samples were collected in 1980, 17 in the
first quarter, 7 in each of the second and third, and 21 in the fourth quarter.
A yearly age-length key was made with the four seines (Danish and Scottish)
samples and applied to nominal catches by those gears and the four longline
samples were used in the same manner. The total catch at age was obtained by
prorating the sum of these catches at age for unsampled catch. The 1979 catch
at age presented by Maguire (1980) was prorated upwards to account for the 1979
revised total nominal catch figure.

Table 5 shows a matrix of removals at age by Canadian otter trawlers since
1960. From 1960 to 1977 all otter trawl samples were combined on a yearly basis
and applied to the total Canadian otter trawls nominal catches. The same A and
B parameters of the length-weight relationship (A = 0.0071 and B = 3.084) were
used for that period. For 1978 to 1980, yearly A and B parameters from the
summer R.V. surveys were used and there were enough samples in those years to

construct quarterly age-length keys and apply them to quarterly nominal catches.

Weights at age:

Weights at age (Table 6) for 1966 to 1978 were available from unpublished data sheets (D. Gray pers. comm.), the 1979 from last year's assessment and the 1980 were calculated from this year's sampling data. The average weights at age for 1966 to 1980 were used for 1958 to 1965.

Stock size indices:

Research vessel surveys

Stratified random groundfish surveys have been conducted during the summer since 1970 on the Scotian Shelf. As mentioned in the introduction these data were most important in the recent assessment of the stock complex. Tables 7a and 7b show the average number caught per set per stratum for both of 4Vs and 4W. High catches in one set of each of stratum 58 and 59 in 1973 made the population estimate for that year out of proportion with the neighbouring years results (Table 8a). The population size was re-estimated without those two sets and the new population size estimates are shown in Table 8b for 4Vs and 4W combined while Table 8c and 8d show the corrected data for 4Vs and 4W separately. Figure 2a shows the R.V. population estimates since 1970 for ages 3+, 4+ and 5+. There was a general decline from 1971-72 to 1975 and the rebuilding started in 1976. Ages 3 and older increased very rapidly to above the 1971 level in 1978 followed by a slight decline in 1979 and stabilizing at the 1979 level in 1980. Ages 4 and older show a slower increase to 1978 and stability afterwards while the ages 5 and older show increases in 1976 and 1977 then a slight decline in 1978, a rapid increase in 1979 above the 1971 estimate and the 1980 level is slightly above 1979.

The same data for 4Vs and 4W separately are shown in Figure 2b. The 4W population estimates have remained relatively stable from 1970 to 1975, then rapidly increased to 1978 for ages 3+ and 4+ followed by declines in 1979 and 1980. For ages 5 and older the increase is to 1979 and the 1980 estimate is approximately at the 1978 level. There was a very pronounced decline from 1971-72 to 1974-75 in 4Vs, followed by an increase to 1977, a dip in 1978 and then a continuous rapid increase to 1980. It is interesting to note that the predominance in contribution to the catch of 4W over 4Vs observed for the period 1973 to 1979 (Table 1) is generally parallelled by the 3+ population estimates (Figure 2b). The decline in population estimates since 1978 in 4W would tend to support the hypothesis that in recent years the fishing fleet has exerted a high fishing effort on relatively localized but dense schools of fish (CAFSAC Advisory Document 79/7, App. I. p.43) as most of the fishing occurred on Middle Ground in both of 1978 and 1979.

An index of year-class size at age 3 and 4 was developed from the R.V. survey population estimates at age by dividing the yearly population estimates

by the averages from 1970 to 1980 for each respective age. The sum of those ratios for ages 2 and 3 was taken as an index of year-class size at age 3 and the sum of 3+4 as an index of year-class size at age 4 (Table 9 and Figure 3). Both indices indicate the same general trends except that the 1972 year-class appears strong at age 3 but below average at age 4. This is due to a high population estimates of 2 year olds in 1974. It appears that the above average 1968 year-class has been followed by a succession of four weaker than average year-classes. The 1973 year-class would be of moderate strength at age 4 while the 1974 and 1975 year-class at the same age would be above average and the 1976 slightly below average but stronger than the 1969 to 1972 year-classes. The same pattern is indicated by the index at age 3 and the 1977 year-class would also be slightly below average.

Commercial catch per unit of effort

Since this fishery is now almost 100% Canadian, the analysis of commercial catch rates was limited to Canadian vessels. Tonnage classes 2 and 3 nominal catches have historically been small and apparently randomly distributed over the year. Due to their low contribution to the total catches, their catch rates were not considered to be useful as an index of stock size fluctuations. Tonnage classes 4 and 5 boats took the main share of the Canadian catch but since Gray (1979) found that TC4 catch rates did not correlate well with R.V. survey population estimates, TC5 catch rates nor Spanish pair trawlers catch rates, the CPUE analysis was limited to Canadian TC5 otter trawlers. This fleet usually took the bulk of its catch in the beginning and end of the year but more so in the beginning. The averages of January to April catch rates were thus calculated for TC5 trips in which cod represented 50% or more of the total catch by dividing the total cod catches by total effort. Gray (1979) mentions that "In 1974-75 the Canadian tonnage class 5 vessels changed from a Western trawl to an Engel trawl with an estimated" (by the industry)" increase in efficiency of 30-40%". Since the change occurred over a two year period, it was assumed that half the vessels changed to an Engel trawl in 1974 (C/E multiplied by 0.825) and the other half in 1975 (C/E multiplied by 0.65) and that the average increase in efficiency was 35%, the middle point of the figures mentioned by the industry. Less than 400 mt of cod were caught by TC5 vessels from January to April of both 1965 and 1966 and the catch rates for those years are not believed to be representative of the stock size; they were thus excluded. The CPUE data are shown in Table 10 and Figure 4. The TC5 catch rates show a general decline from 1967-68 to 1976, with a little hump in 1972-73, and a steady increase to 1980 surpassing in 1979 the highest catch rates levels previously recorded in 1968.

A catch per unit of effort at age matrix was developed from the Canadian otter trawl catch at age matrix (Table 5) and an index of relative effort (Table 10) computed by dividing the yearly total Canadian otter trawl nominal catches by the yearly TC5 catch rates during January to April. The CPUE at age matrix (Table 11) was obtained by dividing the catch at each age by the yearly relative effort index. Similar results could have been achieved by multiplying the yearly Canadian otter trawlers percentage catch at age by the TC5 catch rates in January to April. The only difference between such a matrix and Table 11 would be a scaling factor. These data (Table 11) indicate that the Canadian otter trawl fleet generally exploited mainly ages 4, 5 and 6. The various ages

indicate different relative sizes for the year-classes considered e.g. the 1971 year-class shows up as the strongest observed at age 3 but at older ages it is one of the weakest. This may be due to the inherent variability of catch at age data but similar observations can be made for the 1969 and 1970 year-classes. This would support the hypothesis that the decrease in stock size observed in the mid-seventies was due to overexploitation of average or above average year-classes at young ages. At age 4, the 1966, 1967, 1969, 1971, 1972 and 1973 year-classes are weaker than average while at age 5 and 6 every year-classes from the 1963 year-class to the 1972 year-class inclusive would have been smaller than average and all subsequent would have been stronger than average, the 1974 year-class being the strongest. At age 7, the 1973 year-class is the strongest followed by the 1968 year-class.

Sequential population analysis

Total instantaneous mortality rates (Z) were calculated from the R.V. population estimates (Table 8b) and from the Canadian otter trawl catch per unit of effort at age (Table 11) by taking the ratio of the sum of the population estimates of ages 5 to 11 in year t to the sum of the population estimates of ages 6 to 12 in year t+1 for the surveys and the ratios of the sum of CPUE at ages 5-15 in year t and 6-16 in year t+1 for the CPUE at age. The average Z value for 1979-80 was .507 for the survey data and 0.406 for the otter trawl CPUE at age data, giving an average Z of 0.457 or F of 0.257. This value was used as the 1980 fully recruited F to run a first VPA with partial recruitment multipliers on ages 2 to 4 similar to those used in last year's assessment (Maguire, 1980), and full recruitment at ages 5 and older. The resulting 1979 fishing mortalities at age were decreasing after age 6. A three point median smoothing (Smith, 1981) applied to these F's showed a continuous decline of F's from age 7 to 11, increases at ages 12 and 13, decreases at 14 and 15 and an increase at age 16. To reconcile the decrease in F's from ages 7 to 11 with the subsequent increases and decreases the 1980 partial recruitment vector was defined as follows:

Age	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
PR	.0018	.1135	.60	1.0	1.0	.85	.70	.60	.5	.5	.5	.5	.5	.5	.5

This partial recruitment vector was used to tune VPA ages 5 and older mean numbers (as an approximation to mid-year numbers) with the R.V. surveys ages 5 and older population estimates and VPA ages 5 and older beginning of the year biomass with Canadian tonnage class 5 catch per unit of effort in January to April.

In addition to estimates of fishing mortalities in the last year, VPA requires as input values an estimate of M (0.2) and the fishing mortalities for the oldest age for every year. In every case, a first VPA was run with initial estimates of age 16 F's, then the yearly average F's on ages 6 to 9 were calculated and compared with the previous estimates. If the difference for any of the F's was greater than $\pm$ 0.001 another VPA run was made using the yearly average F's on ages 6 to 9 as input values for F_{16}. The process was repeated until the difference between any of the input F_{16} and ages 6 to 9

average F's was smaller than $\pm$ 0.001. It took usually between 3 and 5 runs to obtain stable F_{16}.

Runs with 1980 fully recruited F equal of 0.20, 0.225, 0.25, 0.275 and 0.300 were made, and the results are given in Table 12. The relationship between VPA numbers and R.V. population estimates was calculated excluding the 1970 point since it was an outlier at every starting fishing mortality and also because there were some changes made to the gear used in the survey between 1970 and 1971 (Halliday and Kohler, 1971). The relationships were not very sensitive to changes in the 1980 F's ranging from 0.20 to 0.30. The best correlations were obtained for both relationships with a 1980 fully recruited F of 0.25 but 1980 fully recruited F = 0.225 was taken as best representing the stock status based on the close agreement between the 1980 VPA calculated 5+ biomass and mean population numbers and the values predicted by the G.M. regressions with TC5 catch rates and R.V. surveys population estimates (Fig. 5a-b).

The R.V. index of year-class size at ages 3 and 4 (Table 9) was used to adjust fishing mortalities on those ages by changing the 1980 fishing mortalities at age 3 and 4 to obtain the 1976 and 1977 year-classes calculated by cohort on the G.M. regression line (Figures 6 and 7). Fishing mortalities of 0.026 and 0.163 on ages 3 and 4 respectively were obtained giving partial recruitment multipliers of 0.116 and 0.724. It should be noted that although the fishing mortalities at ages 3 and 4 were adjusted as the 1980 values were exactly on the G.M. regression line, it is not suggested that these are exact estimates. There are sufficient uncertainties regarding the accuracy of the catch at age matrix that one may be surprised to obtain any relationship with the R.V. population estimates especially since the latter also have relatively high inherent variability.

A plot of year-class size at age 1 versus ages 7 and older biomass during the year of birth of the year-class was then made with the data from the VPA run with the partial recruitment multipliers on ages 3 and 4 obtained above and there appeared to be a relationship between those two variables (Figure 8). There was no evidence for a dome and a Beverton and Holt (1957) stock-recruitment model was fitted to these data by the method of Paulik (1973). This method estimates 1/R and inverting the estimated values of 1/R represents the harmonic mean of expected recruitments at each stock size which tends to be below the arithmetic mean of expected recruitments (Ricker, 1975). Ricker (1975) recommends multiplying the inverse of the expected values by the ratio of the sum of the observed to the sum of the predicted recruitment values. This ratio was 1.0375. From the 1978, 1979 and 1980 ages 7 and older biomasses, the respective year-classes would be approximately 95, 116 and 141 million fish. Partial recruitment on age 2 in 1980 was adjusted to obtain a 1978 year-class size at age 1 of approximately 95 million fish while P.R. on age 1 in 1980 was adjusted to obtain a 1979 year-class size at age 1 approximately equal to the geometric mean recruitment from 1958 to 1977 at age 1 (101,287,000 fish).

The resulting VPA population estimates at age are shown in Table 13. There are some differences between the trends when different groups of ages were considered but all age-groupings indicate a decline from the late sixties to mid seventies followed by an increase to 1980. The age 1 and older population went from a high of 445 million fish in 1966 to a low of 244.5 million in 1973,

increasing continuously afterwards to reach 369.9 million fish in 1980. The ages 2 and older population was at its maximum in 1968 (320 million), reached a minimum in 1974 (155.7 million) and increased regularly afterwards to reach 269 million in 1980. For ages 3 and older the maximum was in 1968 (222.7 million), the minimum in 1975 (93 million), and the 1980 value is 190.8 million. The maximum ages 4 and older numbers was recorded in 1961 (133.6 million) and the stock would have increased from the lowest recorded value of 49 million in 1975 to 139 million in 1980, a slight decrease over the 150 million fish for ages 4 and older estimated in 1979. The 1980 ages 5 and older population estimate is 103 million fish having rapidly increased from an all time low of 26.4 million fish in 1976. The 1980 value is slightly higher than the previously recorded high of 82.7 million fish in 1961. Stock recruitment relationships have seldom been demonstrated and, again, given the uncertainties associated with the catch at age matrix, it is not suggested that one has been demonstrated here. The relationship observed may well be spurious and as more reliable catch at age data accumulate, the relationship may or may not hold.

