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Status of the 4VsW Cod Stock Complex

by

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Abstract

Provisional statistics reveal that the 1982 reported landings from the 4VsW cod stock complex were the same as in 1981 at 56,000 t. Almost 100% of this total was taken by Canadian vessels. Stock size indices indicate that the total biomass has stabilised over the last few years. The age composition data show that the fishery is supported by several year-classes and suggest that good recruitment can be expected for the next few years. The population size was estimated from Cohort analyses calibrated with standardised commercial catch and effort data. It is estimated that a fishing mortality of 0.25 was applied on the fully recruited ages in 1982 and that the total population biomass at the beginning of that year was near 400 thousand tons. The projected $F_{0.1}$ catch for 1984 assuming that the TAC of 64,000 t is taken in 1983 was calculated at 53,000 t.

Résumé

Les statistiques préliminaires révèlent que tout comme en 1981, les débarquements totaux provenant du complex de stocks de morue de 4VsW a atteint les 56,000 t en 1982. Les navires canadiens se sont accaparés près de 100% de ce total. Selon les indices d'abundance utilisés, la biomasse totale serait demeurée à peu près constante ces dernières années. Il appert que la pêche commerciale dépend actuellement d'un bon nombre de classes d'âge et que le recrutement à court terme sera supérieur à la moyenne. Nous avons estimé la taille de la population au moyen d'analyses de cohortes calibrées à l'aide de données normalisées de prises commerciales par unité d'effort. Les résultats indiquent que le taux de mortalité par pêche souffert par les classes d'âge pleinement recrutées fut de 0.25 en 1982 et que la biomasse totale en début d'année approchait les 400 milles tonnes. Si le TPA de 64,000 t est atteint en 1983, les prises totales au niveau $F_{0.1}$ sont estimées à 53,000 t pour 1984.

The 4VsW cod stock complex represents the major cod management unit on the Scotian Shelf. It was heavily exploited in the early 1970's, mainly by foreign fleets. High exploitation rates and especially high mortality of young fish due to the small mesh gear used, brought the complex to a critical low level in the mid-1970s. Stringent regulations were imposed in 1977 to correct this situation. The complex has since recovered and landings are now over 55,000 t again. We present an analytical assessment of the current status of that complex.

Nominal Catch

Preliminary figures indicate that the total nominal catch in 1982 was the same as in 1981 at 55,800 t (Table 1). These are the highest catches from the stock complex since 1972 and Canada's total (55,675 t) was the highest ever.

The TAC for 1982, initially set at 50,000 t, was increased to 55,600 t in September. This came at a time when the "fixed gear less than 65'" component of the fishery had already exceeded its initial quota. At year end, the same component had overrun its final quota by 1,000 t. However, the catch reported for the other components was generally close to the permitted level, bringing the total nominal cach for 1982 to within 200 t of the final TAC. This is the closest match between catch and TAC ever.

The Canadian portion of the total catch has increased from 39% in 1976 to nearly 100% in 1982. Since 1978, the Canadian otter trawlers have, on the average, taken 70% of the total catch (Table 2). The remainder is divided among the foreign otter trawler fleet and Canadian longliners,

Danish and Scottish seiners and pair seiners.

The catch in 4W exceeded that in 4Vs from 1969 to 1979, except for 1972 (Table 1). Since 1980 however, the trend has been reversed resulting in 72% of the 1982 catch coming from 4Vs. The catch in 4Vs has been continuously increasing since 1977 while that in 4W has fluctuated around 20,000 t. Tables 3 and 4 present the breakdown of the catch by unit area for otter trawlers (T.C. 2-6) longliners (T.C. 2-4) and seiners. A map of the unit areas in 4VsW is shown in Figure 1. Table 3 indicates that the increase in the 4Vs catch results from higher catches being taken by all the major gears in that Division, especially in unit area 4VSc. The recent cod catches in 4Vs are not only higher than those prior to 1980, but also make up a higher proportion of the total catch by each one of the major gears in 4VsW. The most noticeable increase in catch in the 4Vs unit areas was experienced by the longliners. In the years prior to 1980, over 80% of their catch came from 4W. Since 1980, 52, 54, and 76% of their annual catch was taken in 4Vs. These vessels are now steaming much longer distances to the fishing grounds in unit area 4VSc.

Age Composition of Reported Landings

Sampling of the 4VsW cod stock complex was again quite extensive in 1982 and good coverage of the major sectors of the fleet was achieved (Table 5). A total of 73 samples were processed in time for the May meeting of the CAFSAC Groundfish Subcommittee. Of these, the only handline sample as well as seven other samples from which less than 20 otoliths had been read were not included in our analysis. The 1981 catches at age were also updated using the additional samples processed after the May 1982

Subcommittee meeting.

To generate age-length keys, the coefficients a and b of the equation describing the weight-length relationship for the stock complex must be provided. These coefficients are estimated from the results of the summer groundfish research surveys and are available either for 4Vs and 4W separately or for 4VsW combined. All the 1982 and seven of the 1981 keys were calculated from some combination of samples of catches taken in 4Vs and/or 4W. For these keys, the coefficients for the combined areas were used (Table 6). The four remaining keys for 1981 were calculated with the 4W parameters since they were associated only with 4W catches. These keys were used to determine the age composition of 98 and 99% of the non-USSR catch for 1981 and 1982 respectively. The resulting values were bumped up to 100%.

The cod catches at age in the USSR silver hake fishery were calculated as in Maguire et al. (MS 1982) from length frequencies collected by the International Observer Program and age-length keys from the summer research surveys in 4W. We recalculated the 1980 and 1981 values using the most recent catch statistics available (Table 7). The USSR catches at age were then added to the others to obtain the final matrix presented in Table 8.

The weights at age, shown in Table 9, were calculated without the data from the USSR catches. The age composition of the commercial catch in weight is presented in Table 10.

As in 1981, the 1977 year-class was the most important in the catch, representing 36% of the total in number. Its contribution in weight went from 20% in 1981 (second) to 28% in 1982 (first). In both years, the 1975 to 1978 year-classes together accounted for over 80% of the catch in number

while the ages 4 to 8 provided more than 80% of the catch biomass.

Stock Size Indices

Groundfish Research Surveys

From 1970 to 1981 the groundfish research surveys on the Scotian Shelf were conducted by the A.T. Cameron using a Yankee 36 bottom trawl with a 0.6 cm liner over the codend. In 1982, the Cameron was replaced by the Lady Hammond fishing with a newer Western IIA trawl equipped with a 1.9 cm codend liner. Comparative fishing experiments were carried out with the two vessels between 1979 and 1981. A preliminary analysis of the results (Koeller and Smith MS in prep.) was presented at the May meeting of the CAFSAC Groundfish Subcommittee. The indications were that the catch ratio (Hammond:Cameron) for cod was generally close to one which suggested that the Hammond data needed not to be adjusted to produce a consistent time series.

We compare in Figure 2 the catches at age of cod in 4VsW by both vessels. Although two of the four graphs show higher catches of younger cod by the Lady Hammond, no consistent trend emerges. The results of a much more detailed analysis are required before it can be established if and how the two data sets can be properly merged together. Since such results are not available yet, and in agreement with the indications from the preliminary analysis of Koeller and Smith (MS in prep.), we did not apply any correction factor to the survey data analysed here. We used the A.T. Cameron data for the period 1970 to 1981 and the Lady Hammond data for 1982.

We show in Table 11 the average number of fish caught per set in each

stratum of 4Vs and 4W. Two sets in 1973, one in stratum 58 and one in 59, and one set in 1982 in stratum 55 caught unusually large amounts of cod. These very high catches resulted in a dramatic increase in the estimated 4W population size in both years (Table 12). Because these estimates are unrealistically high when compared to the other years, the data must be adjusted. One way of doing it is to remove the unusually high catches from the calculations (Tables 13 and 14). However, to take out these high numbers is to ignore that very high concentrations of fish were actually present in the survey area. It is therefore more appropriate to winsorise these high values i.e. to replace them with the next highest catch within the same stratum. Doing this resulted in a marginal increase in the population estimate for 1973 but in an important one for 1982 (Tables 13 and 14). The data sets with the winsorised values are used in the following analysis.

The survey biomass estimate (Figure 3) increased from 37,000 t in 1975 to 115,000 t in 1978. It has since remained fairly stable around 110,000 t. Between 1973 and 1977, the cod biomasses in 4Vs and 4W were similar. The large difference observed in 1978 is likely to result from some undetermined sampling problems because it is inconsistent with either the preceeding or the following trends. Since 1980, the biomass has remained higher in 4Vs than in 4W which is in agreement with the recent distribution of the commercial catch locations.

Figure 4 suggests that the number of young fish has been increasing recently while the abundance of age 3 fish and older has remained fairly stable. Although the introduction in 1982 of a new survey vessel fishing with a different trawl complicates the analysis, it appears that good year-

classes are presently recruiting to the 4VsW cod stock complex. Indeed, Tables 14c and 15 indicate that the 1978, 1979, and especially the 1980 year-classes are at least average if not strong year-classes.

Commercial Catch Per Unit of Effort

The multiplicative catch rate standardisation model (Gavaris, 1980) was used to generate a commercial catch rate series. Data from Spanish pair trawlers, T.C. 4 and 5, Canadian (Maritime based) longliners, T.C. 2-4 (combined), side otter trawlers T.C. 4, and stern otter trawlers T.C. 5 were used for the years 1968 to 1982. Semi-annual values of total catch and total effort were entered as observations. The data for Spanish vessels were the same as used by Maguire et al. (MS 1982) which were taken from NAFO Statistical Bulletins. The Canadian data were obtained from summary files produced by the Marine Fish Division from Canadian landings statistics tapes. The Canadian stern trawlers T.C. 5 in 1968 were used as the reference.

The resulting standardised catch rate is presented in Figure 5. We compare it to the original commercial catch rates used as input to the multiplicative model in Figure 6. The general trends followed by the individual catch rates are well reflected by our standard which therefore appears to be a good index of the commercial fleet fortunes over that period of time. From 0.8 $t.h^{-1}$ in 1969, the standard dropped to 0.5 $t.h^{-1}$ in 1975 and 1976 (Figure 5). It then increased rapidly to reach a maximum of 1.3 $t.h^{-1}$ in 1979. It has since remained quite stable around 1.1 $t.h^{-1}$. In Figure 7 we compare our standardised catch rate to that of Maguire et al. (MS 1982). The two series are in close agreement except between 1980 and 1981 when the new series shows a decrease rather

than an increase. There are two major causes responsible for the observed differences; an error in the catch statistics generated by the Marine Fish Division was detected and corrected in 1983 (Branton and Charlton 1983 unpubl. manuscript). The Canadian statistics that we used were therefore different than those available to Maguire et al. (MS 1982). The second reason is that we used semi-annual observations rather than monthly ones as did Maguire et al.. These differences also explain why unlike last year's standardised catch rate, the new one does not closely parallel the annual variations followed by the research survey biomass estimates (Figure 8).

Estimation of Stock Size

We followed as closely as possible the procedure of Maguire et al. (MS 1982) to estimate the size of the 4VsW cod stock complex. However, we used fishable biomass as a calibration variable rather than total population biomass as the former is more directly related to commercial catch rates.

Terminal F

Initial Cohort runs (Pope 1972) were carried out with a variety of terminal F values ranging from 0.150 to 0.350 in 0.025 increments and using the partial recruitment vector determined by Maguire et al. (MS 1982). Starting F for the oldest age (age 16) was set at 0.250 and iterations were continued until the difference between F at age 16 and the average F for the fully recruited ages 7 to 10 was 0.001 or less. Beginning-of-year fishable biomass and mid-year population numbers were then calculated and used to calibrate the Cohort estimates against the standardised commercial catch rate and the summer research survey population estimate respectively. The partial-recruitment matrix required to calculate the fishable biomass

was obtained as follows: the F matrix was divided by the weighted-mean of the F values for ages 5 to 16. All numbers greater than 1.0 in the resulting array were replaced by 1.0.

We summarise in Table 16 the results of the regression analyses between the fishable biomass estimates and the standardised commercial catch rate. The criteria used to select the best relationship were the coefficient of determination, the intercept and the ratio between the predicted and the Cohort values for 1981 and 1982. F values between 0.150 and 0.225 yield the highest r^2 values but the associated intercepts are very different from zero. The intercept closest to zero is obtained at F = 0.250 and the differences between the predicted and the Cohort values are also smaller at that F level than at the lower ones. These differences keep decreasing as the value of F increases but at the same time, r^2 also decreases and the intercept becomes increasingly larger than zero. It therefore appears that the best relationship between fishable biomass and the standardised commercial catch rate is obtained with a terminal F value of 0.250 (Figure 9).