Table 14 shows the mean population estimates used in calculating the different relationships between VPA population estimates and R.V. population estimates while Table 15 shows the beginning of year population biomass estimates. This last table essentially shows the same patterns as those of Table 13 (population numbers).

It appears that the 1980 fishing mortality is slightly above the 1979 value (Table 16). The average fishing mortalities on ages 6 to 9 has consistently been above $F_{0.1}$ from 1970 to 1976 and was below F_{max} only in 1970 for that period. The extension of the jurisdiction over fisheries has substantially reduced the fishing mortalities from 0.641 for ages 6 to 9 in 1976 to below 0.20 for the same age groups since 1977.

Figure 9 shows the relationships obtained between VPA year-class size estimates at age 4, 5, 6 and 7 versus the catch per unit of effort of Table 11 at the same ages. These relationships were not used in fine tuning VPA and are only presented as confirmatory evidence that the 1980 fishing mortality and partial recruitment multipliers chosen are consistent with the CPUE at age data set. There is some indication from these figures that the ages 5 and older 1980 fishing mortalites may be slightly overestimated since the last points are always under the G.M. regression lines. This is especially true for the age 5 plot where a regression calculated with the 1963 to 1973 year-classes would predict much higher 1974 and 1975 year-classes than those from VPA in this analysis; 73 and 47 million compared to 51 and 38 million for VPA. As mentioned earlier, however, there is some indication that the behaviour of the Canadian otter trawl fleet has changed in recent years and the CPUE values now obtained may not be directly comparable with previous figures. The relationships are nevertheless indicating that the 1973 to 1975 year-classes are fairly strong compared to earlier ones and that the analysis presented is probably not overestimating the size of these year-classes.

Yield per recruit

A Thompson and Bell yield per recruit calculation was made with the partial recruitment multipliers and weights at age of Table 17. Maximum yield per recruit (0.681 kg) occurred at F_{max} = 0.395 and the yield at $F_{0.1}$ = 0.234 is 0.640 kg per recruit, 94% of the yield at F_{max}, but the catch rate at $F_{0.1}$ would be approximately 1.6 times that at F_{max}. The $F_{0.1}$ value of 0.234 is slightly above the common $F_{0.1}$ = 0.2 value for cod in the northwest Atlantic. However this fishing mortality of 0.234 is applied only on fully recruited ages (5 and 6). Fishing at $F_{0.1}$ in 1982 with partial recruitment multipliers as in Table 17 would generate a weighted (by population) average F of 0.199 on age 5 to 16, a value identical to the usually accepted value of 0.2. Figure 10 shows the yield per recruit curve.

Projections:

Projections to 1982 fishing at $F_{0.1}$ were made assuming that the 1981 catch would be equal to the 50,000 mt TAC, using the average weights at age observed in the 1980 fishery and assuming that the 1980 and 1981 year-classes will be equal to the geometric mean recruitment for the 1957 to 1976 year-classes (101,287,000 fish). Under these conditions the 1982 catch would be 53,700 mt. The contribution of each age to the 1981 and 1982 catches are shown in Table 18.

Conclusion:

The recovery of this stock complex has been rapid although it is not yet quite complete and it would seem that lower by-catches of young cod in small meshed fisheries combined with substantially reduced fishing mortalities on all age-groups made it possible for that stock complex to increase quickly to population sizes comparable to historical levels. If recruitment levels are maintained, it is expected that catches in the order of the pre-1972 average levels (60,000 mt) could be achieved in the not so far future.

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

YEAR	CANADA	FRANCE	PORTUGAL	SPAIN	USSR	OTHERS	TOTAL	DIV. 4Vs	DIV. 4W	TAC
1958	17938	4577	1095	14857	0	124	38591	23790	14801	
1959	20069	16378	8384	19999	0	1196	66026	47063	18963	
1960	18389	1018	1720	29391	0	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	0	39690	7133	1094	63257	25496	37761	
1965	23104	536	88	39280	7856	124	70988	36713	34275	
1966	17690	1494	0	43157	5473	356	68170	27136	41007	
1967	18464	77	102	33934	1068	512	54157	26607	27550	
1968	24888	225	0	50418	4865	29	80425	48781	31644	
1969	14188	217	0	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	0	11090	1018	2035	24407	11553	12854	30000
1977	9890	68	0	0	97	335	10390	2873	7517	7000
1978	24642	437	0	57	218	51	25405	10357	15048	7000[2]
1979[1]	39219	18	0	2	683	108	40030	15393	24637	30000
1980[3]	48778	0	2	0	319	65	49164	31399[4]	17381[4]	45000

[1]   Advance Release

[2]   By-catch only

[3]   Preliminary

[4]   Canada only

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

Year	Div. 4VS		Div. 4W		Totals		Total[5]
	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	8695	1662	7303	7745	15998	9407	25405
1979[3]	14853	524	13784	10058	28637	10582	39219
1980[4]	28902	2497	6234	11147	35136	13644	48778

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

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

[3] Advance release

[4] Preliminary, Maritimes only Newfoundland is included in Table 1

[5] Totals may differ from Table 1 due to rounding

Table 3. Canadian commercial samples for cod caught in 4Vs and 4W for 1979 and 1980[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

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

TABLE 4: 4VSW COD REMOVALS AT AGE

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	0	0	0	35	734	2931	2200	2423	1688	330	1501	858	778	1390	1433	813
2	138	0	0	223	4684	18689	14133	15460	10761	2844	9707	5472	5347	9348	11686	7092
3	2854	2499	7016	3404	5200	13656	12259	15998	12880	5367	13312	5338	6761	8784	10311	12301
4	3534	8887	6118	9581	10184	11669	8481	12002	13135	7826	17038	13297	14415	8456	12649	7017
5	2533	8811	6655	9338	6322	10716	11629	5180	10297	9401	15385	10106	13545	8579	9424	9540
6	3726	6490	4525	6676	7887	5423	4696	6130	4461	4338	8297	6073	4539	10262	8780	3820
7	1610	4384	2811	2885	2744	4875	2874	3135	3256	1467	3482	2144	1942	5160	3432	2984
8	1465	1467	1827	1882	2538	2183	2345	4477	1590	1239	895	510	759	1849	1919	3719
9	2014	878	290	1212	686	346	1047	2127	856	664	816	237	236	496	358	1165
10	859	1101	133	169	478	134	312	1583	496	647	361	50	72	114	393	273
11	543	318	122	147	169	121	145	172	666	325	152	95	137	131	79	299
12	58	251	75	88	75	50	75	91	24	65	211	58	56	72	2	3
13	51	27	1	66	68	26	50	96	14	16	33	12	9	98	37	7
14	11	0	15	3	0	0	0	88	0	5	17	7	12	12	0	5
15	10	0	0	0	5	0	0	163	2	7	1	2	4	51	1	5
16	53	21	6	0	0	1	11	7	1	2	10	2	3	17	1	20
1+	19459	35134	29594	35708	41775	70819	60258	69132	60127	34543	71218	44261	48614	54819	60505	49063

	1974	1975	1976	1977	1978	1979	1980
1	931	1029	474	2	177	0	0
2	5382	5727	2640	16	153	36	128
3	10342	5961	2408	305	1004	1550	1962
4	9512	3739	3512	1030	3650	6054	5075
5	7066	4462	4788	1549	4621	9119	7060
6	2737	2555	2398	869	2441	4912	6137
7	944	2627	1426	501	768	1177	2928
8	1321	609	610	220	213	377	1071
9	413	497	184	128	112	77	321
10	369	660	49	35	80	23	89
11	15	153	22	44	26	10	47
12	5	126	107	55	28	5	26
13	0	36	1	11	26	4	4
14	0	9	4	3	9	1	1
15	0	9	1	2	4	0	4
16	0	18	1	7	2	0	8
1+	39038	28216	18624	4777	13314	23345	24861

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Table 5.   4 VSW COD CANADIAN OTTER TRAWL CATCH AT AGE   4/ 5/81

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	45	9	0	0	0	0	0	37	679	13	15	0	0	0	9
3	209	39	179	58	510	1144	496	78	352	170	8	320	810	546	831	24	0	66	694
4	628	636	1643	1226	955	2282	2580	1490	2372	1083	618	745	2519	935	1314	327	443	316	2843
5	1496	2038	1408	1790	1792	1819	2455	2974	2742	1309	1282	1245	1659	1782	1002	835	872	720	3538
6	1230	1863	1550	736	585	2208	972	1122	1786	969	633	1048	1582	640	376	601	457	405	1559
7	812	514	579	590	277	678	507	340	804	373	376	700	803	643	86	556	291	256	451
8	653	412	473	293	445	514	226	297	263	100	166	408	456	907	158	118	204	131	94
9	128	227	152	56	166	351	117	150	229	56	62	155	84	322	25	94	51	94	41
10	46	20	90	23	68	192	75	131	98	83	22	78	114	74	27	128	17	24	29
11	61	68	40	17	40	72	99	75	69	19	21	34	17	105	0	32	12	33	13
12	26	48	17	7	8	37	9	20	105	7	19	35	1	2	0	23	36	34	6
13	5	7	20	3	14	28	1	5	28	2	4	33	9	4	0	8	0	9	7
14	5	1	0	0	0	11	0	3	9	0	7	18	0	4	0	1	0	2	3
15	0	0	1	0	0	14	0	5	0	0	3	6	1	3	0	1	0	2	1
16	2	3	0	1	8	5	0	1	2	0	1	12	1	9	0	3	0	6	0
1+	5301	5876	6152	4800	4913	9364	7537	6691	8859	4171	3222	4874	8735	5989	3834	2751	2383	2095	9288

	1979	1980
1	0	0
2	25	24
3	1134	1053
4	4687	3199
5	6690	4822
6	3722	4615
7	782	2482
8	265	972
9	46	292
10	20	80
11	9	40
12	3	25
13	3	4
14	1	1
15	0	4
16	0	8
1+	17388	17620

Table 6. 4VSW COD WEIGHTS AT AGE

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
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	0.050
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	0.180
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	0.440
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	0.810
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	1.290
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	1.850
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	2.480
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	3.140
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	3.830
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	4.520
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	5.200
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	5.870
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	6.520
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	7.140
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	7.730
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	8.290

	1973	1974	1975	1976	1977	1978	1979	1980
1	0.080	0.130	0.100	0.100	0.100	0.200	0.000	0.000
2	0.220	0.330	0.270	0.280	0.280	0.620	0.530	0.570
3	0.450	0.620	0.530	0.570	0.810	0.950	0.760	0.800
4	0.790	1.020	0.890	0.960	1.090	1.250	1.060	1.150
5	1.210	1.530	1.340	1.460	1.670	1.680	1.700	1.600
6	1.720	2.130	1.870	2.030	2.360	2.470	2.390	2.210
7	2.280	2.820	2.470	2.660	3.170	3.610	3.130	3.080
8	2.900	3.580	3.120	3.350	4.580	5.230	3.710	4.310
9	3.540	4.410	3.810	4.070	4.140	5.590	4.770	5.260
10	4.220	5.280	4.530	4.800	5.330	6.540	6.840	6.920
11	4.900	6.190	5.270	5.550	4.650	7.920	7.960	7.560
12	5.590	7.130	6.010	6.290	4.910	9.210	9.410	10.190
13	6.280	8.090	6.760	7.020	7.140	10.400	10.630	7.920
14	6.960	9.050	7.510	7.740	8.590	9.750	10.030	8.130
15	7.620	10.010	8.240	8.430	10.600	8.680	11.450	14.450
16	8.270	10.960	8.960	9.100	14.940	12.210	12.510	14.030

Table 7.a.   4 VS COD AVERAGE NUMBER PER SET PER STRATUM IN R.V. SURVEYS   4/ 5/81

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
43	20.370	28.310	17.880	9.140	3.930	14.100	1.170	2.890	4.050	12.320	38.670
44	26.720	110.650	123.970	20.290	12.430	6.360	14.210	46.690	18.790	25.280	23.760
45	0.850	81.840	7.110	25.980	2.050	2.750	3.820	17.950	3.330	3.610	60.160
46	1.540	3.500	2.920	0.780	1.110	1.060	3.680	0.310	0.000	1.900	5.900
47	36.150	1.890	29.990	38.030	20.450	64.060	69.610	54.940	21.490	52.910	76.220
48	33.210	3.610	4.520	12.720	4.310	3.270	12.550	51.220	37.690	50.660	6.460
49	59.680	2.870	0.490	13.130	0.390	0.730	4.830	0.320	0.000	7.110	18.470
50	1.090	1.520	3.380	14.770	24.960	1.290	4.230	4.740	13.610	2.860	0.000
51	0.000	1.170	2.140	0.550	0.920	7.400	0.550	0.000	0.000	5.830	1.030
52	0.000	1.520	1.840	0.380	72.360	17.010	9.040	3.830	1.940	13.070	0.670

Table 7b.   4 W COD AVERAGE NUMBER PER SET PER STRATUM IN R.V. SURVEYS   4/ 5/81

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
53	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.320	0.000	0.000
54	0.000	0.000	5.830	2.130	0.730	0.620	10.500	2.570	0.650	14.130	4.510
55	4.600	8.950	21.700	24.250	135.440	38.310	42.500	41.820	45.690	67.530	35.100
56	15.940	17.340	15.820	42.640	18.080	26.500	38.410	53.300	18.480	190.230	27.610
57	1.520	1.020	1.380	20.070	178.470	1.640	0.000	2.390	659.530	0.000	99.300
58	20.200	18.880	105.000	2811.080	10.540	45.210	37.540	100.550	81.540	63.150	186.900
59	11.360	54.690	3.400	340.640	11.060	7.500	39.150	38.700	9.780	13.220	1.080
60	4.030	1.750	0.000	1.540	0.000	1.250	0.490	0.000	1.190	0.000	1.110
61	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.650	0.000	0.000
62	3.890	1.230	2.920	0.000	0.240	2.420	3.560	0.570	0.000	0.730	0.610
63	13.130	13.610	18.690	12.590	42.280	14.320	4.230	43.350	3.280	3.750	2.660
64	31.990	6.260	8.840	89.180	47.350	21.610	29.130	14.330	26.060	37.520	53.920
65	3.920	3.110	0.190	0.320	1.660	1.170	5.880	0.660	7.290	10.050	2.060
66	0.000	0.000	0.000	0.000	0.280	0.000	0.000	0.000	0.000	0.000	0.530

Table 8a.　4VsW cod R.V. surveys population estimate not corrected for 1973.