A similar calibration procedure was attempted between the mid-year 5+ Cohort numbers and the summer survey 5+ population estimates. It suggested higher terminal F values around 0.300 or 0.325 but the relationships obtained were not as good and harder to discriminate among than those with the commercial catch rate. Because of these differences and of the uncertainty around the 1982 survey estimate, it was decided not to use the survey data to calibrate the Cohort analysis. The results of these runs are nevertheless presented in Appendix 1 for reference purposes.

Partial Recruitment

A) AGE 4

Using the new results of the commercial catch rate standardisation, we recalculated the index of year-class size developed by Maguire et al. (MS 1982) by dividing the removals at age (Table 8) by the effort index of Figure 5. Cohort runs were carried out with F_t = 0.250 and $F_{4,82}$ (fishing mortality at age 4 in 1982) at 0.100, 0.150, and 0.200. The numbers at age 4 were then calibrated against the index of year-class size. The intercepts could not be used to discriminate between the three relationships as they were all similar and positive. We decided to replace that criterion by a plot against time of the Cohort numbers and the year-class index, each series being divided by the mean of its first 11 observations. The results of these calibration runs are presented in Table 17 and Figure 10. The r^2 value and the proximity of the 1982 point to the predicted line indicate that $F_{4,82}$ = 0.150 and 0.200 give a better relationship than $F_{4,82}$ = 0.100. The plots of the scaled variables show that a better parallelism is achieved for the period 1980 to 1982 if $F_{4,82}$ = 0.150. With F_t = 0.250 a partial recruitment value at age 4 of 0.600 is required to produce $F_{4,82}$ = 0.150. Since 0.600 is very close to the value of 0.556 used by Maguire et al. (MS 1982), 0.556 was kept for the current assessment.

B) AGES 1 TO 3

We could not determine a proper index of year-class size for ages 1 to 3. The partial recruitment of these ages was therefore adjusted to produce year-class sizes at age 1 approximately equal to the long term geometric mean, 108 million fish. The final partial recruitment vector is shown on Table 18. Tables 19 to 21 present the population number, the fishing mortality and the population biomass matrices resulting from this

analysis.

Yield-Per-Recruit Analysis and Catch Projections

The new partial recruitment vector and the 1982 commercial weights at age (Table 22) were used to perform a Thompson-Bell yield-per-recruit analysis. The results indicate that maximum yield per recruit would result if F = 0.27 and that $F_{0.1}$ equals 0.16 (Table 23).

In agreement with the current trends in cod stock assessments for the Northwest Atlantic however, a value of $F_{0.1}$ = 0.2 was used to project the catch levels for 1984. Assuming, as did Maguire et al. (MS 1982), an incoming year-class size at age 1 of 100 million fish, slightly below the long term geometric mean of 108 million, and that the 1983 TAC of 64,000 t will be caught, the projected $F_{0.1}$ catch for 1984 is 53,000 t (Table 24).

Discussion and Conclusion

The recovery of the 4VsW cod stock complex initiated in the mid-1970s now appears to be finished; the research survey biomass estimate (Figure 3) and the standardised commercial catch rate (Figure 5) indicate a fairly stable situation for the last few years. The complex looks healthy with several year-classes supporting the fishery (Tables 8 and 10) and good recruitment prospects (Tables 14 and 15). Why then a reduction in the proposed $F_{0.1}$ catch from 64,000 t in 1983 to 53,000 t 1984?

Prior to the present assessment, an error was detected in the catch statistics used to generate the catch rate required to calibrate the Cohort population estimates. The corrected catch rate shows a decrease as opposed

to an increase between 1980 and 1981 (Figure 7). As a result of this error, fishing mortality on the fully recruited ages in 1981 was underestimated by the previous assessment. The required correction accounts for most of the 11,000 t difference. The remainder is due to lower weights at age in 1982 than in 1981.

The projected $F_{0.1}$ catch of 53,000 t is based on the assumption that the 1979 and 1980 year-classes are of average size. The limited information currently available however, suggests that these year-classes may be better than average. If that were the case, a substantially higher yield could be harvested from the stock complex. Total annual catches in the order of 60,000 t can therefore be anticipated for a good part of the 1980s.

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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	-	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[2]	55180	-	-	-	630	35	55845	34590	21255	50000
1982[2]	55675	-	-	-	45	34	55754	40112[3]	15642	55600

[1] By-catch only

[2] Final Maritimes, preliminary Newfoundland

[3] Canada only

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

Year	Division 4VS Trawls	Division 4VS Other Gear	Division 4W Trawls	Division 4W Other Gear	Totals Trawls	Totals Other Gear	Totals[4]
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	30668	3922	8792	11798	39460	15720	55180
1982[3]	32274	7838	6352	9211	38626	17049	55675

[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. Percent catch distribution of cod by year and area for different gears in 4VsW.

a) Otter trawlers

UNIT AREA	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
4WK	0.5	0.5	0.0	0.0	0.0	1.6	0.2	0.9	0.3	2.5	0.8	0.3	0.7	2.3	0.3
4WD	0.9	1.3	1.5	6.5	8.9	14.0	3.0	35.5	12.1	23.2	2.9	3.2	1.3	0.7	0.4
4WE	4.3	3.6	4.7	15.3	13.9	16.3	11.0	19.4	5.1	6.1	28.7	38.2	7.3	11.3	10.8
4WH	12.8	5.2	6.6	9.7	5.1	7.0	3.5	1.8	0.6	6.9	2.6	2.3	4.5	3.0	1.2
4WL	13.0	17.2	16.2	4.8	0.9	1.3	1.4	0.7	0.5	2.1	1.3	0.3	0.6	1.1	1.1
4WJ	3.0	2.2	5.1	1.1	0.5	0.1	0.0	0.0	0.0	1.0	2.6	0.1	3.3	3.2	2.0
4WF	0.1	0.7	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.2	0.1	3.0	1.1	1.9	1.7
4WG	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.1	0.3	0.6	0.7	1.3	1.7	1.0
4VB	0.8	0.0	4.5	3.6	10.2	6.7	11.8	6.9	21.5	23.6	4.6	2.6	10.9	4.2	10.5
4VC	64.7	69.2	61.4	58.9	59.2	53.0	69.0	34.6	59.9	34.2	55.6	49.3	69.1	70.6	71.0
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

b) Longliners

UNIT AREA	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
4WK	3.2	11.6	0.3	0.9	8.2	8.3	1.9	2.3	3.2	1.7	3.1	1.4	1.5	7.2	1.0
4WD	12.0	5.3	7.8	36.7	26.6	13.8	7.4	1.8	2.1	12.3	7.2	1.1	3.2	0.8	0.7
4WE	0.1	0.0	0.0	10.1	7.2	8.1	7.2	5.4	16.9	18.1	15.5	9.0	6.3	4.6	1.5
4WH	48.9	69.0	81.9	34.0	35.3	44.3	59.4	24.0	18.1	10.5	16.3	7.0	9.4	6.8	5.5
4WL	30.4	5.9	4.2	4.9	1.7	7.2	7.6	29.2	31.0	18.4	20.0	50.1	8.4	6.3	5.5
4WJ	1.4	0.1	2.6	0.0	0.0	3.4	8.8	28.5	21.5	32.9	17.2	16.1	18.0	9.0	5.9
4WF	0.0	5.0	1.0	6.3	4.2	0.7	0.0	0.0	1.2	2.0	3.7	1.2	0.4	6.1	1.3
4WG	0.6	0.6	0.3	0.9	2.5	5.1	0.1	0.1	0.3	0.3	0.6	1.2	0.7	3.1	2.8
4VB	0.6	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	1.6	5.8	0.8	15.3	19.3	17.7
4VC	2.7	2.5	1.9	6.1	13.9	9.1	7.5	8.7	5.7	2.3	10.5	12.1	36.9	36.8	58.1
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

c) Seiners

UNIT AREA	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
4WK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	6.3	0.1	0.0	4.9	4.6
4WD	0.0	0.0	21.8	5.9	0.0	0.0	0.0	0.0	0.0	43.1	0.9	0.3	0.1	0.4	1.7
4WE	1.1	18.2	3.6	23.5	33.3	25.0	0.0	0.0	71.4	17.2	89.4	95.6	89.9	80.0	43.8
4WH	7.4	18.2	0.0	23.5	22.2	50.0	100.0	100.0	28.6	12.1	0.7	0.1	0.6	3.2	1.1
4WL	72.6	36.4	72.7	17.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	1.3
4WJ	0.0	0.0	0.0	29.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.2	0.2
4WF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.2	0.0	1.0	0.0	1.9	14.0
4WG	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.1	0.4	0.3	0.0	0.0	1.3
4VB	18.9	27.3	1.8	0.0	44.4	8.3	0.0	0.0	0.0	1.7	0.5	0.0	0.0	0.0	1.2
4VC	0.0	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0	1.7	1.8	2.4	9.4	7.3	30.8
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table 4. Cod catch (t) by year and area in 4VsW.

a) Otter trawlers

UNIT AREA	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
4WK	37	22	0	0	1	46	5	26	8	101	81	80	183	778	101
4WD	70	59	44	248	479	411	66	996	379	944	282	761	365	221	130
4WE	350	160	139	585	745	477	243	544	159	250	2759	9015	2061	3782	3562
4WH	1048	235	196	369	276	204	78	51	19	280	251	531	1271	1020	403
4WL	1069	770	477	184	46	38	32	20	16	84	129	64	174	366	353
4WJ	245	100	149	42	29	3	0	1	0	42	254	20	924	1075	655
4WF	5	32	0	0	67	0	1	0	0	7	6	706	311	651	551
4WG	12	0	1	8	2	0	0	0	2	13	61	176	354	574	335
4VB	66	0	133	136	549	196	261	194	675	963	447	604	3048	1397	3475
4VC	5315	3102	1810	2249	3183	1552	1526	970	1880	1392	5349	11623	19397	23714	23412
TOTAL	8217	4480	2949	3821	5377	2927	2212	2802	3138	4076	9619	23580	28088	33578	32977

b) Longliners

UNIT AREA	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
4WK	26	84	2	5	67	67	13	17	21	21	54	34	60	371	88
4WD	96	38	54	203	217	111	50	13	14	155	125	27	128	39	61
4WE	1	0	0	56	59	65	49	40	112	228	271	216	255	236	131
4WH	393	499	567	188	288	357	404	177	120	133	285	167	382	347	482
4WL	244	43	29	27	14	58	52	215	206	232	349	1200	340	325	477
4WJ	11	1	18	0	0	27	60	210	143	415	301	386	729	462	515
4WF	0	36	7	35	34	6	0	0	8	25	65	29	15	311	110
4WG	5	4	2	5	20	41	1	1	2	4	11	29	29	161	248
4VB	5	0	0	0	3	0	0	0	0	20	102	19	619	988	1543
4VC	22	18	13	34	113	73	51	64	38	29	184	290	1497	1890	5064
TOTAL	803	723	692	553	815	805	680	737	664	1262	1747	2397	4054	5130	8719

c) Seiners

UNIT AREA	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
4WK	0	0	0	0	0	0	0	0	0	4	52	2	0	115	108
4WD	0	0	12	1	0	0	0	0	0	25	7	9	4	10	41
4WE	1	2	2	4	3	3	0	0	5	10	735	3120	3080	1866	1026
4WH	7	2	0	4	2	6	1	3	2	7	6	2	19	74	26
4WL	69	4	40	3	0	0	0	0	0	0	0	10	0	0	30
4WJ	0	0	0	5	0	0	0	0	0	0	0	0	0	52	4
4WF	0	0	0	0	0	0	0	0	0	3	0	33	0	44	329
4WG	0	0	0	0	0	0	0	0	0	7	3	9	1	0	30
4VB	18	3	1	0	4	1	0	0	0	1	4	0	0	0	29
4VC	0	0	0	0	0	2	0	0	0	1	15	79	321	171	722
TOTAL	95	11	55	17	9	12	1	3	7	58	822	3264	3425	2332	2345

Table 5. 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	-	-	-	-	4234/633	
		OTB-2	-	-	1411/209	662/124	-	315/67	1000/137	-	233/41	864/162	-	-	4485/740	
		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	-	-	-	-	-	800/146	
		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	16470/2654

Table 5. (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	-	-	676/39	563/101	578/107	574/72	-	248/36	-	-	840/176	-	3479/531	
		OTB-2	-	1370/209	1141/88	845/138	958/142	820/99	472/70	-	312/46	317/49	-	1048/0	7283/841	
		SNU	-	-	-	-	-	-	460/56	-	-	-	-	-	460/56	
		LL	-	-	-	-	544/121	2094/503	684/128	-	206/58	-	-	-	3528/810	
	4W	OTB-1	-	-	-	-	-	-	514/56	-	-	-	-	-	514/56	
		OTB-2	257/48	-	-	-	281/31	-	-	-	296/27	-	-	-	834/106	
		SNU	-	-	-	-	-	1495/187	-	-	-	-	-	-	1495/187	
		LL	-	-	-	336/72	427/78	1414/312	203/46	205/38	186/47	-	-	-	2771/593	
		LHP	-	-	-	-	-	121/32	-	-	-	-	-	-	121/32	
	4VsW	OTB-2	-	-	-	302/65	949/170	-	295/47	272/24	-	-	-	-	1818/306	22303/3518

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

Table 6. Data used to generate the age-length keys for 1981 and 1982. Keys number 1, 2, 3, 4, and 8 for 1981 were updated while the others remained as calculated by Maguire *et al.* (MS 1982). For 1981, some samples were used in two keys *as described* by Maguire *et al.*, but not for 1982.