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
0	0	0	0	0	0	0	0	0	174	1017	50
1	1478	1539	6210	16128	5174	3372	2242	808	3033	1213	690
2	16388	7680	9674	122780	32961	8412	14066	10145	13065	10612	7064
3	5250	35664	11881	104965	19246	13000	16098	26372	31245	16044	18488
4	7714	8027	31536	59948	5623	6171	10187	17059	34205	16595	10260
5	3742	15803	5812	22524	2017	2959	6621	11353	9461	18075	17365
6	1228	5775	5989	1870	2244	675	1264	4893	3490	9053	12099
7	1532	3459	1621	2907	372	867	656	1081	889	2696	4794
8	466	1475	547	901	463	235	1308	878	185	1009	1302
9	104	638	495	431	224	433	0	244	90	411	338
10	249	70	153	514	161	23	929	0	79	83	265
11	209	137	0	166	63	0	38	161	0	45	93
12	101	58	0	0	59	68	0	62	79	5	0
UK	142	206	0	230	57	0	213	0	0	19	0
5+	7773	27621	14617	29543	5660	5260	11029	18672	14273	31396	36256

Table 8b.　4VsW cod R.V. surveys population estimate corrected for 1973.

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
0	0	0	0	0	0	0	0	0	174	1017	50
1	1478	1539	6210	2295	5174	3372	2242	808	3033	1213	690
2	16388	7680	9674	8779	32961	8412	14066	10145	13065	10612	7064
3	5250	35664	11881	13761	19246	13000	16098	26372	31245	16044	18488
4	7714	8027	31536	10790	5623	6171	10187	17059	34205	16595	10260
5	3742	15803	5812	6798	2017	2959	6621	11353	9461	18075	17365
6	1228	5775	5989	429	2244	675	1264	4893	3490	9053	12099
7	1532	3459	1621	950	372	867	656	1081	889	2696	4794
8	466	1475	547	676	463	235	1308	878	185	1009	1302
9	104	638	495	97	224	433	0	244	90	411	338
10	249	70	153	274	161	23	929	0	79	83	265
11	209	137	0	166	63	0	38	161	0	45	93
12	101	58	0	0	59	68	0	62	79	5	0
UK	142	206	0	96	57	0	213	0	0	19	0
5+	7773	27621	14617	9486	5660	5260	11029	18672	14273	31396	36256

Z 5+/6+ 　 -.437 　 1.136 　 .734 　 2.085 　 .89 　 .177 　 .391 　 1.356 　 .069 　 .507

Table 8c.

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                        4VS COD R,V, POPULATION ESTIMATE                    29/ 6/81
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	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
0	0	0	0	0	0	0	0	0	0	0	0
1	162	0	181	360	1277	171	185	481	200	289	114
2	11992	1638	5189	4317	3450	2989	5736	4365	3137	3107	1415
3	2219	30138	9550	6266	3503	6881	6643	14393	6964	6152	4150
4	5142	4468	29774	3240	1151	2575	2104	8030	5618	6526	4811
5	2730	12129	4365	4835	1112	1805	2019	6014	1151	6218	11017
6	867	4209	5649	242	1658	465	346	2092	280	3366	8426
7	777	2260	1541	736	151	649	294	523	108	1474	2720
8	278	1062	513	262	340	235	1308	604	67	848	955
9	25	70	254	27	159	285	0	244	66	297	260
10	22	70	153	0	46	23	929	0	26	83	265
11	209	0	0	166	63	0	0	161	0	45	93
12+	0	0	0	0	0	0	0	0	0	5	0
0+	24423	56044	57169	20451	12910	16078	19564	36907	17617	28410	34226
1+	24423	56044	57169	20451	12910	16078	19564	36907	17617	28410	34226
2+	24261	56044	56988	20091	11633	15907	19379	36426	17417	28121	34112
3+	12269	54406	51799	15774	8183	12918	13643	32061	14280	25014	32697
4+	10050	24268	42249	9508	4680	6037	7000	17668	7316	18862	28547
5+	4908	19800	12475	6268	3529	3462	4896	9638	1698	12336	23736

Table 8d.

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                        4W COD R,V, POPULATION ESTIMATE                     29/ 6/81
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	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
0	0	0	0	0	0	0	0	0	174	1017	50
1	1316	1539	6029	1935	3897	3201	2057	327	2853	924	576
2	4396	6042	4485	4462	29511	5423	8330	5780	9928	7505	5649
3	3031	5526	2331	7495	15743	6119	9455	11979	24281	9992	14338
4	2572	3559	1762	7550	4472	3596	8083	9029	28587	10069	5449
5	1012	3674	1447	1963	905	1154	4602	5339	8310	11857	6348
6	361	1566	340	187	586	210	918	2801	3210	5687	3673
7	755	1199	80	214	221	218	362	558	781	1222	2074
8	188	413	34	414	123	0	0	274	119	161	347
9	79	568	241	70	65	148	0	0	24	114	78
10	227	0	0	274	115	0	0	0	53	0	0
11	0	137	0	0	0	0	38	0	0	0	0
12+	101	58	0	0	59	68	0	62	0	0	0
0+	14038	24281	16749	24564	55697	20137	33845	36149	78319	48448	38582
1+	14038	24281	16749	24564	55697	20137	33845	36149	78145	47431	38532
2+	12722	22742	10720	22629	51800	16936	31788	35822	75292	46507	37956
3+	8326	16700	6235	18167	22289	11513	23458	30042	65364	39002	32307
4+	5295	11174	3904	10672	6546	5394	14003	18063	41083	29110	17969
5+	2723	7615	2142	3122	2074	1798	5920	9034	12496	19041	12520

Table 9.   INDEXES OF YEAR-CLASS SIZE FROM R.V.SURVEYS   4/ 5/81

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.542	9.015	0.443
1	0.580	0.603	2.435	0.900	2.029	1.322	0.879	0.317	1.189	0.476	0.271
2	1.298	0.608	0.766	0.696	2.611	0.666	1.114	0.804	1.035	0.841	0.560
3	0.279	1.895	0.631	0.731	1.022	0.691	0.855	1.401	1.660	0.852	0.982
4	0.536	0.558	2.193	0.750	0.391	0.429	0.708	1.186	2.379	1.154	0.714
5	0.412	1.738	0.639	0.748	0.222	0.325	0.728	1.249	1.041	1.988	1.910
6	0.287	1.348	1.398	0.100	0.524	0.158	0.295	1.142	0.814	2.113	2.823
7	0.891	2.011	0.943	0.552	0.216	0.504	0.381	0.629	0.517	1.568	2.788
8	0.600	1.899	0.704	0.870	0.596	0.303	1.684	1.130	0.238	1.299	1.676
9	0.372	2.283	1.771	0.347	0.802	1.549	0.000	0.873	0.322	1.471	1.209
10	1.198	0.337	0.736	1.318	0.775	0.111	4.470	0.000	0.380	0.399	1.275
11	2.521	1.652	0.000	2.002	0.760	0.000	0.458	1.942	0.000	0.543	1.122
12	2.572	1.477	0.000	0.000	1.502	1.731	0.000	1.579	2.012	0.127	0.000
13	2.131	3.091	0.000	1.441	0.855	0.000	3.196	0.000	0.000	0.285	0.000

Table 10. 4VsW cod - Catch, effort, catch per unit effort and relative effort
series for Canadian tonnage class 5 otter trawls during January to
April.

			T.C. 5		
Year	Catch	Effort hrs	C/E	Total[1] O.T. Catch	Relative Effort
1967	885	1152	.768	13190	17169
1968	3353	4241	.791	17784	22494
1969	1671	2997	.558	7965	14285
1970	1367	2458	.556	6650	11957
1971	2546	4801	.530	10571	19934
1972	5017	8387	.598	14263	23844
1973	3868	6374	.607	10204	16815
1974	1282	2414	.438[2]	5474	12494
1975	1641	2366	.451[2]	5371	11914
1976	879	1849	.309[2]	4430	14336
1977	990	1707	.377[2]	4597	12194
1978	1360	1502	.589[2]	16078	27318
1979	7252	5401	.873[1,3]	23914	27393
1980	10006	5623	1.157	35084	30332

[1] The total is the total yearly nominal catch by otter trawlers.

[2] C/E corrected for increased efficiency for gear change that occurred in
1974-75. Correction is C/E x .835 for 1974 and C/E x .65 for other years.

[3] Fishery was reopended in May so that month is included in the calculations.

Table 11.

CANADIAN OTTER TRAWL CATCH PER UNIT OF EFFORT AT AGE (x1000)   6/ 7/81

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	1.9	28.5	0.8	1.2	0.0	0.0	0.0	0.3	0.9	0.8
3	4.5	15.6	11.9	0.7	16.1	34.0	32.5	66.5	2.0	0.0	5.4	25.4	41.4	34.7
4	86.8	105.5	75.8	51.7	37.4	105.6	55.6	105.2	27.4	30.9	25.9	104.1	171.1	105.5
5	173.2	121.9	91.6	107.2	62.5	69.6	106.0	80.2	70.1	60.8	59.0	129.5	244.2	159.0
6	65.4	79.4	67.8	52.9	52.6	66.3	38.1	30.1	50.4	31.9	33.2	57.1	135.9	152.1
7	19.8	35.7	26.1	31.4	35.1	33.7	38.2	6.9	46.7	20.3	21.0	16.5	28.5	81.8
8	17.3	11.7	7.0	13.9	20.5	19.1	53.9	12.6	9.9	14.2	10.7	3.4	9.7	32.0
9	8.7	10.2	3.9	5.2	7.8	3.5	19.1	2.0	7.9	3.6	7.7	1.5	1.7	9.6
10	7.6	4.4	5.8	1.8	3.9	4.8	4.4	2.2	10.7	1.2	2.0	1.1	0.7	2.6
11	4.4	3.1	1.3	1.8	1.7	0.7	6.2	0.0	2.7	0.8	2.7	0.5	0.3	1.3
12	1.2	4.7	0.5	1.6	1.8	0.0	0.1	0.0	1.9	2.5	2.8	0.2	0.1	0.8
13	0.3	1.2	0.1	0.3	1.7	0.4	0.2	0.0	0.7	0.0	0.7	0.3	0.1	0.1
14	0.2	0.4	0.0	0.6	0.9	0.0	0.2	0.0	0.1	0.0	0.2	0.1	0.0	0.0
15	0.3	0.0	0.0	0.3	0.3	0.0	0.2	0.0	0.1	0.0	0.2	0.0	0.0	0.1
16	0.1	0.1	0.0	0.1	0.6	0.0	0.5	0.0	0.3	0.0	0.5	0.0	0.0	0.3

Table 12. 4VsW cod results of fine tuning of VPA.