Key	Gear	Period Covered	No. of Samples	Coefficients a	b	area	Catch
			- 1 9 8 1 -				
1	Otter trawls	Jan.-March	15	.012	2.937	4VsW	8782
2	Otter trawls	April-June	11	.012	2.937	4VsW	9858
3	Otter trawls	July-Sept.	15	.012	2.937	4VsW	4211
4	Otter trawls	Oct.-Dec.	21	.012	2.937	4VsW	16644
5	Seines	Sept.-Dec.	3	.011	2.976	4W	1013
6	Seines	Jan.-Aug.	4	.011	2.976	4W	1586
7	Longlines	July-Sept.	8	.012	2.937	4VsW	4319
8	Longlines	July-June	9	.012	2.937	4VsW	5106
9	Longlines	Oct.-Dec.	4	.011	2.976	4W	1962
10	Handlines	Jan.-Dec.	3	.011	2.976	4W	569
			- 1 9 8 2 -				
1	Otter trawls	Jan.-March	8	.010	2.985	4VsW	13123
2	Otter trawls	April-June	18	.010	2.985	4VsW	13197
3	Otter trawls	July-Sept.	9	.010	2.985	4VsW	3168
4	Otter trawls	Oct.-Dec.	4	.010	2.985	4VsW	8905
5	Longlines	Jan.-June	14	.010	2.985	4VsW	6108
6	Longlines	July-Dec.	6	.010	2.985	4VsW	7595
7	Seines	Jan.-Dec.	6	.010	2.985	4VsW	2796

Table 7. 4VsW cod catch at age in the 1978-1982 USSR silver hake fishery.

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

Table. 8 .

{VSW COD} REMOVALS AT AGE, 7/ 5/

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	0	0	0	45	935	3730	2799	3083	2806	548	2495	1426	1293	2311	2383	1413
2	138	0	0	283	5962	23782	17955	19668	17891	4235	16045	9097	9631	15219	17738	12142
3	2854	2499	7016	3443	6026	16949	14731	18721	17493	6267	17413	7684	9886	12582	14227	14881
4	3534	8887	6119	9588	10335	12267	8930	12497	13973	7999	17783	13724	14802	9146	13361	7507
5	2533	8811	6655	9340	6372	10916	11779	5345	10577	9456	15633	10248	13673	9809	9661	9755
6	3726	6490	4525	6676	7987	5423	4696	6130	4461	4339	8297	6073	4539	10252	9780	3823
7	1610	4384	2811	2885	2744	4875	2874	3135	3256	1467	3482	2144	1942	5160	3432	2996
8	1465	1467	1827	1882	2538	2183	2345	4477	1590	1239	895	510	759	1849	1919	3724
9	2014	378	290	1212	686	346	1047	2127	856	664	816	237	236	496	358	1166
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	35826	44279	80803	67749	77384	74106	37270	83644	51369	55054	66329	72372	58024
2+	19459	35134	29594	35782	43344	77073	64950	74301	71300	36722	81149	49943	53761	64017	69989	56606
3+	19321	35134	29594	35499	37383	53291	46995	54633	53409	32487	65104	40846	45130	48799	52251	44464
4+	16467	32635	22578	32056	31357	36342	32264	35912	35916	26220	47691	33162	36244	36217	38024	29583
5+	12933	23748	16460	22468	21022	24075	23334	23414	21943	18231	29908	19438	21442	27071	24663	22075
6+	10400	14937	9805	13128	14650	13159	11555	18069	11366	8775	14275	9190	7769	18262	15002	12321
7+	6674	8447	5280	6452	6763	7736	6859	11939	6905	4437	5978	3117	3230	8000	6222	8498

	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	1482	1792	728	2	177	12	31	3	5
2	8451	9979	4061	24	153	81	152	348	41
3	12885	9485	3587	386	1004	1629	2034	3742	1845
4	9947	4341	3713	1073	3650	6164	5119	9724	6589
5	7130	4549	4818	1559	4621	9145	7112	7276	9903
6	2766	2594	2412	871	2441	4871	6147	4852	3853
7	944	2627	1426	501	768	1162	2929	2991	2822
8	1323	612	611	220	213	371	1066	1455	1489
9	413	497	184	128	112	76	319	393	733
10	369	660	49	35	80	23	88	126	293
11	15	153	22	44	26	10	47	62	143
12	5	126	107	55	29	5	26	32	63
13	0	36	1	11	26	4	4	21	65
14	0	9	4	3	9	1	1	2	57
15	0	9	1	2	4	0	4	6	20
16	0	18	1	7	2	0	8	6	23
1+	45730	37487	21725	4921	13314	23554	25087	31039	27944
2+	44248	35695	20997	4919	13137	23541	25056	31036	27939
3+	35797	25716	16936	4895	12984	23460	24904	30688	27898
4+	22912	16231	13349	4509	11980	21831	22870	26946	26053
5+	12965	11890	9636	3436	8330	15666	17751	17222	19464
6+	5835	7341	4818	1877	3709	6522	10639	9946	9561
7+	3069	4747	2406	1006	1268	1651	4492	5094	5708

Table 9.

4VSW COD; WEIGHTS AT AGE 6/ 5/83

	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	1981	1982
1	0.080	0.130	0.100	0.100	0.100	0.200	0.000	0.000	0.000	0.000
2	0.220	0.330	0.270	0.280	0.280	0.620	0.530	0.570	0.616	0.576
3	0.450	0.620	0.530	0.570	0.810	0.950	0.760	0.800	0.833	0.743
4	0.790	1.020	0.890	0.960	1.090	1.250	1.060	1.150	1.139	1.045
5	1.210	1.530	1.340	1.460	1.670	1.680	1.700	1.600	1.693	1.577
6	1.720	2.130	1.870	2.030	2.360	2.470	2.390	2.210	2.133	2.389
7	2.280	2.820	2.470	2.660	3.170	3.610	3.130	3.080	2.965	2.708
8	2.900	3.580	3.120	3.350	4.580	5.230	3.710	4.310	3.941	3.695
9	3.540	4.410	3.810	4.070	4.140	5.590	4.770	5.260	5.698	5.019
10	4.220	5.280	4.530	4.800	5.330	6.540	6.840	6.920	7.163	7.037
11	4.900	6.190	5.270	5.550	4.650	7.920	7.960	7.560	7.673	8.796
12	5.590	7.130	6.010	6.290	4.910	9.210	9.410	10.190	9.261	9.107
13	6.280	8.090	6.760	7.020	7.140	10.400	10.630	7.920	11.868	11.397
14	6.960	9.050	7.510	7.740	8.590	9.750	10.030	8.130	8.654	10.914
15	7.620	10.010	8.240	8.430	10.600	8.680	11.450	14.450	9.836	12.514
16	8.270	10.960	8.960	9.100	14.940	12.210	12.510	14.030	14.107	13.878

Table 10.

4VSW COD; CATCH BIOMASS (T) 4/11/93

	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	24	23	119
2	38	0	0	78	1645	6564	4956	5428	2684	678	2407	1274	1295	1674	3193
3	1613	1412	3954	1945	3405	9576	8323	10577	7972	2945	7489	3227	3988	4021	3260
4	3333	8380	5769	9041	9746	11568	8421	11785	12576	7669	15471	11335	13470	5853	10822
5	3711	12908	9750	13683	9335	15992	17257	7931	15760	15035	22512	14450	20510	9426	12463
6	7913	13610	9489	14000	16539	11372	9848	12855	9725	10108	17424	12571	9940	16009	16243
7	4551	12394	7947	9156	7757	13782	8125	8863	9573	4592	9819	5960	5709	10794	8511
8	5378	5385	6707	6909	9317	8014	8608	16435	5915	4906	3195	1795	2931	4900	6026
9	8731	3806	1257	5254	2974	1500	4539	9221	3852	3131	3533	1010	1064	1592	1371
10	4521	5795	700	889	2516	705	1642	8331	2614	3830	1827	249	380	429	1776
11	3234	1894	727	376	1007	721	864	1024	3996	2077	377	540	905	541	411
12	397	1718	513	602	513	342	513	623	161	463	1357	368	376	343	12
13	382	203	9	495	510	195	375	720	103	125	233	93	66	513	241
14	88	0	120	24	0	0	0	704	0	42	130	53	95	18	0
15	90	0	0	0	45	0	0	1471	17	63	3	16	34	309	3
16	531	210	60	0	0	10	110	70	9	19	36	17	27	103	3
1+	44411	67715	47010	61955	65363	80556	73742	96117	74911	55543	86415	53306	60647	56616	67164
2+	44411	67715	47010	61952	65309	80340	73580	95938	74854	55532	86365	53279	60621	56593	67045
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	55329	50893	57892
5+	39428	57922	37277	50887	50513	52632	51880	68148	51723	44240	61000	37112	41958	45039	47079
6+	35717	45014	27527	37205	41178	36641	34624	60317	35964	29205	38488	22662	21349	38811	34607
7+	27904	31405	18038	23205	24639	25269	24776	47462	26239	19097	21065	10091	11408	19605	18364

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	113	193	179	73	0	35	0	0	0	0
2	2671	2789	2694	1137	7	95	43	87	214	24
3	6696	7989	5027	2045	313	954	1238	1627	3117	1371
4	5931	10146	3863	3564	1170	4562	6534	5887	11076	6897
5	11804	10909	6096	7034	2604	7763	15546	11379	12318	15616
6	6576	5892	4851	4896	2056	6029	11641	13585	10349	9205
7	6831	2662	6489	3793	1588	2772	3637	9021	8868	7542
8	10800	4736	1909	2047	1008	1114	1377	4594	5734	5302
9	4128	1921	1894	749	530	626	362	1678	2239	3679
10	1152	1948	2990	235	187	523	155	609	903	2062
11	1465	93	906	122	205	206	78	355	476	1258
12	17	36	757	673	270	258	46	265	296	374
13	14	0	243	7	79	270	42	32	249	741
14	35	0	68	31	26	98	10	9	17	622
15	38	0	74	9	21	35	0	59	59	250
16	165	0	161	9	105	24	0	112	95	319
1+	58465	49213	38102	26424	10165	25356	40708	49299	56001	55752
2+	58352	49021	37923	26352	10165	25321	40708	49299	56001	55752
3+	55680	46232	35229	25214	10158	25226	40665	49211	55787	55728
4+	48984	38243	30201	23170	9846	24272	39427	47584	52670	54358
5+	43053	28097	26338	19605	8676	19709	32893	41697	41594	47742
6+	31250	17188	20242	12571	6073	11946	17347	30318	29276	31954
7+	24674	11297	15391	7675	4017	5917	5706	16733	18927	22649

Table 11.

4VS COD; AVERAGE NUMBER PER SET PER STRATUM IN R,V, SURVEYS 6/ 5/83

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
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
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
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
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
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
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
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
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
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
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

4W COD; AVERAGE NUMBER PER SET PER STRATUM IN R,V, SURVEYS 6/ 5/83

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
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
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
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
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
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
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
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
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
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
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
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
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
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
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

Table 12. Research survey population estimates (000's).

A) 4VS, 13/10/83

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

B) 4W; NOT CORRECTED FOR UNUSUALLY HIGH CATCHES, 13/10/83

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

Table 13. Research survey population estimates (000's).

A) 4W; UNUSUALLY HIGH CATCHES OF 1973 AND 1982 REMOVED, 13/10/83

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	0	0	0	0	0	0	0	0	174	1017	50	74	9
1	1316	1539	6029	1935	3897	3201	2057	327	2853	924	576	4259	2116
2	4396	6042	4485	4462	29511	5423	8330	5780	9928	7505	5649	4445	11874
3	3031	5526	2331	7495	15743	6119	9455	11979	24281	9892	14338	7368	12052
4	2572	3559	1762	7550	4472	3596	8083	9029	28587	10069	5449	7670	5709
5	1012	3674	1447	1963	905	1154	4602	5339	8310	11857	6348	2711	2563
6	361	1566	340	187	586	210	918	2801	3210	5687	3673	3258	723
7	755	1199	80	214	221	218	362	558	781	1222	2074	1865	402
8	188	413	34	414	123	0	0	274	118	161	347	620	135
9	79	568	241	70	65	148	0	0	24	114	78	141	107
10	227	0	0	274	115	0	0	0	53	0	0	68	0
11	0	137	0	0	0	0	38	0	0	0	0	68	0
12	101	58	0	0	59	68	0	62	0	0	0	0	0
0+	14038	24281	16749	24564	55697	20137	33845	36149	78319	48448	38582	32547	35690
1+	14038	24281	16749	24564	55697	20137	33845	36149	78145	47431	38532	32473	35681
2+	12722	22742	10720	22629	51800	16936	31788	35822	75292	46507	37956	28214	33565
3+	8326	16700	6235	18167	22289	11513	23458	30042	65364	39002	32307	23769	21691
4+	5295	11174	3904	10672	6546	5394	14003	18063	41083	29110	17969	16401	9639
5+	2723	7615	2142	3122	2074	1798	5920	9034	12496	19041	12520	8731	3930

B) 4W; UNUSUALLY HIGH CATCHES OF 1973 AND 1982 WINSORISED, 13/10/83

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	0	0	0	2317	0	0	0	0	174	1017	50	74	9
1	1316	1539	6029	8489	3897	3201	2057	327	2833	924	576	4259	2072
2	4396	6042	4485	9455	29511	5423	8330	5780	9928	7505	5649	4445	19830
3	3031	5526	2331	4647	15743	6119	9455	11979	24281	9892	14338	7368	17073
4	2572	3559	1762	3624	4472	3596	8083	9029	28587	10069	5449	7670	6840
5	1012	3674	1447	-4379	905	1154	4602	5339	8310	11857	6348	2711	2761
6	361	1566	340	739	586	210	918	2801	3210	5687	3673	3258	760
7	755	1199	80	29	221	218	362	558	781	1222	2074	1865	411
8	188	413	34	-155	123	0	0	274	118	161	347	620	140
9	79	568	241	231	65	148	0	0	24	114	78	141	102
10	227	0	0	166	115	0	0	0	53	0	0	68	0
11	0	137	0	-166	20	0	38	0	0	0	0	68	0
12	101	58	0	102	59	68	0	62	79	0	0	0	0
0+	14038	24281	16749	25099	55717	20137	33845	36149	78378	48448	38582	32547	48998
1+	14038	24281	16749	22782	55717	20137	33845	36149	78204	47431	38532	32473	48989
2+	12722	22742	10720	14293	51820	16936	31788	35822	75371	46507	37956	28214	46917
3+	8326	16700	6235	4838	22309	11513	23458	30042	65443	39002	32307	23769	28087
4+	5295	11174	3904	191	6566	5394	14003	18063	41162	29110	17969	16401	11014
5+	2723	7615	2142	-3433	2094	1798	5920	9034	12575	19041	12520	8731	4174

Table 14. Research survey population estimates (000's).

A) 4VSW; NOT CORRECTED FOR UNUSUALLY HIGH CATCHES, 4/11/83

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	0	0	0	0	0	0	0	0	174	1017	50	74	9
1	1478	1539	6210	16129	5174	3372	2242	808	3033	1213	690	4589	2633
2	16388	7680	9674	122780	32961	8412	14066	10145	13065	10612	7064	12770	226029
3	5250	35664	11881	104965	19246	13000	16099	26372	31245	16044	18489	18936	188892
4	7714	8027	31536	59948	5623	6171	10187	17059	34205	16595	10260	30753	35976
5	3742	15803	5812	22524	2017	2959	6621	11353	9461	18075	17365	12057	14824
6	1228	5775	5989	1870	2244	675	1264	4893	3490	9053	12099	9570	3020
7	1532	3459	1621	2907	372	867	656	1031	889	2696	4794	4404	4325
8	466	1475	547	901	463	235	1308	979	185	1009	1302	1553	1850
9	104	638	495	431	224	433	0	244	90	411	338	533	413
10	249	70	153	514	161	23	929	0	79	33	265	650	419
11	209	137	0	166	63	0	38	161	0	45	93	163	226
12	101	58	0	0	59	68	0	62	79	5	0	74	0
0+	38461	90325	73918	333134	68607	36215	53409	73056	95995	74859	72909	95126	517615
1+	38461	90325	73918	333134	68607	36215	53409	73056	95821	75841	72759	95052	515326
2+	36983	78786	67708	317006	63433	32843	51167	72248	92739	74629	72069	90463	510973
3+	20595	71106	58034	194226	30472	24431	37101	62103	79723	64016	65004	77693	284945
4+	15345	35442	46153	89261	11226	11431	21003	35731	48478	47972	46516	58757	96053
5+	7631	27415	14617	29313	5603	5260	10816	18672	14273	31377	36256	28004	30077

B) 4VSW; UNUSUALLY HIGH CATCHES OF 1973 AND 1982 REMOVED, 4/11/83

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	0	0	0	0	0	0	0	0	174	1017	50	74	9
1	1478	1539	6210	2295	5174	3372	2242	808	3033	1213	690	4589	2499
2	16388	7680	9674	8779	32961	8412	14066	10145	13065	10612	7064	12770	33090
3	5250	35664	11881	13761	19246	13000	16099	26372	31245	16044	18489	18936	33654
4	7714	8027	31536	10790	5623	6171	10187	17059	34205	16595	10260	30753	16887
5	3742	15803	5812	5799	2017	2959	6621	11353	9461	18075	17365	12057	9493
6	1228	5775	5989	429	2244	675	1264	4893	3490	9053	12099	9570	7429
7	1532	3459	1621	950	372	867	656	1081	889	2696	4794	4404	4147
8	466	1475	547	676	463	235	1308	979	185	1009	1302	1553	1954
9	104	638	495	97	224	433	0	244	90	411	338	533	391
10	249	70	153	274	161	23	929	0	79	33	265	650	419
11	209	137	0	166	63	0	38	161	0	45	93	163	226
12	101	58	0	0	59	68	0	62	79	5	0	74	0
0+	38461	90325	73918	45015	68607	36215	53409	73056	95995	74859	72909	95126	110071
1+	38461	90325	73918	45015	68607	36215	53409	73056	95821	75841	72759	95052	110062
2+	36983	78786	67708	42729	63433	32843	51167	72248	92739	74629	72069	90463	107573
3+	20595	71106	58034	33941	30472	24431	37101	62103	79723	64016	65004	77693	74489
4+	15345	35442	46153	20180	11226	11431	21003	35731	48478	47972	46516	58757	40833
5+	7631	27415	14617	9390	5603	5260	10816	18672	14273	31377	36256	28004	23949

Table 14. (Cont'd)

C) 4VSW; UNUSUALLY HIGH CATCHES OF 1973 AND 1982 WINSORISED, 4/11/93

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	0	0	0	2317	0	0	0	0	174	1017	50	74	9
1	1478	1539	6210	8849	5174	3372	2242	808	3033	1213	690	4589	2444
2	16388	7680	9674	13772	32961	8412	14066	10145	13065	10612	7064	12770	40046
3	5250	35664	11891	10913	19246	13000	16098	26372	31245	16044	18488	18936	38675
4	7714	8027	31536	6864	5623	6171	10187	17059	34205	16595	10260	30753	18013
5	3742	15803	5812	456	2017	2959	6621	11353	9461	18075	17365	12057	9691
6	1228	5775	5989	981	2244	675	1264	4893	3490	9053	12099	8570	7465
7	1532	3459	1621	765	372	867	656	1081	889	2696	4794	4404	4156
8	466	1475	547	107	463	235	1308	878	185	1009	1302	1553	1659
9	104	638	495	258	224	433	0	244	90	411	338	533	386
10	249	70	153	166	161	23	929	0	79	83	265	650	419
11	209	137	0	0	63	0	38	161	0	45	93	163	226
12	101	58	0	102	59	68	0	62	79	5	0	74	0
0+	38461	80325	73918	45550	68607	36215	53409	73056	95995	76858	72908	95126	123394
1+	38461	80325	73918	43233	68607	36215	53409	73056	95821	75841	72758	95052	123375
2+	36983	78786	67708	34384	63433	32843	51167	72248	92788	74628	72068	90463	120931
3+	20595	71106	58034	20612	30472	24431	37101	62103	79723	64016	65004	77693	80885
4+	15345	35442	46153	9699	11226	11431	21003	35731	48478	47972	46516	58757	42210
5+	7631	27415	14617	2835	5603	5260	10816	18672	14273	31377	36236	28004	24192

Table 15. 4VsW cod; R.V. population estimates ('000) from Lady Hammond summer surveys. The age-length keys used to generate the 1980 and 1981 estimates come from the A.T. Cameron comparative surveys.

12/10/83

	1980	1981	1982
0	0	0	9
1	581	7518	2444
2	14783	15196	40046
3	44538	25472	38675
4	16544	33630	18018
5	10704	10560	9681
6	5074	7219	7465
7	2434	3905	4156
8	650	1961	1859
9	260	543	386
10	164	353	419
11	35	152	226
12	0	39	0
0+	95767	106548	123384
1+	95767	106548	123375
2+	95186	99030	120931
3+	80403	83834	80885
4+	35865	58362	42210
5+	19321	24732	24192

Table 16a. Results of calibration of fishable biomass against the standardised commercial catch rate.

YEAR	STD. COMM. CATCH RATE	COHORT	PRED.	P/C	COHORT	PRED.	P/C	COHORT	PRED.	P/C
1968	.741	160488	156703	0.98	159971	143301	.90	159796	138829	.87
1969	.788	143966	171934	1.19	143685	154497	1.08	143531	148682	1.04
1970	.736	206454	155083	0.75	205893	142110	.69	205705	137780	.67
1971	.685	134488	138556	1.03	133903	129961	.97	133709	127088	.95
1972	.702	142995	144065	1.01	140819	134011	.95	140093	130652	.93
1973	.693	113932	141148	1.24	111454	131867	1.18	110629	128765	1.16
1974	.549	127875	94483	0.74	122801	97564	.79	121109	98576	.81
1975	.485	87333	73743	0.84	82034	82319	1.00	80267	85158	1.06
1976	.508	68987	81197	1.18	63419	87798	1.38	61569	89980	1.46
1977	.611	79375	114575	1.44	70175	112333	1.60	67040	111574	1.66
1978	.914	149650	212766	1.42	133266	184511	1.39	127814	175098	1.37
1979	1.249	195609	321327	1.64	173042	264312	1.53	165537	245331	1.48
1980	1.109	247186	275958	1.12	209141	230962	1.10	196480	215980	1.10
1981	1.079	345322	266237	0.77	278154	223816	.81	255792	209690	.82
1982	1.165	438222	294106	0.67	335906	244302	.73	301834	227720	.75
r			.79			.78			.77	
r^2			.62			.61			.59	
B_0			-83427			-33213			-16522	
F_t			0.150			0.200			0.225	

Table 16b.

YEAR	COHORT	PRED.	P/C	COHORT	PRED.	P/C	COHORT	PRED.	P/C
1968	159655	135254	.85	159539	132332	.83	159441	129897	.82
1969	143407	144034	1.00	143305	140235	.98	143219	137071	.96
1970	205554	134320	.65	205430	131491	.64	205327	129134	.63
1971	133553	124791	.93	133427	122914	.92	133321	121349	.91
1972	139513	127967	.92	139039	125773	.91	138644	123944	.89
1973	109968	126286	1.15	109428	124259	1.14	108954	122570	1.13
1974	119755	99383	.83	118647	100043	.84	117724	100590	.85
1975	78852	87427	1.11	77695	89280	1.15	76730	90820	1.18
1976	60092	91724	1.53	58886	93148	1.58	57883	94331	1.63
1977	64533	110966	1.72	62484	110470	1.77	60778	110053	1.81
1978	123457	167574	1.36	119897	161425	1.35	116935	156304	1.34
1979	159542	230161	1.44	154644	217761	1.41	150569	207440	1.38
1980	186364	204005	1.10	178097	194218	1.09	171218	186070	1.09
1981	237918	198400	.83	223308	189173	.85	211147	181491	.86
1982	274597	214467	.78	252331	203635	.81	233792	194618	.83
r	.76			.74			.71		
r^2	.57			.54			.51		
B_0	-3183			7718			16788		
F_t	0.250			0.275			0.300		

Table 16c.