Year	R.V. 5+ Population	TC5 C/E	F = 0.20 Cohort Numbers	Predicted	Cohort Biomass	Predicted	F = 0.225 Cohort Numbers	Predicted	Cohort Biomass	Predicted	F = 0.25 Cohort Numbers	Predicted	Cohort Biomass	Predicted	F = 0.275 Cohort Numbers	Predicted	Cohort Biomass	Predicted	F = 0.30 Cohort Numbers	Predicted	Cohort Biomass	Predicted
1967	-	.768			122170	172445			122074	161668			121997	153332			121933	146730			121880	141413
1968		.791			122191	179326			122096	167739			122020	158788			121957	151715			121905	146032
1969		.558			110555	109623			110374	106237			110228	103519			110109	101216			110010	99232
1970		.556			150662	109025			150399	105709			150189	103044			150016	100783			149872	98831
1971	27621	.530	52146	71229	115470	101247	52057	65185	115264	98847	51986	60592	115099	96877	51928	56756	114963	95148	51879	53702	114850	93608
1972	14617	.598	36528	38147	111140	121589	36435	36121	110860	116795	36360	34584	110635	113007	36299	33219	110451	109886	36248	32115	110297	107267
1973	9486	.607	28380	25093	84801	124281	28179	24653	84380	119171	28018	24322	84047	115142	27886	23932	83765	111836	27776	23598	83535	109074
1974	5660	.438	22926	15360	75118	73724	22592	16102	74276	74563	22324	16670	73601	75054	22105	17007	73049	75209	21922	17247	72588	75129
1975	5260	.451	18748	14342	57487	77613	18198	15208	56314	77994	17756	15870	55375	78137	17394	16283	54606	78026	17092	16583	53965	77740
1976	11029	.302	19948	29019	55557	35134	18830	28102	53165	40513	17934	27408	51251	44454	17199	26724	49685	47250	16585	26159	48379	49218
1977	18672	.377	31999	48463	81616	55476	29566	45184	75766	58462	27619	42694	71087	60584	26026	40558	67260	61988	24699	38847	64071	62877
1978	14273	.589	59062	37272	158942	118897	54219	35352	146560	114420	50346	33896	136658	110872	47177	32596	128559	107935	44537	31544	121812	105459
1979	31396	.873	87420	80832	237833	203856	79289	73622	217199	189383	72784	68142	200700	178239	67462	63589	187208	169487	63028	59968	175972	162503
1980	36256	1.157	95137	93196	285724	288816	84566	84484	256589	264346	76110	77862	233296	245605	69191	72385	214253	231039	63425	68036	198396	219547
Intercept			961		-57305		3452		-41049		5350		-28843		6762		-19720		7851		-12847	
Coefficient			2.544		299154		2.235		263954		2.0		237207		1.81		216732		1.66		200859	
			.903		.974		.910		.882		.913		.885		.911		.882		.906		.874	

Table 13.   POPULATION NUMBERS

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	104320	93141	104183	85041	128151	143461	137148	136710	155386	119120	79803	95775	80479	83877
2	91497	85410	76258	85298	69593	104233	114709	110226	111296	125638	97218	63931	77610	65162
3	68258	74787	69928	62434	·69628	52593	67889	80707	75799	81055	100224	70521	47223	58551
4	38400	53309	58974	50927	48040	52213	30398	44245	51349	50230	61474	69855	52803	32465
5	22930	28252	35645	42769	33073	30154	32184	17210	25386	30199	34069	34995	45206	30267
6	17737	16490	15227	23195	26620	21383	15062	15913	9422	11558	16288	14138	19572	24850
7	5700	11171	7693	8406	12998	14716	12635	8119	7541	3732	5578	5939	6146	11944
8	4252	3221	5222	3780	4296	8174	7677	7761	3841	3264	1743	1479	2942	3290
9	4249	2169	1327	2638	1417	1263	4731	4182	2374	1723	1563	629	753	1727
10	1750	1681	990	826	1078	548	723	2932	1528	1177	816	552	303	405
11	945	666	401	691	524	455	328	313	991	806	388	346	407	183
12	122	291	262	219	433	277	264	139	103	222	369	181	198	211
13	52	48	20	147	101	287	182	149	33	63	124	114	97	112
14	41	0	15	15	61	22	212	104	37	15	37	72	83	71
15	73	24	0	0	10	50	18	173	9	30	8	15	52	57
16	158	51	19	0	0	4	41	15	2	5	18	5	11	39
1+	360483	370711	376164	366385	396021	429833	424193	430899	445097	428835	399719	358547	333885	313210
2+	256163	277569	271980	281344	267870	286372	287044	292190	289711	309716	319916	262772	253405	229333
3+	164666	192159	195723	196046	198277	182139	172335	181963	178415	184078	222699	198841	175795	164171
4+	96407	117372	125795	133612	128650	129546	104446	101256	102616	103022	122474	128320	128573	105621
5+	58007	64063	66820	82685	80609	77333	74058	57010	51267	52793	61000	58465	75770	73156

	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	68880	73773	102651	126014	100071	68285	77345	95693	100719
2	67370	55052	59636	83174	102203	81491	55905	63165	78346
3	44632	44331	38425	43816	62713	81221	66704	45633	51683
4	39833	27074	25120	22044	30324	49111	66217	53706	35962
5	18949	21232	15837	12027	14651	21652	39277	50921	38514
6	17067	7098	8850	6649	5847	7700	16329	27993	33483
7	11167	6148	2411	4788	3155	2641	5521	11171	18497
8	5167	6064	2370	1129	1582	1310	1712	3828	8085
9	1049	2511	1664	765	382	750	874	1210	2794
10	969	538	1016	991	186	149	498	615	921
11	229	441	197	501	227	108	90	336	482
12	34	117	97	148	273	166	49	51	266
13	108	26	93	75	11	128	87	16	37
14	6	55	15	76	29	8	95	48	9
15	47	5	41	13	54	20	4	70	38
16	3	38	0	33	2	44	15	0	57
1+	275510	244504	258423	302243	321713	314782	330723	354452	369895
2+	206630	170731	155772	176230	221642	246497	253378	258760	269175
3+	139260	115679	96136	93055	119439	165007	197473	195595	190829
4+	94628	71348	57711	49240	56726	83786	130769	149962	139146
5+	54795	44274	32591	27196	26401	34675	64551	96256	103184

Table 14. 4VSW COD MID-YEAR POPULATION NUMBERS   4/ 5/81

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	94550	84418	94426	77059	115781	128550	123197	124501	139986	107798	71574	86374	72551	75322	61708
2	82862	77411	69116	77198	60697	84767	96714	91941	95378	112453	83156	55156	67633	54251	55049
3	60476	66568	59926	54923	60503	40481	55226	64926	62140	70814	84128	61235	39384	48593	35124
4	33067	43886	50438	41360	38406	41394	23178	33947	39843	41628	46998	56639	40495	25104	29564
5	19533	21073	28976	34058	26805	21742	23101	12927	17574	22532	22661	26541	34019	23040	12069
6	14202	11538	11480	17607	20083	16627	11236	11211	6144	8208	10258	9594	15446	17106	10694
7	4343	7823	5507	6123	10400	10818	10001	5716	5107	2612	3087	4267	4570	8088	8357
8	3094	2136	3784	2408	2477	6296	5754	4548	2642	2310	1093	1076	2281	1961	3681
9	2769	1503	1057	1743	914	968	3760	2636	1706	1213	972	446	561	1311	765
10	1122	893	831	663	722	429	490	1790	1128	711	547	476	238	309	671
11	555	433	301	552	388	351	220	189	514	559	272	265	298	89	167
12	79	101	199	152	355	226	201	74	81	168	217	135	150	154	30
13	4	29	17	98	52	248	140	80	23	49	95	98	83	36	79
14	31	0	1	12	56	20	192	38	33	11	25	62	69	58	6
15	61	21	0	0	6	45	16	40	7	24	6	13	46	18	42
16	116	35	14	0	0	3	32	10	2	4	11	4	8	27	2
5+	45910	45584	52167	63417	62258	57773	55142	39258	34962	38401	39245	42974	57770	52196	36563
6+	26377	24511	23192	29358	35453	36031	32040	26331	17388	15869	16584	16433	23750	29156	24494

	1973	1974	1975	1976	1977	1978	1979	1980
1	66454	92571	113693	90463	61889	70016	86731	91287
2	46241	51320	72463	91310	73851	50596	57232	70947
3	33821	29480	36657	55635	73464	59971	40606	45888
4	20956	17777	18096	25745	44011	58235	45690	30076
5	14149	10587	8569	10805	18865	33317	41594	31376
6	4341	6612	4687	4034	6550	13587	22918	27277
7	3963	1689	2895	2099	2143	4623	9545	15308
8	3402	1419	689	1115	1077	1446	3284	6797
9	1653	1298	410	247	616	737	1059	2374
10	339	729	519	144	117	412	546	791
11	227	171	376	195	75	68	300	414
12	105	85	53	192	122	29	44	228
13	20	84	48	10	111	65	12	32
14	48	14	65	24	6	82	43	8
15	0	37	6	49	17	0	63	33
16	23	0	20	2	36	12	0	47
5+	28271	22727	18337	18915	29735	54379	79407	84687
6+	14122	12140	9768	8109	10870	21062	37813	53311

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Table 15.   4 VSW COD POPULATION BIOMASS   4/ 5/81

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	6051	5402	6043	4932	7433	8321	7955	8045	3108	2382	1596	1915	1610	839
2	25253	23573	21047	23542	19208	28768	31660	30422	16694	20102	14583	8950	11642	7168
3	38543	42230	39486	35255	39316	29697	38335	45573	34110	38096	43096	29619	21250	18736
4	36224	50288	55633	48041	45318	49255	28666	41738	46214	48221	53483	59377	48051	20777
5	33600	41399	52232	62671	48463	44186	47160	25218	37825	48016	49060	49342	67809	32386
6	37200	34585	31935	48647	55830	44848	31591	33376	20540	26929	34205	29265	42863	38766
7	16111	31575	21745	23760	36740	41597	35714	22950	22171	11681	15730	16511	18070	24963
8	15612	11826	19172	13879	15772	30008	28186	28492	14289	12924	6221	5204	10974	8719
9	18416	9400	5752	11435	6141	5473	20509	18126	10684	8252	6767	2680	3398	5543
10	9207	8845	5210	4345	5671	2883	3805	15431	8050	6602	4129	2757	1599	1519
11	5628	3968	2389	4114	3121	2711	1954	1865	5948	5149	2237	1963	2451	784
12	834	1991	1791	1499	2966	1899	1807	952	691	1584	2373	1150	1326	1004
13	388	360	148	1101	754	2154	1366	1116	244	492	872	796	710	583
14	327	0	122	122	490	177	1694	834	291	124	283	538	659	401
15	661	213	0	0	88	453	164	1564	73	271	61	122	445	345
16	1580	510	194	0	0	35	411	149	21	50	158	45	96	251
5+	139565	144672	140688	171573	176035	176423	174360	150073	120825	122074	122096	110374	150399	115264
6+	105965	103273	88456	108902	127572	132238	127200	124854	83001	74058	73036	61031	82590	82878
7+	68765	68688	56521	60255	71742	87390	95609	91479	62461	47129	38832	31766	39727	44112

	1972	1973	1974	1975	1976	1977	1978	1979	1980
1	3444	5902	13345	12601	10007	6828	15469	0	0
2	12127	12111	19680	22457	28617	22817	34661	33477	44657
3	19638	19949	23824	23222	35747	65789	63369	34681	41346
4	32265	21388	25622	19619	29111	53531	82772	56929	41356
5	24445	25691	24231	16117	21391	36159	65985	86565	61623
6	31574	12209	18850	12434	11869	18172	40332	66902	73997
7	27694	14017	6798	11827	8393	8372	19930	34964	56971
8	16223	17584	8485	3522	5300	5998	8953	14202	34845
9	4017	8891	7337	2915	1555	3103	4886	5770	14696
10	4378	2270	5366	4489	893	792	3260	4205	6375
11	1193	2163	1220	2643	1261	504	715	2675	3647
12	202	654	691	888	1719	816	455	475	2711
13	703	165	753	506	79	914	903	165	296
14	44	384	138	572	226	71	925	479	76
15	365	39	407	103	458	215	35	796	554
16	21	312	0	298	21	650	181	0	799
5+	110860	84380	74276	56314	53165	75766	146560	217199	256589
6+	86415	58689	50045	40198	31775	39607	80575	130634	194966
7+	54842	46480	31195	27763	19905	21436	40242	63732	120970