YEAR	COHORT	PRED.	P/C	COHORT	PRED.	P/C
1968	159358	127832	.80	159287	126061	.79
1969	143147	134391	.94	143085	132094	.92
1970	205239	127134	.62	205164	125419	.61
1971	133232	120016	.90	133155	118873	.89
1972	138311	122389	.89	138025	121055	.88
1973	108550	121133	1.12	108204	119900	1.11
1974	116943	101037	.86	116274	101416	.87
1975	75905	92105	1.21	75172	93201	1.24
1976	56957	95315	1.67	56164	96153	1.71
1977	59336	109689	1.85	58101	109374	1.88
1978	114432	151974	1.33	112290	148267	1.32
1979	147127	198725	1.35	144182	191268	1.33
1980	165406	179188	1.08	160432	173297	1.08
1981	200869	175001	.87	192070	169447	.88
1982	218121	187003	.86	204704	180486	.88

r	.69	.66
r^2	.48	.44
B_0	24421	30946
F_t	0.325	0.350

Table 17. Results of the calibration of beginning-of-the-year numbers at age 4 against the standardised CPUE at age 4.

Year	CPUE at age 4	COHORT	Pred.	P/C	COHORT	Pred.	P/C	COHORT	Pred.	P/C
1978	0.13	48996	44363	0.90	48996	42757	0.87	48996	41956	0.86
1979	0.19	49954	62787	1.26	49954	61063	1.22	49954	60203	1.20
1980	0.12	44031	39530	0.90	44031	37956	0.86	44031	37170	0.84
1981	0.19	70829	61579	0.87	70829	59863	0.84	70829	59006	0.83
1982	0.14	76267	46477	0.61	52061	44858	0.86	39972	44050	1.10
r			0.78			0.86			0.86	
r^2			0.60			0.74			0.74	
Bo			4796			3445			2770	
$F_{4,82}$			0.10			0.15			0.20	

Table 18. Final partial recruitment vector.

Age	P.R.
1	0.0002
2	0.0020
3	0.1200
4	0.5560
5	1
6	1
7	1
8	1
9	1
10	1
11	1
12	1
13	1
14	1
15	1
16	1

Table 19. 4VsW cod population numbers (000's).

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	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	105369	94741	107781	93155	140515	155458	151974	152222	167316	135859	92774	111200	97119	96625
2	92293	86269	77567	98244	76229	114198	123903	121893	121840	134448	110736	73699	89753	78345
3	68845	75430	70631	63507	71992	57016	71979	95197	82001	83565	106245	76145	52109	65674
4	38783	53783	59496	51479	48879	53490	31345	45603	52814	51308	62747	71230	55390	34622
5	23192	28555	35993	43175	33472	30668	32694	17583	26028	30597	34779	35282	45900	31956
6	17919	16696	15406	23447	26898	21639	15232	16109	9559	11740	16495	14329	19614	25208
7	5761	11300	7797	8519	13156	14886	12810	8222	7642	3790	5686	5997	6237	11951
8	4326	3260	5285	3841	4364	8298	7776	7887	3895	3311	1775	1505	2970	3349
9	4314	2216	1341	2674	1441	1277	4811	4245	2406	1750	1590	644	771	1745
10	1756	1709	1020	836	1092	559	732	2991	1551	1196	832	563	312	418
11	969	661	403	715	531	462	337	317	1017	621	394	354	413	191
12	125	302	253	220	452	282	269	145	104	230	378	185	204	216
13	56	50	20	139	100	302	186	152	36	64	129	119	99	117
14	45	0	17	15	54	21	224	107	38	17	38	76	86	73
15	63	27	0	0	10	45	17	183	8	31	9	15	56	60
16	131	43	22	0	0	4	37	14	3	5	19	7	11	42
1+	363938	375041	383033	379965	419187	458594	454323	462869	476257	458730	434625	391350	371046	350590
2+	258569	280301	275251	286810	278672	303136	302349	310647	308940	322871	341851	280150	273926	253965
3+	166286	194032	197684	198566	202444	188938	178446	188754	187101	188423	231115	206451	184174	175621
4+	97440	118602	127053	135060	130452	131922	106467	103557	105100	104857	124870	130306	132065	109947
5+	58658	64818	67557	83580	81572	78432	75123	57954	52286	53549	62123	59076	76676	75325
6+	35465	36263	31565	40405	48100	47764	42429	40372	26258	22952	27344	23794	30775	43369

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	75794	67255	84483	97376	93515	83124	132717	108228	103206	110534	110336
2	77019	59899	53781	67828	78103	75905	68055	108499	88598	84470	90495
3	50373	47008	38054	36385	46503	60271	62124	55580	88758	72401	68843
4	42384	28369	25022	19498	21207	34828	48996	49954	44031	70829	55891
5	20071	22612	16434	11486	12035	14003	27544	36812	35321	31418	49191
6	18193	7691	9686	7004	5287	5494	10054	18370	21865	22483	19139
7	11353	6950	2838	5428	3387	2147	3710	6023	10633	12339	14018
8	5116	6190	2980	1469	2067	1483	1304	2343	3880	6055	7396
9	1069	2452	1698	1242	649	1139	1015	875	1582	2212	3641
10	980	551	953	1017	567	365	817	730	648	1007	1455
11	239	447	204	446	235	420	267	596	577	451	710
12	38	124	95	154	227	173	304	195	479	430	313
13	112	29	99	73	12	89	92	224	155	369	323
14	7	58	17	81	27	9	63	51	180	124	283
15	49	6	43	14	58	19	4	43	41	146	99
16	3	39	0	35	4	47	14	0	35	30	114
1+	302798	249679	236386	249535	263884	279515	357080	388524	399990	415297	422248
2+	227004	182424	151904	152159	170369	196391	224363	280296	296784	304763	311912
3+	149985	122525	99123	84331	92266	120486	156308	171797	208186	220293	221417
4+	99612	75517	60069	47946	45763	60215	94184	116217	119428	147892	152574
5+	57228	47148	35047	28448	24556	25387	45188	66262	75397	77064	96683
6+	37157	24537	18613	16963	12520	11383	17644	29450	40076	45646	47492

Table 20. 4VsW cod; fishing mortality.

4/11/93

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
1	0.000	0.000	0.000	0.001	0.007	0.027	0.021	0.023	0.019	0.004	0.030	0.014	0.015	0.027	0.035	0.024
2	0.002	0.000	0.000	0.004	0.090	0.262	0.175	0.196	0.177	0.035	0.175	0.147	0.112	0.242	0.294	0.254
3	0.047	0.037	0.116	0.062	0.097	0.398	0.256	0.279	0.269	0.087	0.200	0.112	0.209	0.238	0.374	0.431
4	0.106	0.202	0.121	0.230	0.266	0.292	0.378	0.361	0.346	0.189	0.376	0.339	0.350	0.345	0.429	0.346
5	0.129	0.417	0.229	0.273	0.236	0.500	0.508	0.409	0.596	0.419	0.687	0.387	0.399	0.363	0.739	0.848
6	0.261	0.561	0.392	0.379	0.392	0.324	0.417	0.546	0.725	0.525	0.812	0.632	0.295	0.598	0.762	0.777
7	0.369	0.560	0.508	0.469	0.262	0.449	0.285	0.547	0.636	0.559	1.129	0.503	0.422	0.648	0.407	0.647
8	0.469	0.688	0.481	0.780	1.029	0.344	0.405	0.987	0.600	0.534	0.815	0.469	0.332	0.942	0.535	1.093
9	0.726	0.576	0.273	0.695	0.746	0.356	0.275	0.807	0.499	0.544	0.838	0.523	0.413	0.377	0.462	0.745
10	0.778	1.244	0.156	0.253	0.661	0.307	0.637	0.879	0.436	0.911	0.653	0.103	0.294	0.359	0.536	0.793
11	0.966	0.759	0.407	0.258	0.433	0.342	0.646	0.914	1.287	0.575	0.557	0.351	0.453	1.424	0.455	1.347
12	0.717	2.517	0.396	0.585	0.203	0.218	0.369	1.190	0.294	0.375	0.759	0.426	0.361	0.458	0.061	0.027
13	8.897	0.906	0.057	0.740	1.384	0.100	0.353	1.197	0.562	0.326	0.331	0.119	0.106	2.648	0.454	0.311
14	0.314	0.192	8.175	0.242	0.000	0.000	0.000	2.408	0.000	0.399	0.694	0.107	0.167	0.201	0.000	0.100
15	0.192	0.000	0.300	0.341	0.815	0.000	0.000	4.052	0.330	0.299	0.127	0.156	0.082	2.864	0.023	7.397
16	0.585	0.767	0.355	0.549	0.675	0.364	0.400	0.805	0.543	0.637	0.859	0.399	0.365	0.582	0.497	0.320

	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	0.020	0.021	0.009	0.000	0.001	0.000	0.000	0.000	0.000
2	0.191	0.177	0.059	0.000	0.002	0.001	0.002	0.005	0.000
3	0.469	0.340	0.089	0.007	0.018	0.033	0.026	0.059	0.030
4	0.579	0.282	0.215	0.035	0.086	0.147	0.138	0.165	0.139
5	0.653	0.576	0.584	0.131	0.205	0.321	0.252	0.296	0.250
6	0.379	0.527	0.701	0.193	0.312	0.347	0.372	0.272	0.250
7	0.458	0.766	0.626	0.298	0.260	0.240	0.343	0.312	0.250
8	0.675	0.617	0.376	0.179	0.199	0.192	0.362	0.309	0.250
9	0.313	0.584	0.376	0.133	0.130	0.101	0.252	0.219	0.250
10	0.559	1.264	0.100	0.112	0.115	0.035	0.163	0.149	0.250
11	0.085	0.476	0.109	0.123	0.114	0.018	0.094	0.165	0.250
12	0.060	2.369	0.737	0.434	0.107	0.028	0.062	0.086	0.250
13	0.000	0.782	0.099	0.147	0.377	0.020	0.029	0.065	0.250
14	0.000	0.131	0.175	0.478	0.172	0.021	0.006	0.018	0.250
15	0.000	1.200	0.019	0.125	6.078	0.000	0.113	0.046	0.250
16	0.501	0.808	0.374	0.181	0.176	0.142	0.285	0.247	0.250

Table 21. SPA population biomass (t).

9/ 5/

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
1	6111	5495	6251	5403	8150	9017	8814	8829	3346	2717	1855	2224	1942	966
2	25470	23810	21409	24355	21039	31519	34197	33642	18276	21512	16610	10318	13463	8618
3	38898	42618	39906	35881	40675	32214	40668	48136	36900	39276	45685	31981	23449	21016
4	36572	50718	56105	48545	46093	50441	29558	43003	47532	49256	54590	60545	50405	22158
5	33977	41833	52729	63252	49037	44928	47896	25759	38782	48649	50081	49748	68850	34193
6	37577	35012	32307	49168	56405	45377	31941	33781	20838	27354	34639	29661	42954	39324
7	16286	31945	22043	24084	37192	42082	36213	23242	22469	11861	16036	16672	18336	24978
8	15879	11966	19400	14099	16022	30426	28547	28954	14488	13111	6338	5298	11078	8875
9	18699	9606	5815	11590	6249	5535	20854	18402	10829	8382	6883	2742	3476	5601
10	9244	8996	5367	4399	5749	2944	3854	15743	8173	6708	4209	2810	1650	1566
11	5769	3936	2401	4256	3165	2750	2006	1890	6100	5246	2271	2013	2503	816
12	858	2066	1733	1504	3094	1932	1838	989	697	1636	2431	1171	1371	1033
13	423	376	150	1046	752	2267	1393	1140	264	496	911	824	726	610
14	360	0	133	123	436	164	1791	855	298	142	286	571	686	411
15	571	243	0	0	89	403	152	1655	67	277	75	123	474	361
16	1310	428	221	0	0	36	366	138	23	44	163	56	97	269
1+	248004	269047	265971	287705	294147	302035	290090	286158	229083	236667	243064	216758	241460	170794
2+	241893	263552	259720	282302	285998	293018	281275	277329	225737	233950	241208	214534	239518	169828
3+	216422	239742	238311	257947	264959	261500	247078	243686	207461	212438	224598	204216	226055	161210
4+	177525	197124	198405	222066	224283	229286	206410	195550	170560	173162	178913	172235	202606	140194
5+	140953	146406	142300	173521	178190	178845	176852	152547	123028	123907	124323	111690	152202	118036
6+	106976	104573	89571	110269	129153	133917	128956	126788	84246	75257	74241	61942	83351	83843
7+	69399	69561	57264	61101	72748	88540	97015	93007	63408	47904	39603	32280	40397	44519