Table 16. 4 VSW COD FISHING MORTALITY   4/ 5/81

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
1	0.000	0.000	0.000	0.000	0.007	0.024	0.019	0.020	0.013	0.003	0.022	0.010	0.011	0.019	0.024	0.013	0.010
2	0.002	0.000	0.000	0.003	0.080	0.229	0.152	0.174	0.117	0.026	0.121	0.103	0.082	0.178	0.219	0.160	0.108
3	0.047	0.038	0.117	0.062	0.088	0.349	0.228	0.252	0.211	0.077	0.161	0.089	0.175	0.185	0.300	0.368	0.356
4	0.107	0.203	0.121	0.232	0.266	0.284	0.369	0.356	0.331	0.188	0.363	0.235	0.357	0.338	0.429	0.336	0.536
5	0.130	0.418	0.230	0.274	0.236	0.494	0.504	0.402	0.587	0.417	0.680	0.381	0.398	0.373	0.782	0.675	0.668
6	0.262	0.563	0.394	0.379	0.393	0.326	0.418	0.547	0.726	0.529	0.809	0.633	0.294	0.600	0.821	0.880	0.414
7	0.371	0.560	0.510	0.471	0.264	0.451	0.287	0.548	0.638	0.562	1.128	0.503	0.425	0.638	0.411	0.753	0.559
8	0.473	0.687	0.483	0.782	1.025	0.347	0.408	0.984	0.602	0.536	0.819	0.474	0.333	0.943	0.521	1.093	0.931
9	0.727	0.584	0.274	0.695	0.750	0.357	0.278	0.807	0.502	0.547	0.840	0.531	0.420	0.378	0.468	0.705	0.318
10	0.766	1.233	0.160	0.255	0.662	0.313	0.637	0.885	0.440	0.910	0.659	0.105	0.303	0.369	0.586	0.804	0.506
11	0.978	0.735	0.405	0.266	0.436	0.345	0.659	0.909	1.295	0.581	0.560	0.359	0.459	1.473	0.473	1.316	0.088
12	0.732	2.492	0.377	0.579	0.211	0.221	0.373	1.231	0.295	0.386	0.970	0.431	0.372	0.469	0.066	0.029	0.059
13	13.445	0.946	0.058	0.674	1.312	0.105	0.358	1.198	0.616	0.327	0.346	0.123	0.108	2.688	0.471	0.345	0.000
14	0.349	0.197	12.644	0.244	0.000	0.000	0.000	2.299	0.000	0.466	0.691	0.114	0.173	0.206	0.000	0.105	0.000
15	0.163	0.000	0.310	0.318	0.814	0.000	0.000	4.091	0.296	0.295	0.158	0.156	0.088	2.902	0.024	11.997	0.000
16	0.458	0.598	0.415	0.582	0.608	0.370	0.348	0.722	0.617	0.543	0.899	0.535	0.368	0.640	0.555	0.858	0.555
1+	1.188	0.578	1.031	0.364	0.447	0.263	0.315	0.964	0.455	0.400	0.577	0.299	0.273	0.775	0.384	1.277	0.319

	1975	1976	1977	1978	1979	1980
1	0.009	0.005	0.000	0.002	0.000	0.000
2	0.082	0.030	0.000	0.003	0.000	0.000
3	0.168	0.044	0.004	0.017	0.037	0.026
4	0.209	0.137	0.023	0.063	0.132	0.163
5	0.521	0.443	0.082	0.139	0.219	0.225
6	0.545	0.595	0.133	0.180	0.214	0.225
7	0.907	0.679	0.234	0.166	0.123	0.191
8	0.883	0.547	0.204	0.147	0.115	0.157
9	1.214	0.744	0.208	0.152	0.072	0.135
10	1.273	0.341	0.299	0.194	0.043	0.112
11	0.407	0.113	0.586	0.380	0.034	0.112
12	2.380	0.559	0.450	0.958	0.103	0.112
13	0.742	0.104	0.099	0.398	0.304	0.112
14	0.139	0.164	0.506	0.110	0.019	0.112
15	1.491	0.021	0.115	10.527	0.000	0.112
16	0.887	0.641	0.195	0.161	0.131	0.177
1+	0.741	0.323	0.196	0.850	0.097	0.123

Table 17. 4VsW Cod P.R. multipliers obtained by adjusting ages 3-4 and
predicting sizes of 1978-1979 year-class and older ages P.R., weights-
at-age and $F_{0.1}$ value.

AGE	P.R.	Weights-at-age
1	-	-
2	.008	.57
3	.19	.80
4	.725	1.15
5	1.0	1.60
6	1.0	2.21
7	.85	3.08
8	.70	4.31
9	.60	5.26
10	.50	6.92
11	.50	7.56
12	.50	10.19
13	.50	7.92
14	.50	8.13
15	.50	14.45
16	.50	14.03

$F_{0.1}$ = 0.234

Table 18.   4VsW cod projections results.

1981   TAC = 50,000

1982 $F_{0.1}$ = 0.234

Catch biomass (mt)

AGE	1981	1982
1	0	0
2	76	80
3	1845	2002
4	6956	8471
5	7296	9000
6	10203	6821
7	10674	8315
8	7141	8760
9	3413	5476
10	1337	2807
11	492	1108
12	348	504
13	149	205
14	21	116
15	10	29
16	38	7
Totals	50000	53700

FIGURE 1. 4VsW COD NOMINAL CATCHES SINCE 1958.
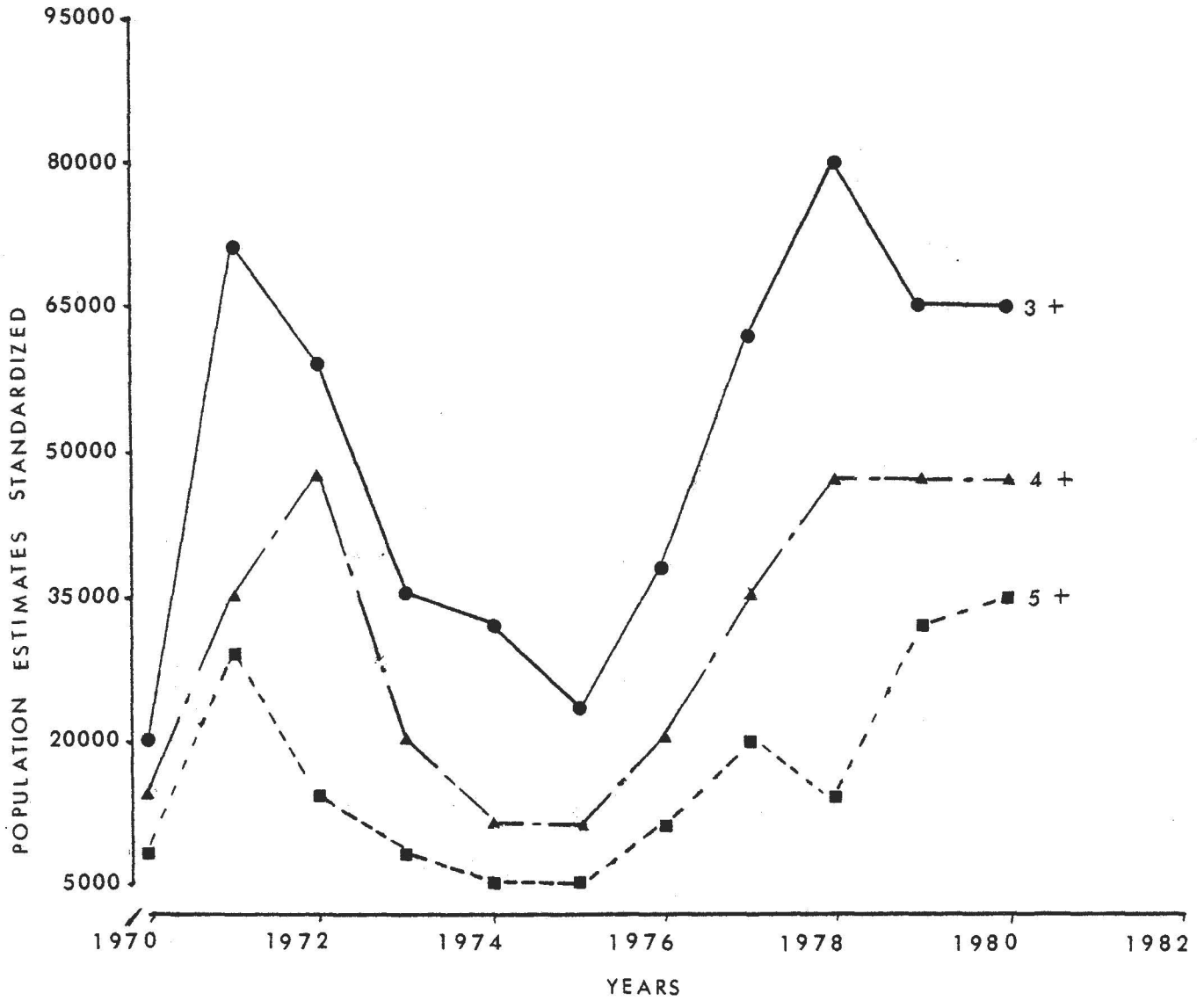
FIG. 2a. 4 VsW COD POPULATION ESTIMATES IN 4 Vs AND 4W COMBINED,
FROM R.V. SURVEYS (1973 VALUES CORRECTED).
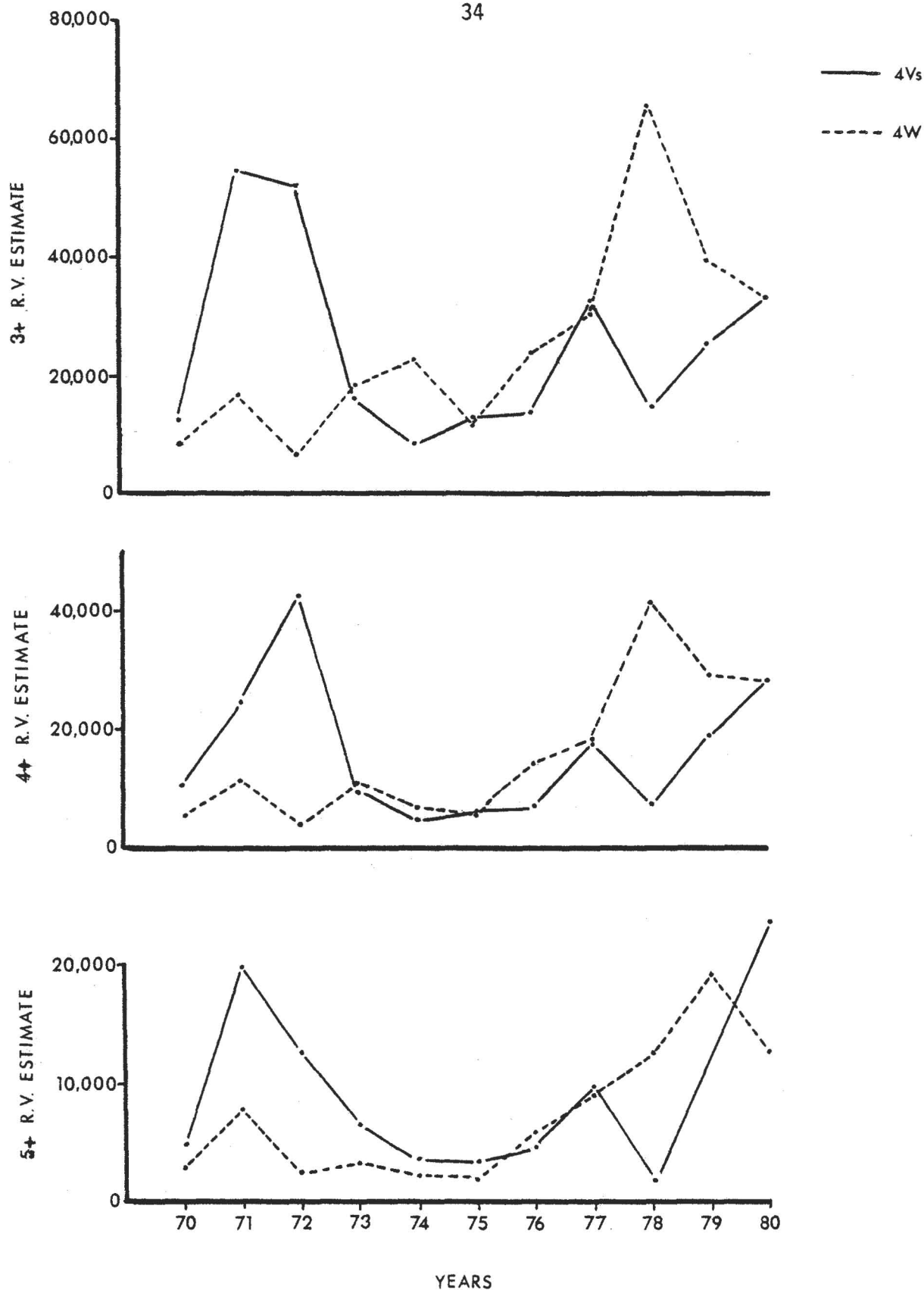
FIGURE 2b. 4VsW COD POPULATION ESTIMATES IN 4Vs & 4W SEPARATELY
FROM R.V. SURVEYS (1973 VALUES CORRECTED).
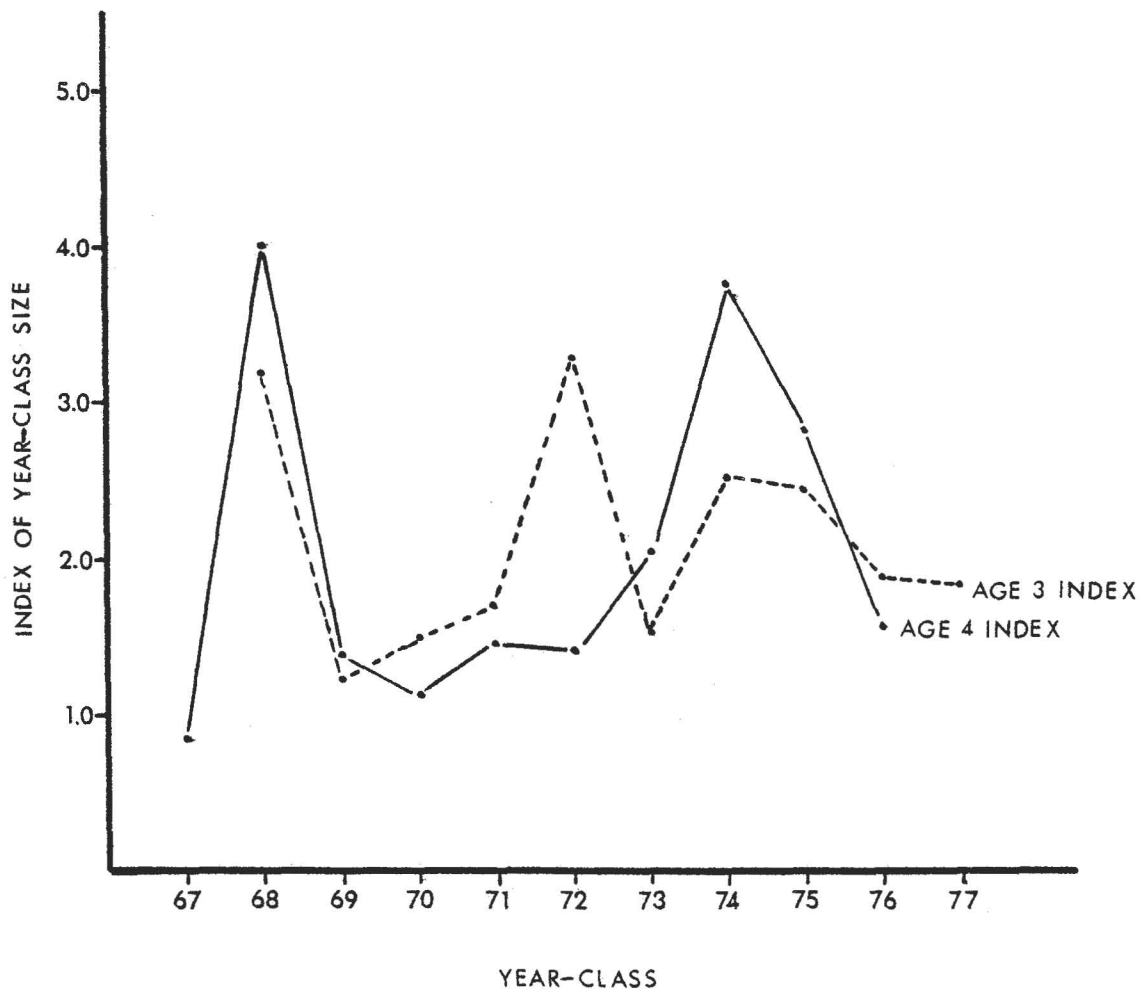
FIGURE 3.   RESEARCH VESSEL SURVEYS INDEX OF YEAR-CLASS SIZE.
(1973 VALUE CORRECTED.)
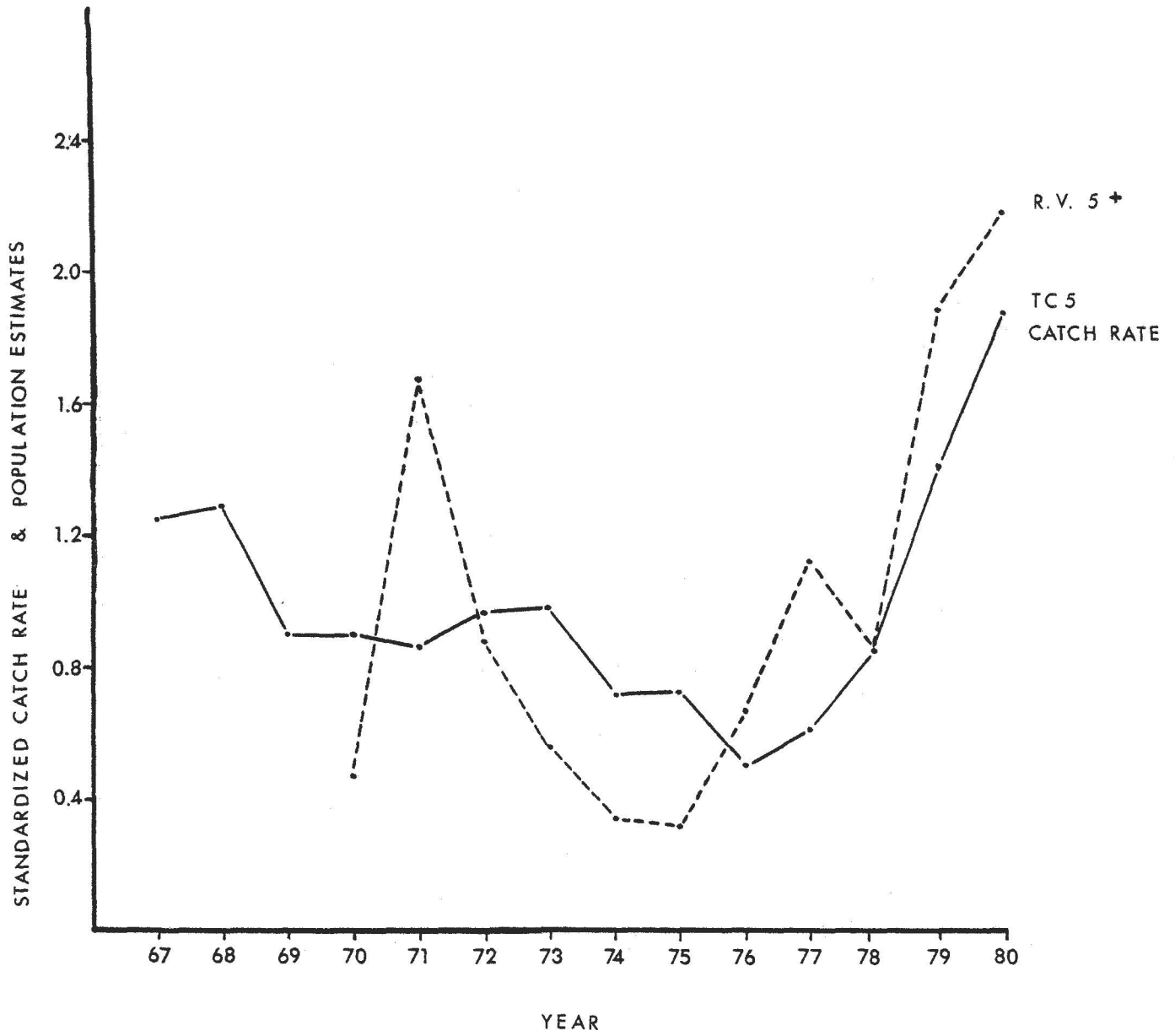