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	3790	5380	10983	9738	9352	8312	26543	0	0	0	0
2	13863	13178	17748	18313	21869	21253	42194	57505	50501	52034	52114
3	22164	21153	23594	19284	26507	48820	59018	42241	71007	60310	51148
4	34331	22412	25522	17353	20359	37963	61246	52952	50635	80674	58422
5	25891	27360	25144	15391	17572	23385	46274	62581	56514	53190	77571
6	33656	13229	20632	13097	10734	12966	24834	43904	48321	47957	45722
7	28156	15847	8002	13406	9009	6805	13394	18852	32749	36586	37959
8	16064	17950	10667	4584	6924	6790	6821	8691	16722	23863	27331
9	4094	8681	7489	4733	2642	4717	5673	4174	8323	12604	18275
10	4429	2326	5030	4605	2724	1945	5343	4990	4483	7212	10242
11	1241	2188	1264	2351	1305	1954	2115	4748	4361	3459	6248
12	221	693	678	923	1427	847	2802	1836	4886	3980	2850
13	731	182	799	496	83	635	952	2379	1230	4380	3680
14	48	406	157	607	213	75	612	516	1460	1069	3090
15	376	42	432	117	489	200	38	496	596	1438	1243
16	23	322	0	317	32	697	167	0	497	425	1586
1+	189078	151348	158141	125315	131237	177364	298025	305863	352285	389180	397482
2+	185289	145968	147158	115578	121886	169051	271482	305863	352285	389180	397482
3+	171425	132790	129410	97264	100017	147798	229288	248359	301784	337146	345368
4+	149261	111637	105817	77980	73510	98979	170270	206118	230778	276836	294220
5+	114930	89225	80294	60627	53151	61016	109025	153166	180142	196162	235798
6+	89038	61865	55151	45237	35580	37631	62751	90585	123628	142973	158227
7+	55382	48636	34519	32140	24846	24664	37917	46681	75307	95015	112505

Table 22. Input variables for yield-per-recruit analysis and catch projection.
NB: SPA numbers at age, F_t = 0.250
PR: Partial recruitment vector

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	13.879	1.00000

Table 23. Results of Thompson-Bell yield-per-recruit analysis.

YIELD PER RECRUIT ANALYSIS

	FISHING MORTALITY	CATCH (NUMBER)	YIELD (KG)	AVG. WEIGHT (KG)	YIELD PER UNIT EFFORT
	0.1000	0.170	0.573	3.370	1.000
F0.1---	0.1620	0.232	0.682	2.942	0.734
	0.2000	0.260	0.710	2.727	0.619
FMAX---	0.2725	0.302	0.726	2.399	0.464
	0.3000	0.315	0.724	2.297	0.421
	0.4000	0.352	0.707	2.007	0.308
	0.5000	0.379	0.685	1.807	0.239
	0.6000	0.399	0.664	1.664	0.193
	0.7000	0.416	0.647	1.557	0.161
	0.8000	0.429	0.633	1.475	0.138
	0.9000	0.440	0.621	1.409	0.120
	1.0000	0.450	0.610	1.356	0.106

Table 24. Projected $F_{0.1}$ catch biomass for 1984, assuming that the 1983 TAC of 64,000 t is caught and $F_{0.1}$ = 0.20.

	1982	1983	1984
1	0	0	0
2	24	25	17
3	1371	1546	1181
4	6887	7047	5869
5	15616	13185	10062
6	9205	15733	9877
7	7642	6939	8819
8	5502	6935	4682
9	3679	4970	4638
10	2062	3430	3446
11	1258	1714	2120
12	574	966	877
13	741	478	536
14	622	472	226
15	250	474	267
16	319	185	260
1+	55752	64000	52899
2+	55752	64000	52898
3+	55728	63975	52881
4+	54358	62429	51701

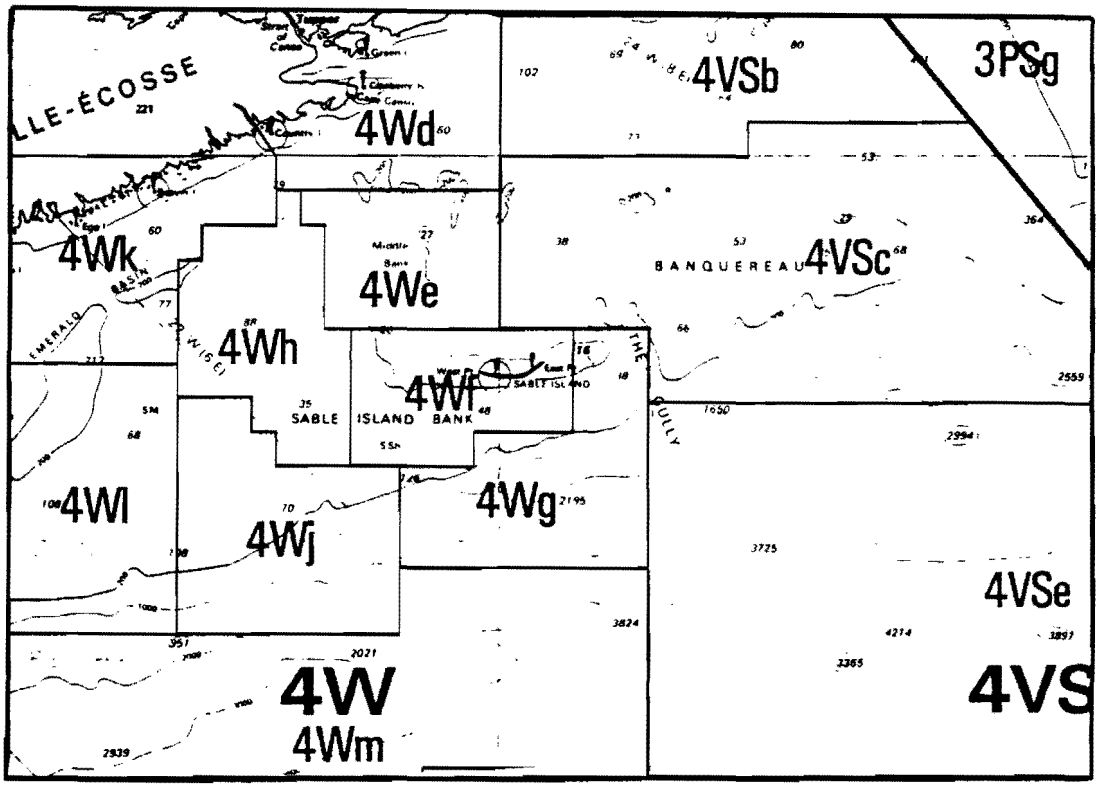


Figure 1. Unit areas 4VsW.

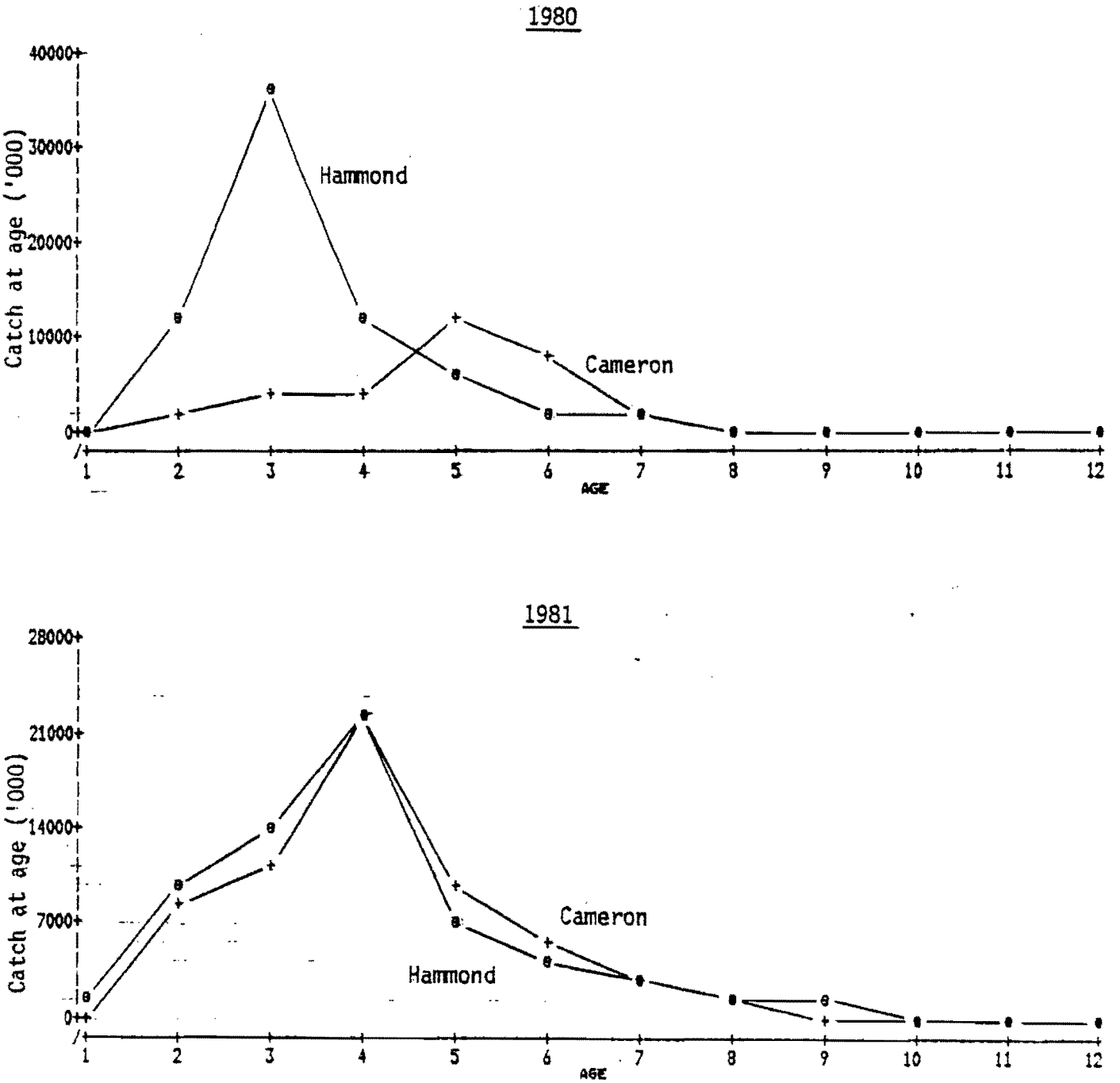
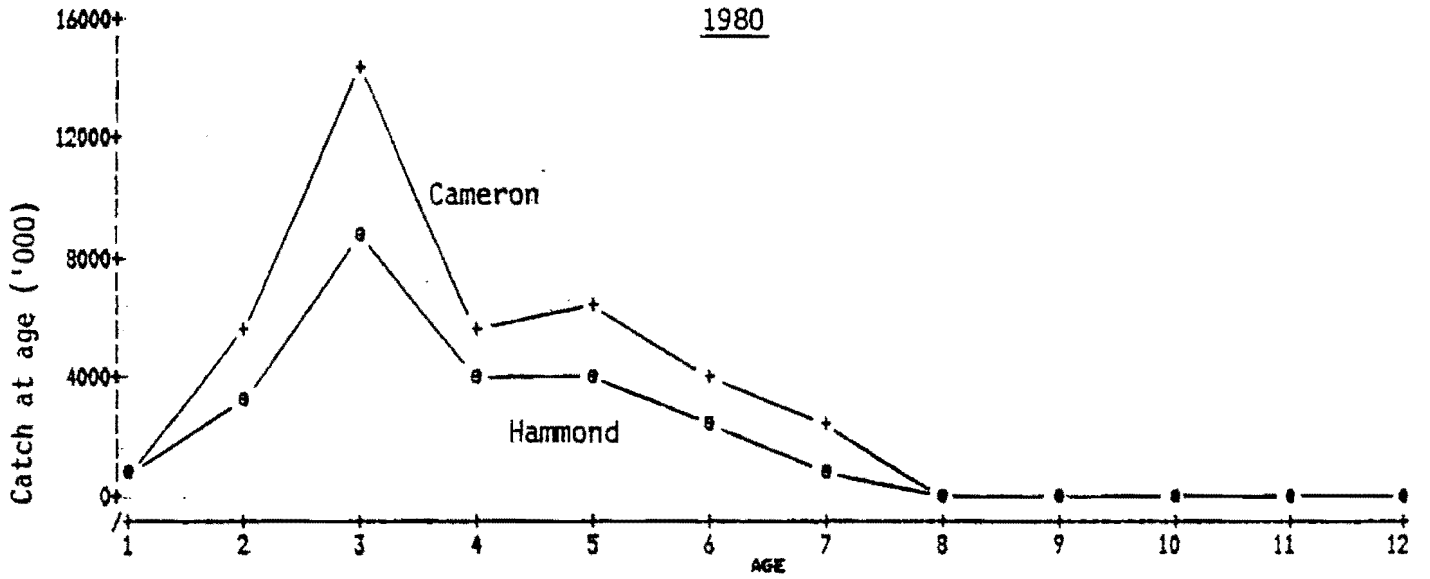


Figure 2a. Catches at age of cod in 4Vs by the A.T. Cameron and the Lady Hammond during the 1980 and 1981 summer groundfish surveys.