FIGURE 4. 4VsW COD CANADIAN TC 5 CATCH RATE & 5+ R.V. SURVEY POPULATION ESTIMATES. BOTH HAVE BEEN STANDARDIZED TO THEIR MEAN TO PUT THEM ON THE SAME SCALE.
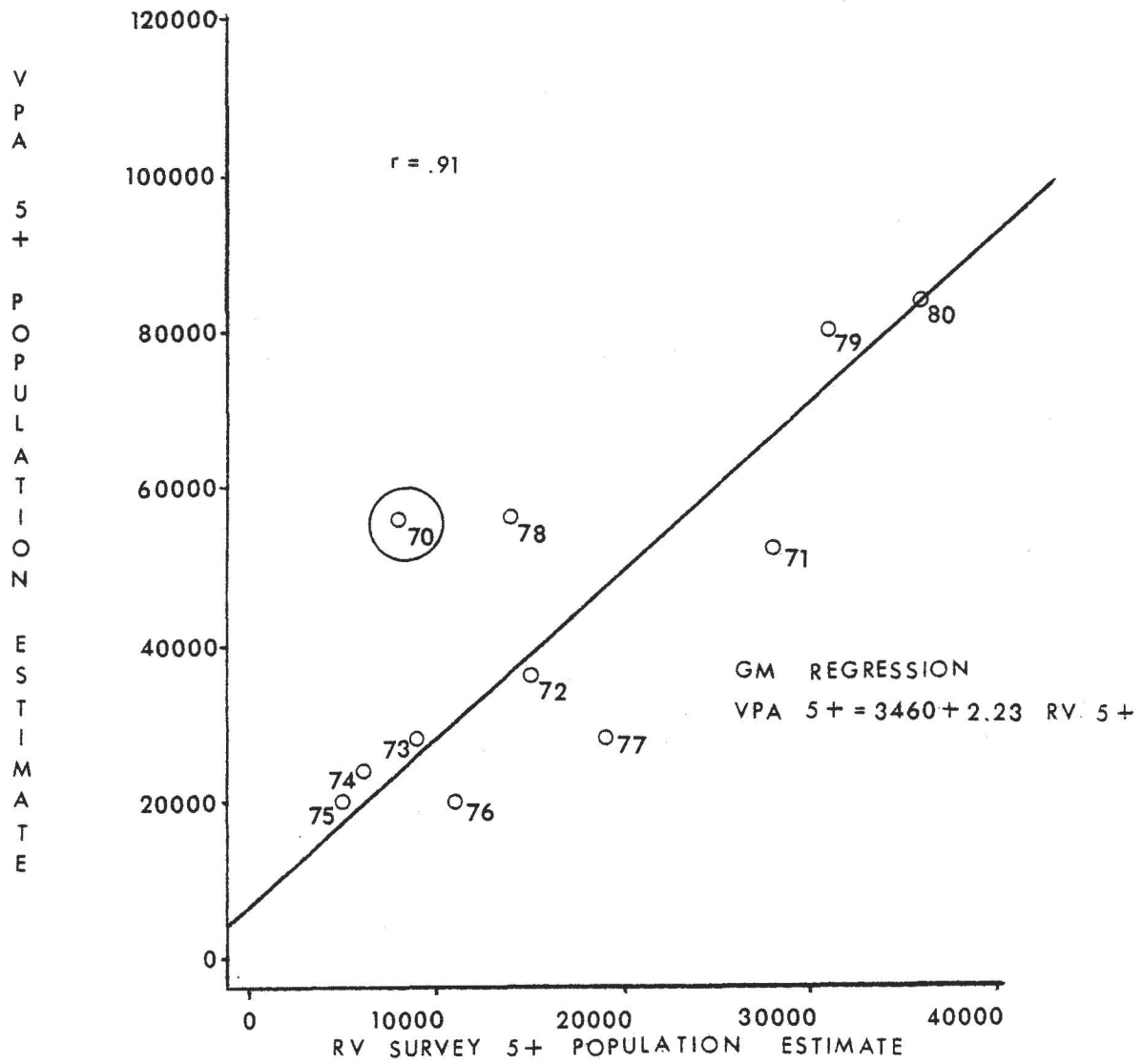
FIG. 5a.   VPA 5+ POPULATION ESTIMATE VS R.V. 5 + POPULATION
ESTIMATE FOR F_T = 0.225.
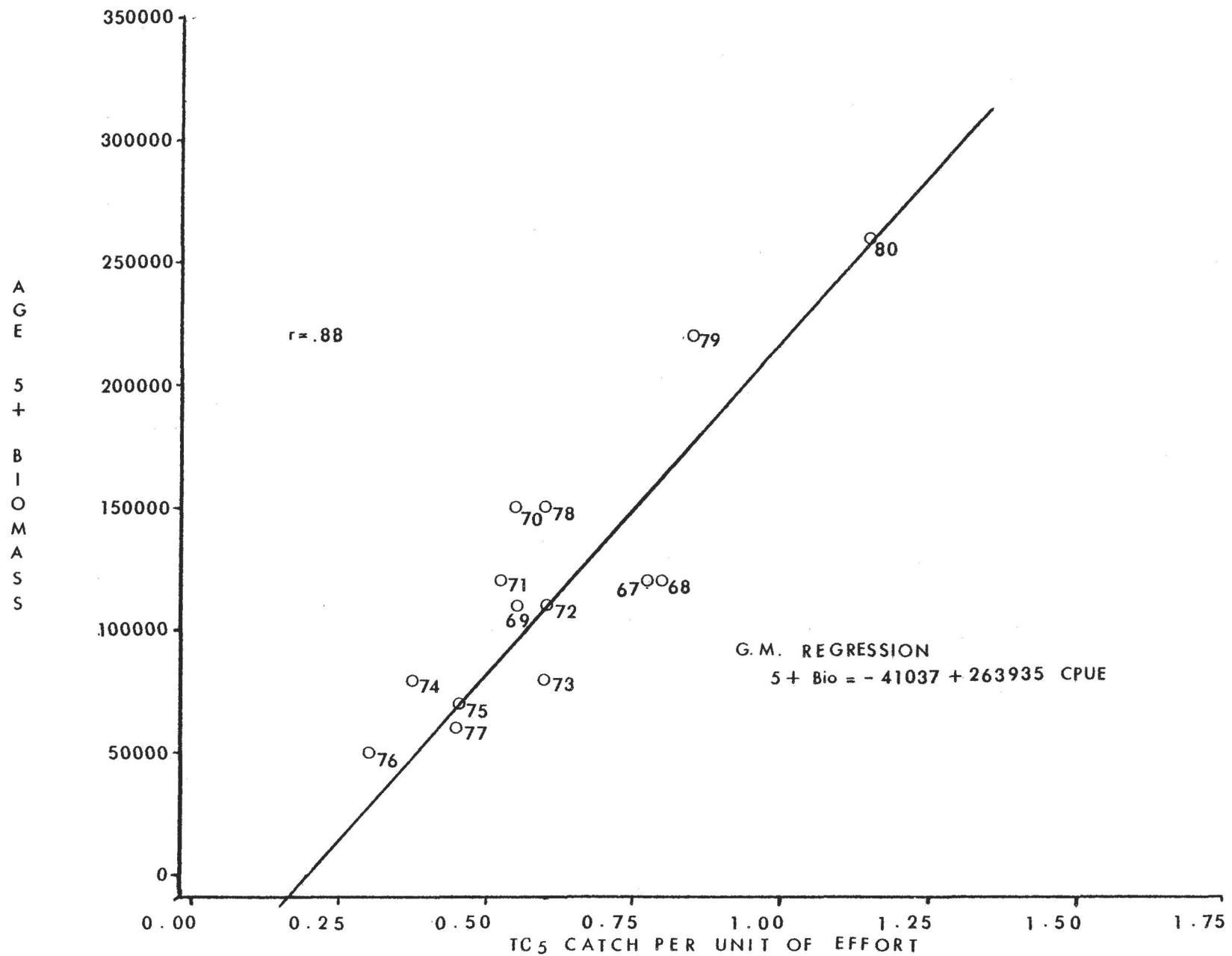
FIG. 5b. VPA 5+ BIOMASS VS TC5 C4E WITH $F_T = 0.225$.
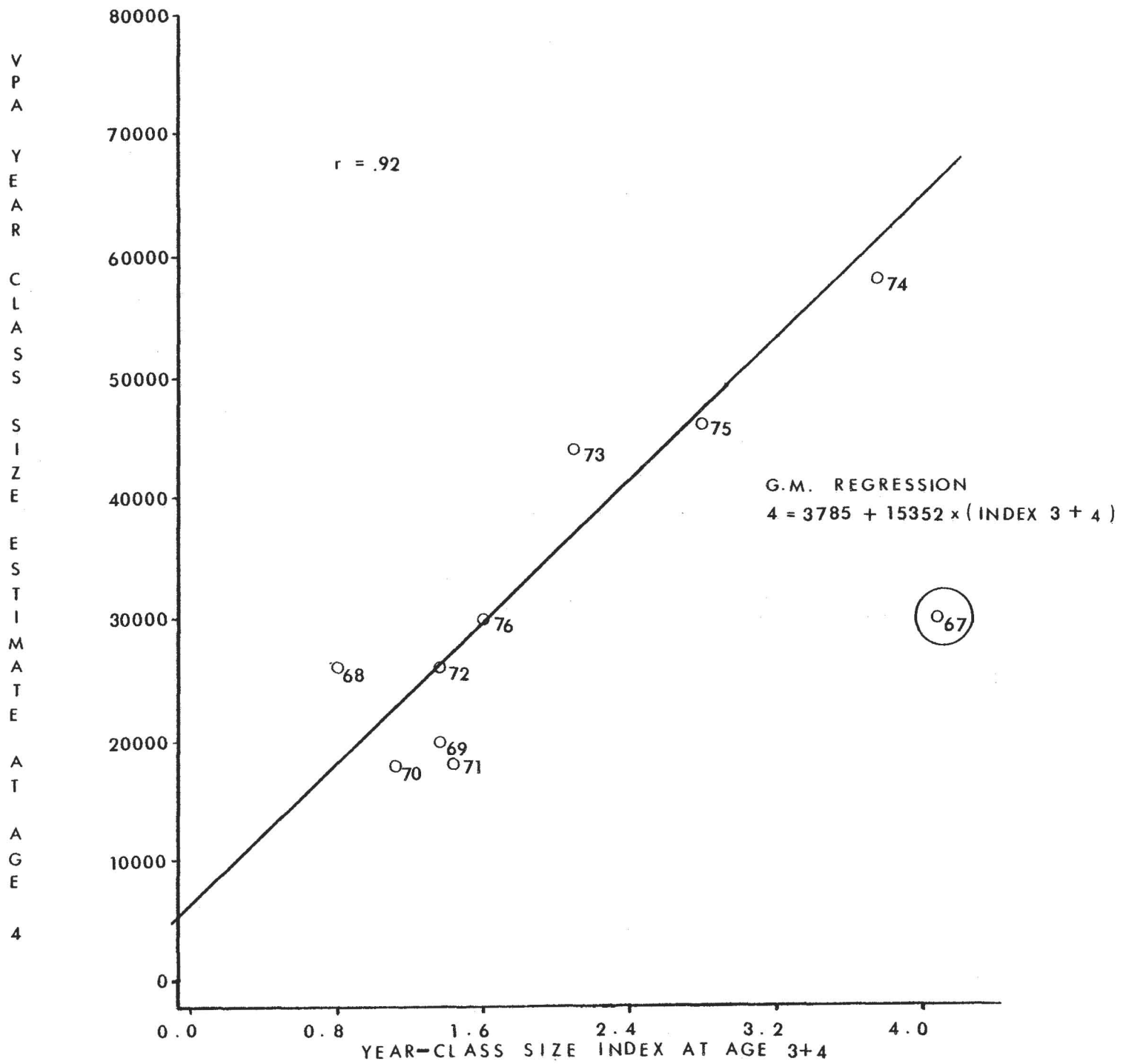
FIG. 6. 4 Vs W COD; VPA Y.C. AT AGE 4 VS INDEX OF Y.C. SIZE AT AGE 3 & 4
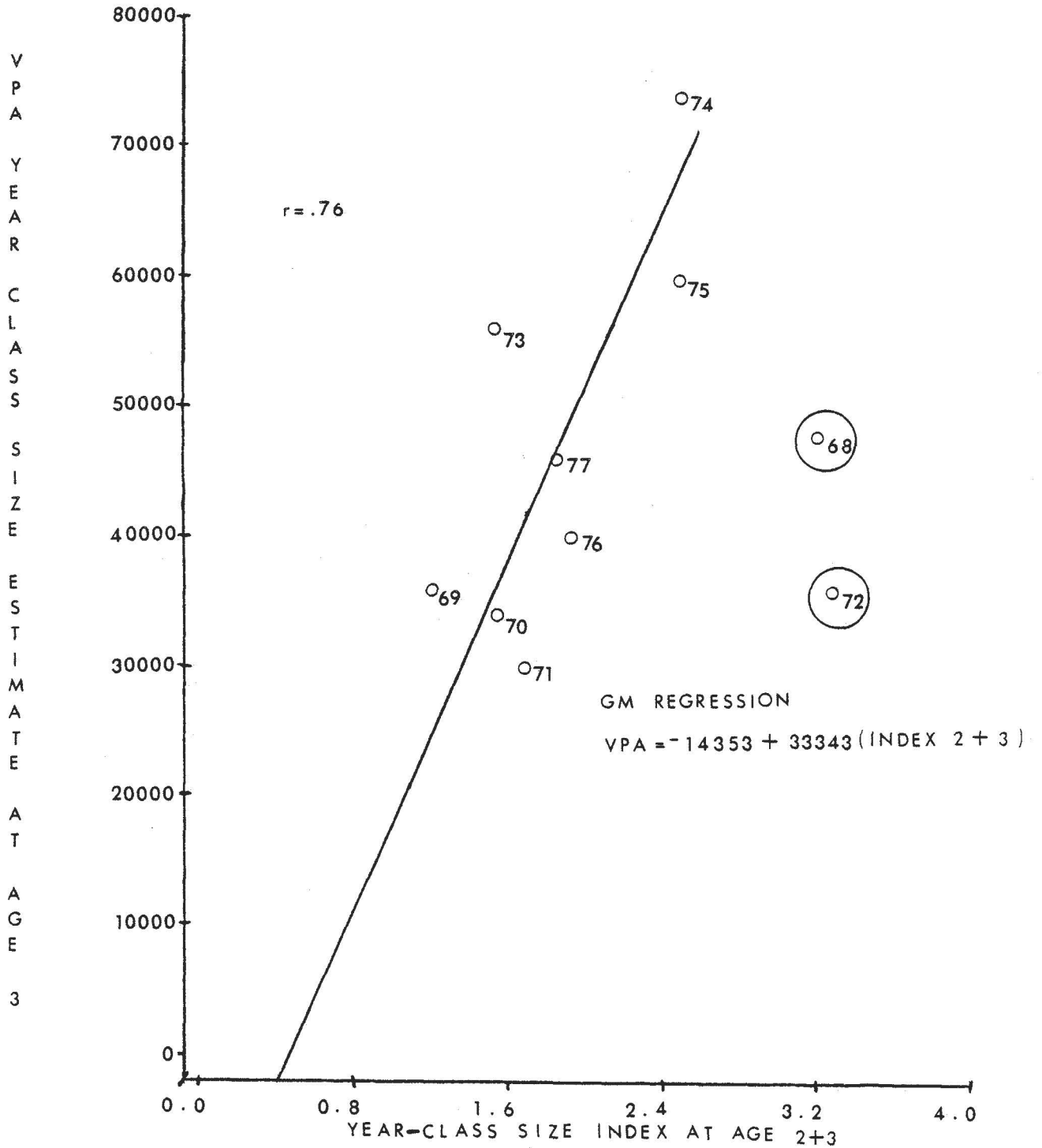
FIG. 7. 4VsW COD VPA Y.C. SIZE AT AGE 3 VS INDEX OF
Y.C. SIZE AT AGE 2 + 3.
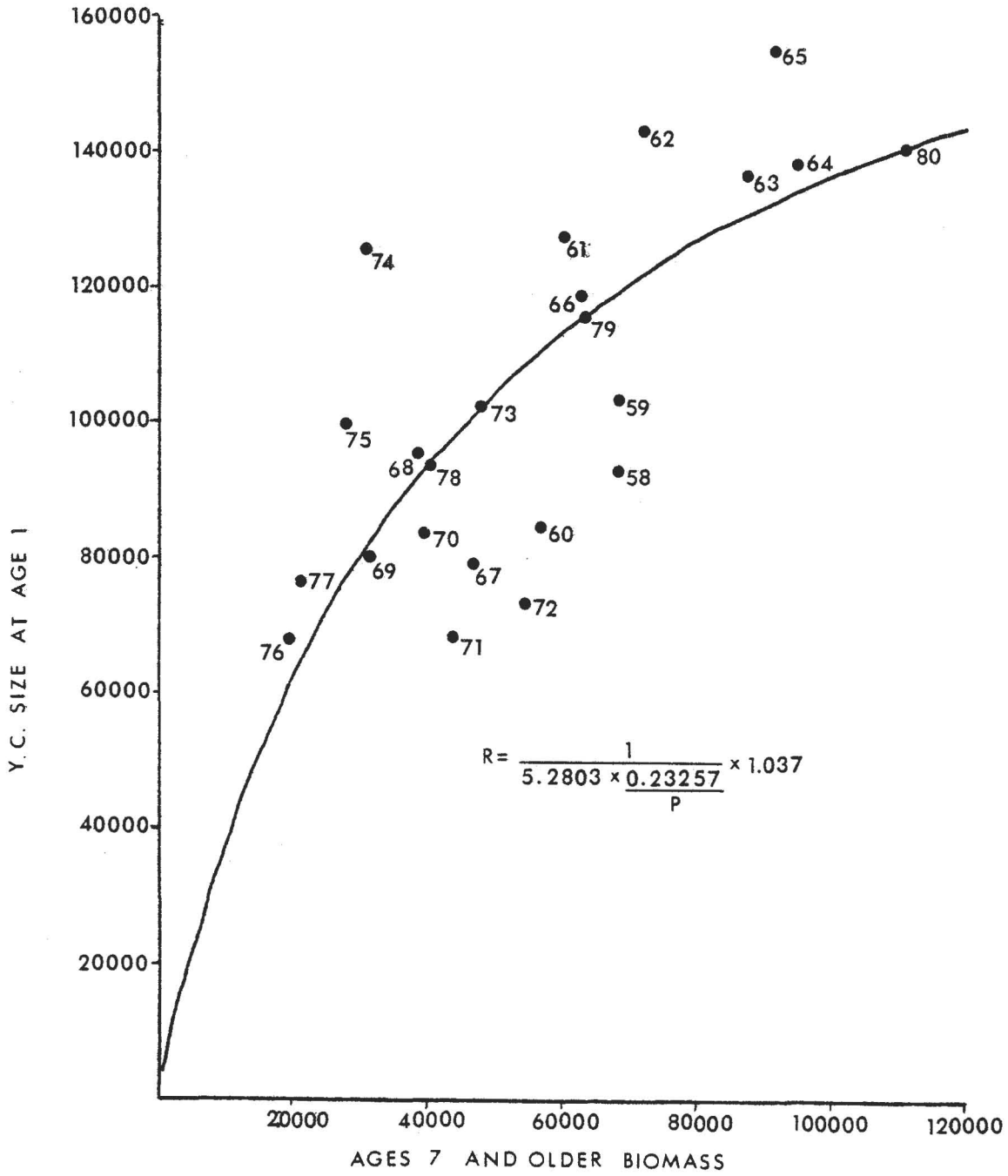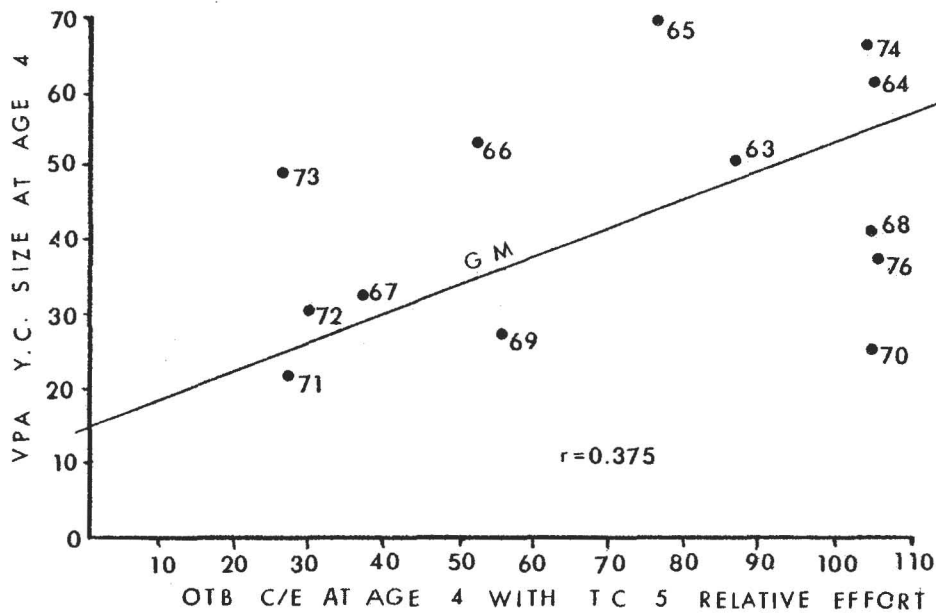
FIG. 8. 4 Vs W COD STOCK - RECRUITMENT RELATIONSHIP.
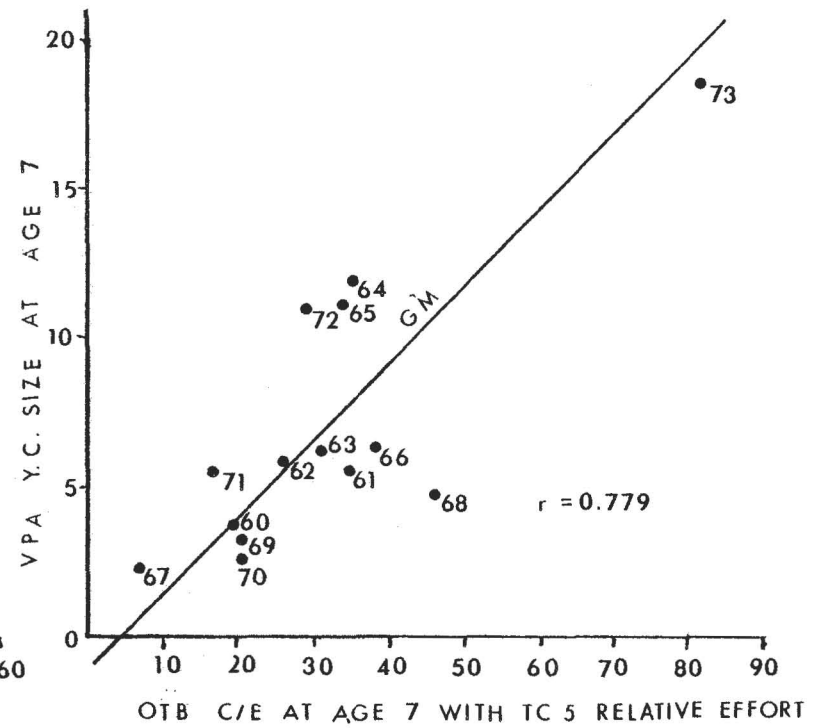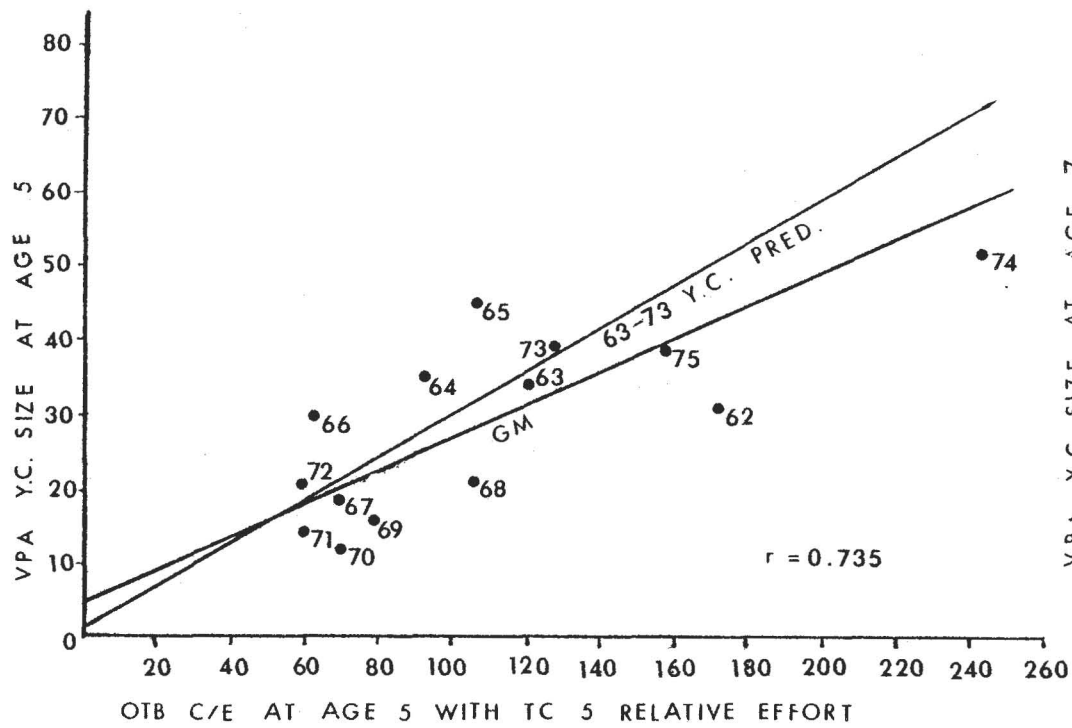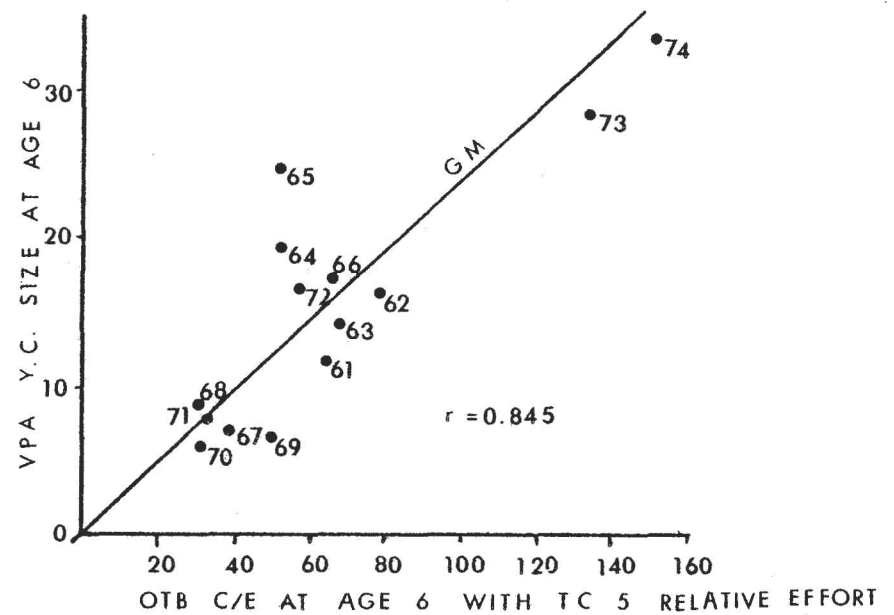
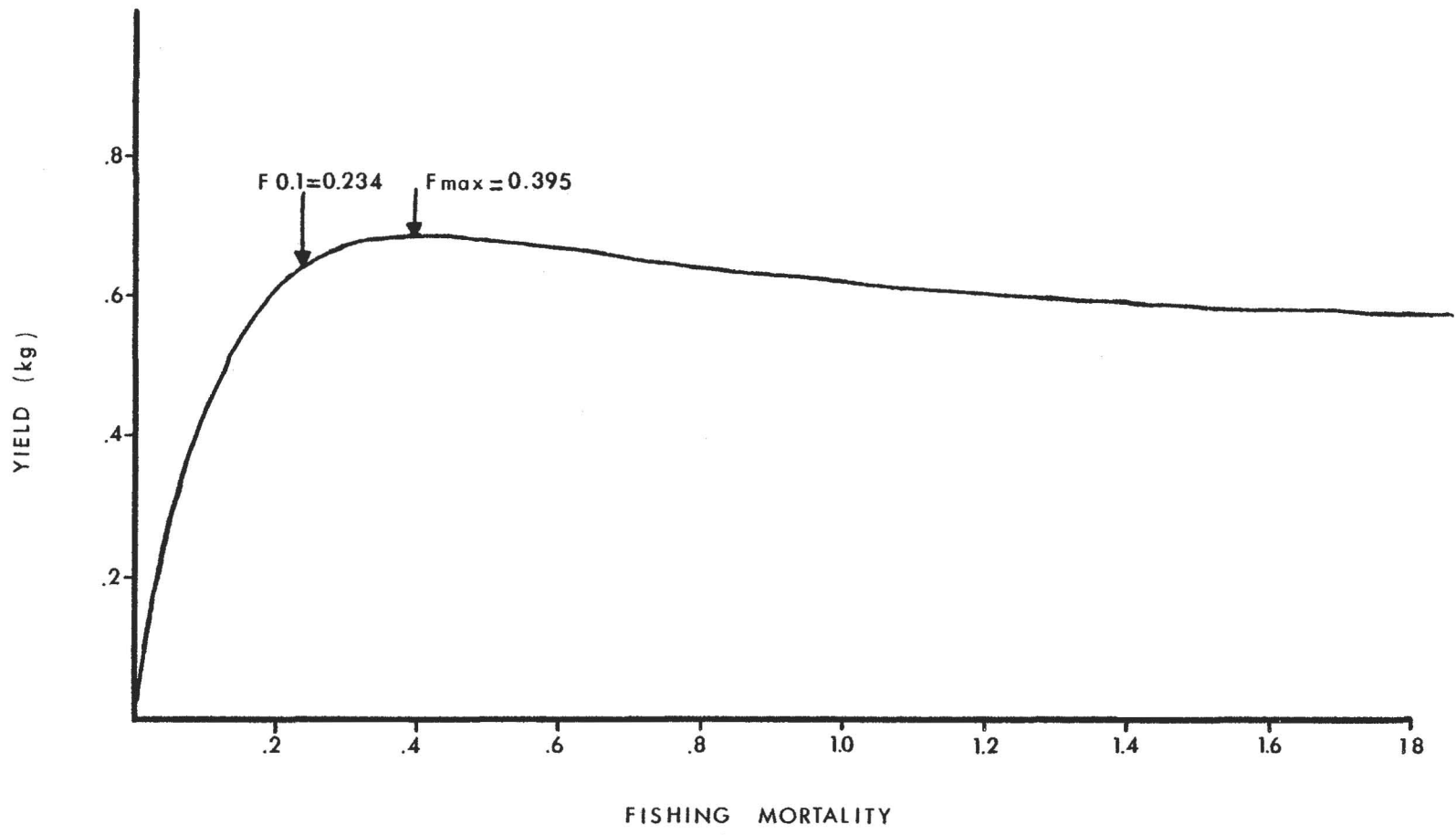FIGURE 9. 4VsW COD V.P.A. YEAR-CLASS SIZE AT AGE vs. C.P.U.E. AT AGE IN CANADIAN OTTER TRAWL FISHERY.

FIGURE 10.   4 VsW COD YIELD PER RECRUIT CURVE.