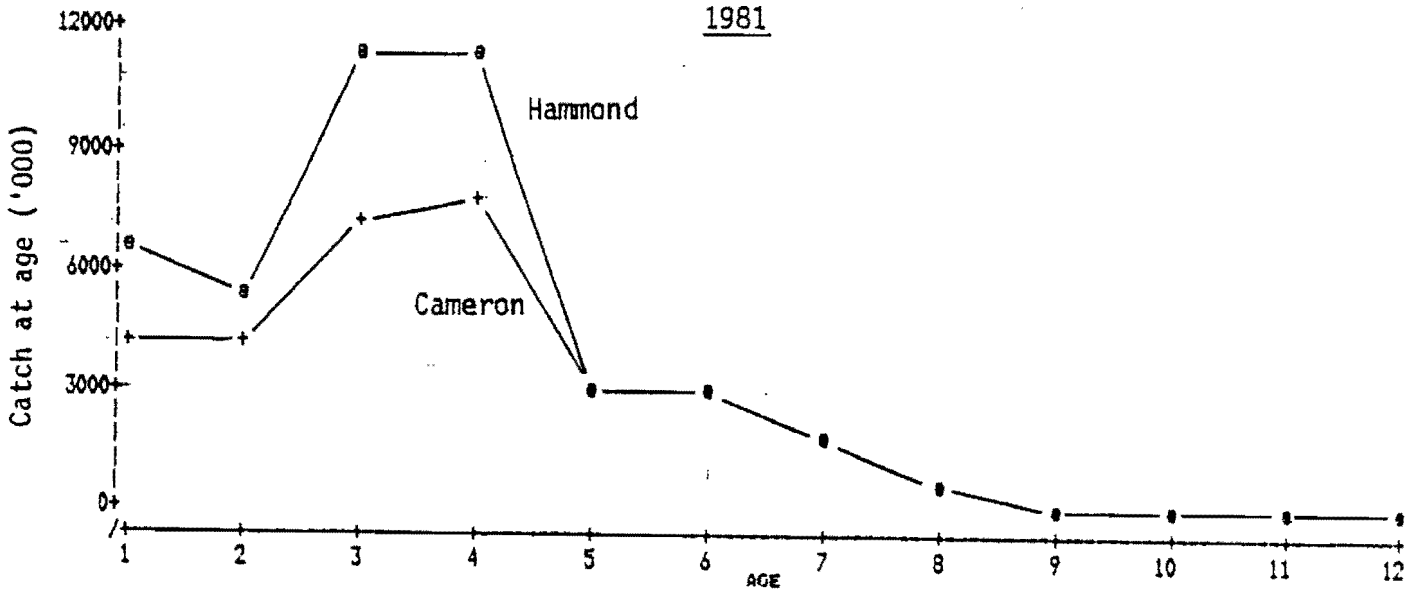


Figure 2b. Catches at age of cod in 4W by the A.T. Cameron and the Lady Hammond during the 1980 and 1981 summer groundfish surveys.

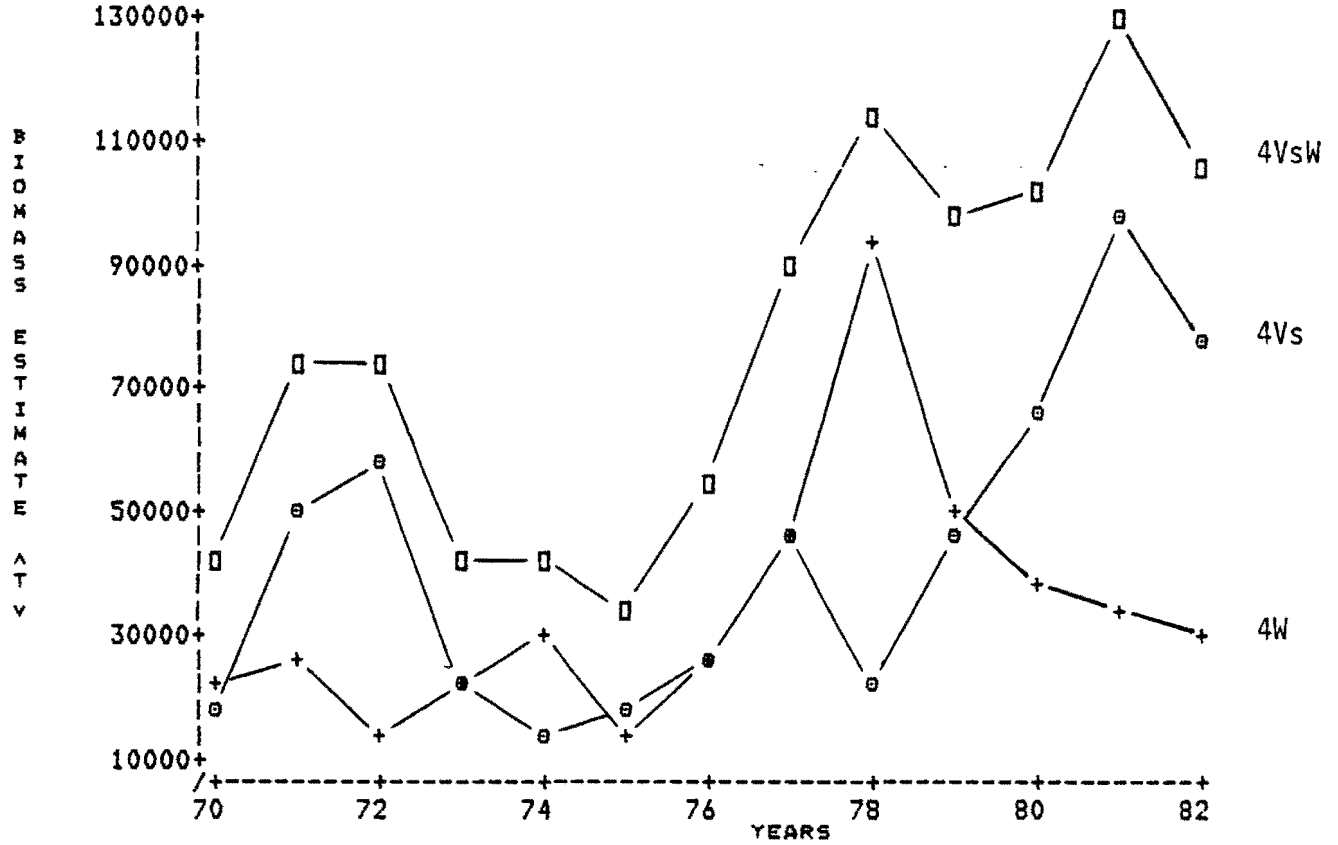
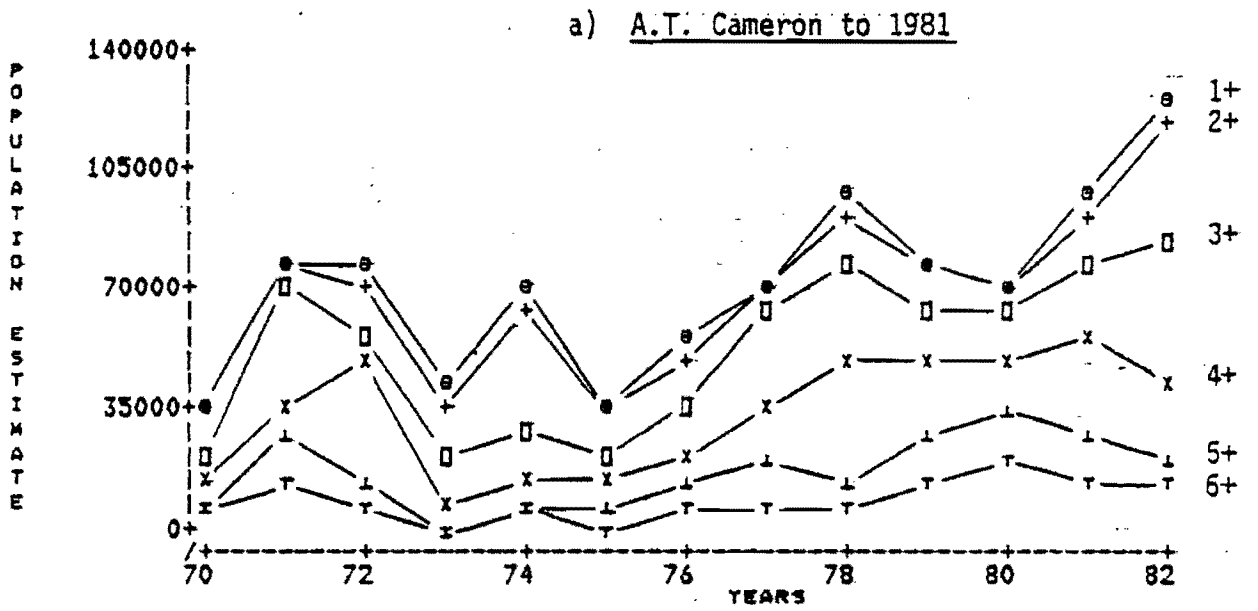


Figure 3. Research survey biomass estimates in 4VsW. The high catch values of 1973 and 1982 have been winsorised (cf. text).



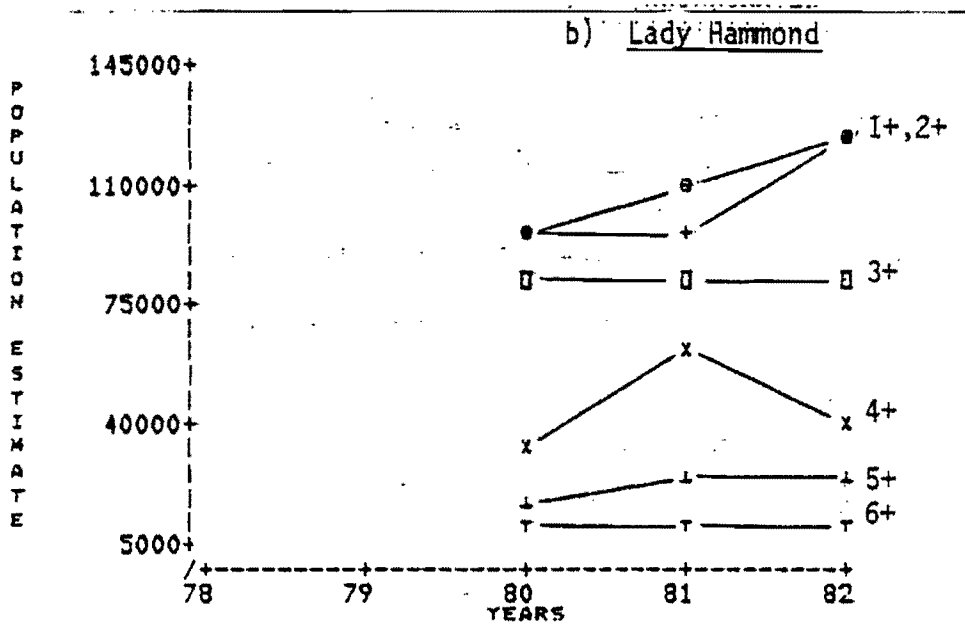
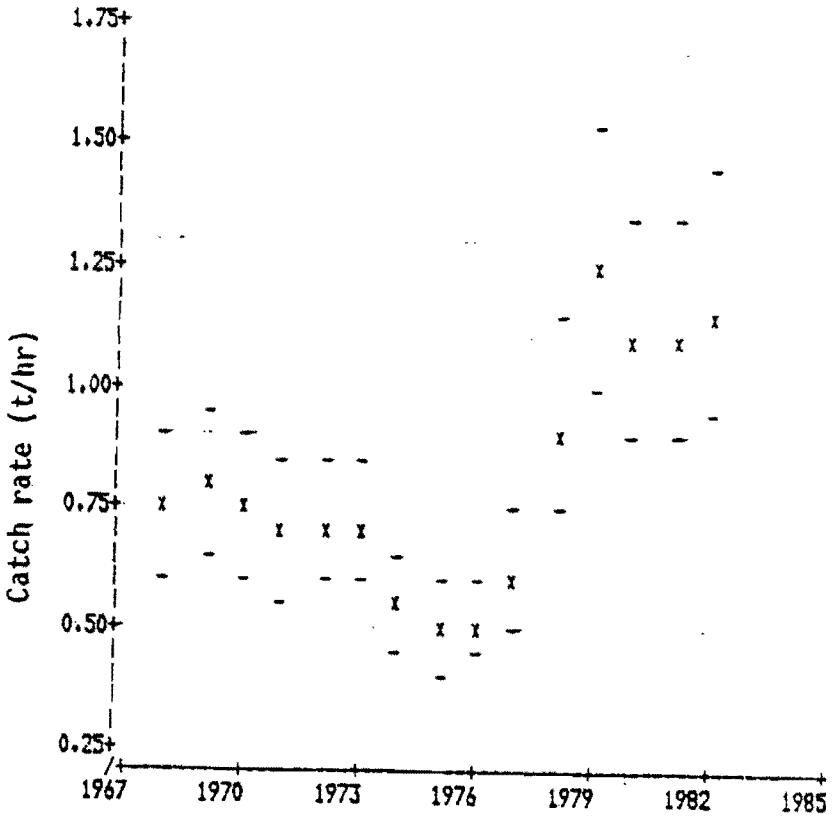


Figure 4. Research survey population estimate of 4VsW cod;
a) Lady Hammond data used for 1982 only
b) Lady Hammond data for 1980 to 1982



YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	S.E.	EFFORT
1968	80425	0.705	0.741	0.084	108606
1969	50157	0.688	0.788	0.096	63646
1970	57427	0.717	0.736	0.084	78019
1971	52563	0.641	0.685	0.078	76769
1972	61645	0.512	0.702	0.075	87773
1973	54070	0.625	0.693	0.078	78002
1974	43739	0.668	0.549	0.059	79698
1975	32517	0.491	0.485	0.054	67102
1976	24407	0.575	0.508	0.054	48039
1977	10390	0.339	0.611	0.082	17016
1978	25405	0.555	0.914	0.115	27803
1979	40030	0.546	1.249	0.157	32038
1980	49252	0.488	1.109	0.140	44412
1981	53718	0.500	1.079	0.136	49805
1982	55754	0.476	1.165	0.147	47869

AVERAGE C.V. FOR THE MEAN:0.118

Figure 5. Results of commercial catch rate standardisation.

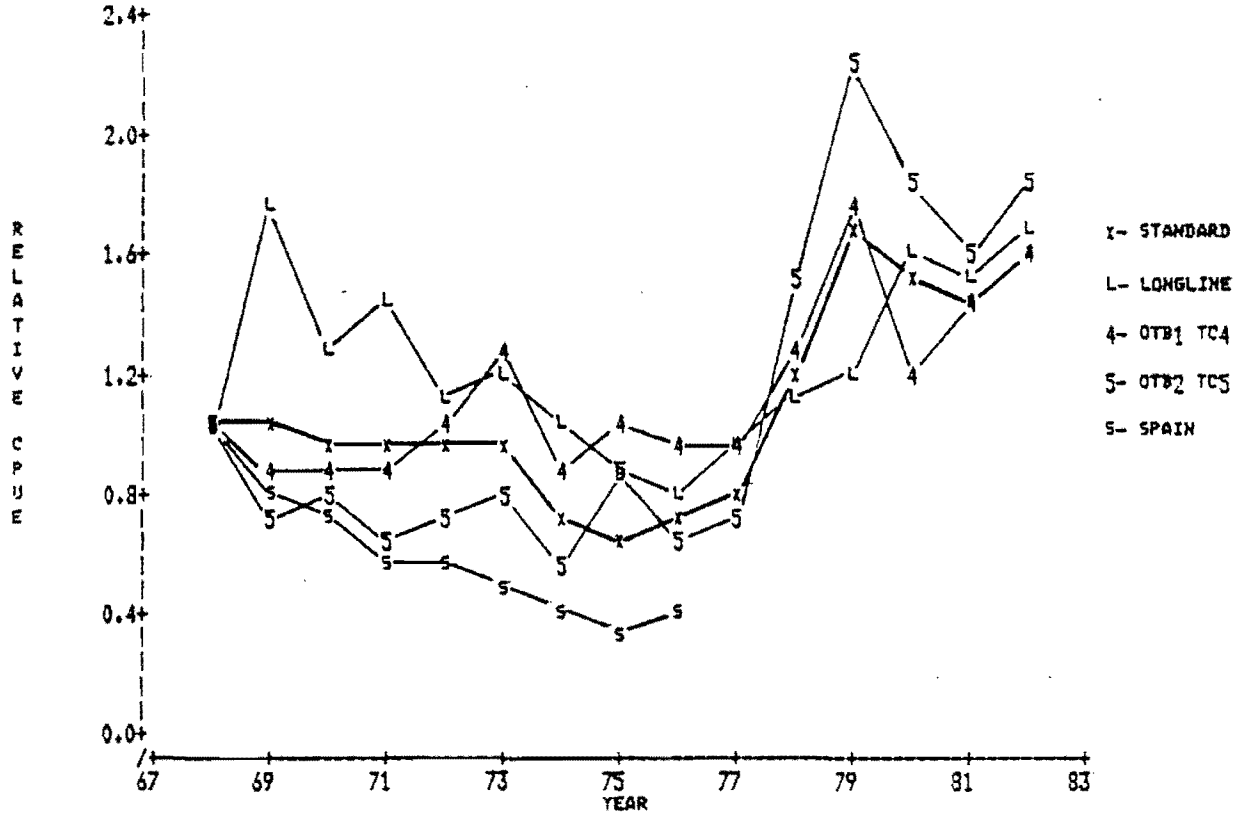


Figure 6. Comparison of standardised commercial catch rate with the original catch rates used for its calculation. Each series was divided by its 1968 value.

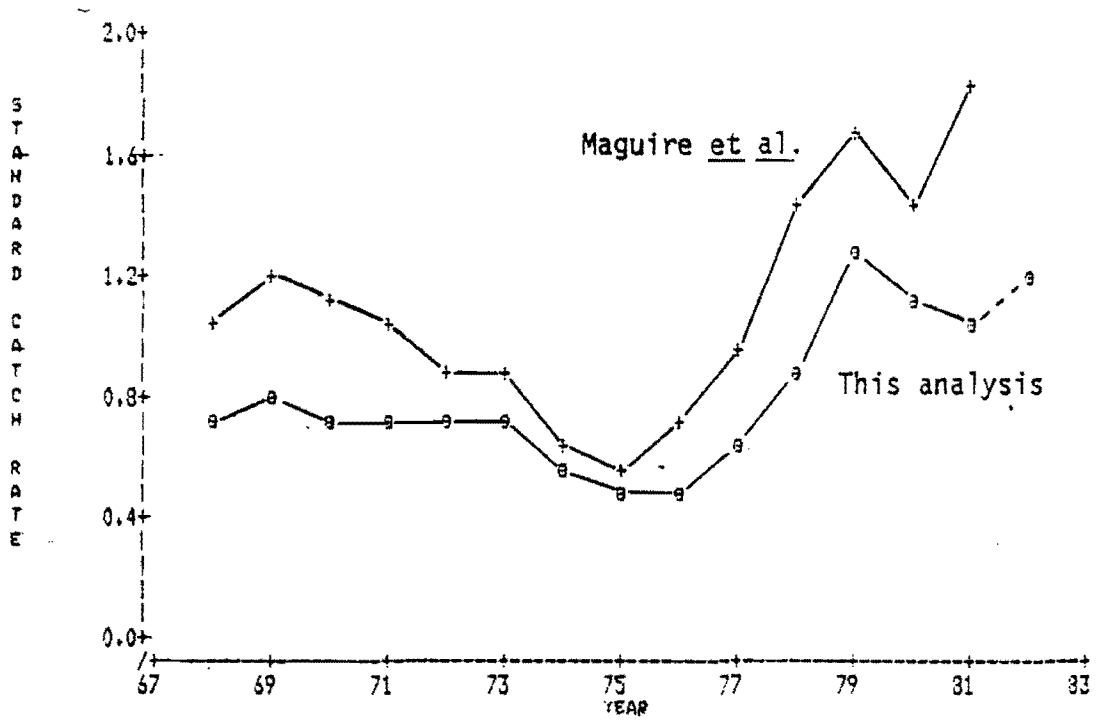


Figure 7. Comparison of our standardised commercial catch rate with that of Maguire et al. (MS 1982).

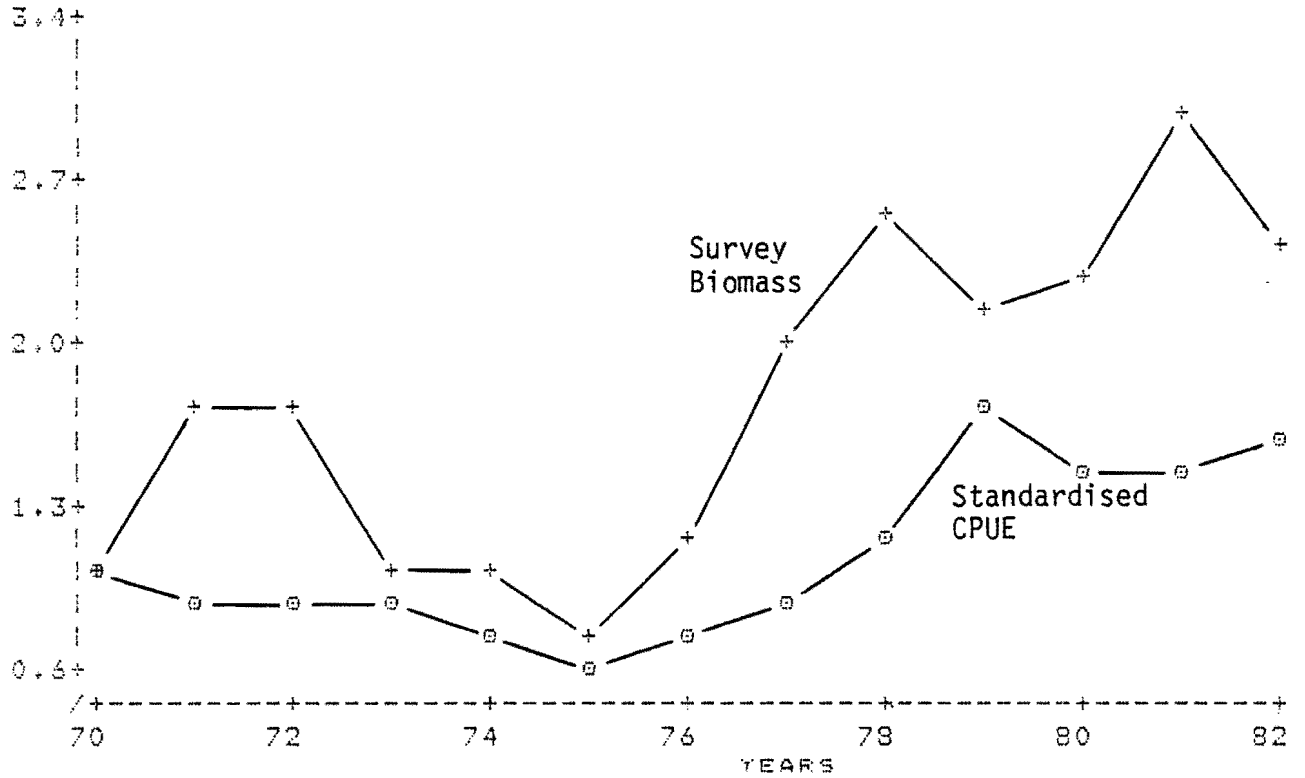


Figure 8. Comparison between the research survey biomass estimate (high catches of 1973 and 1982 winsorised) and the standardised CPUE. Each variable was divided by its 1970 value.

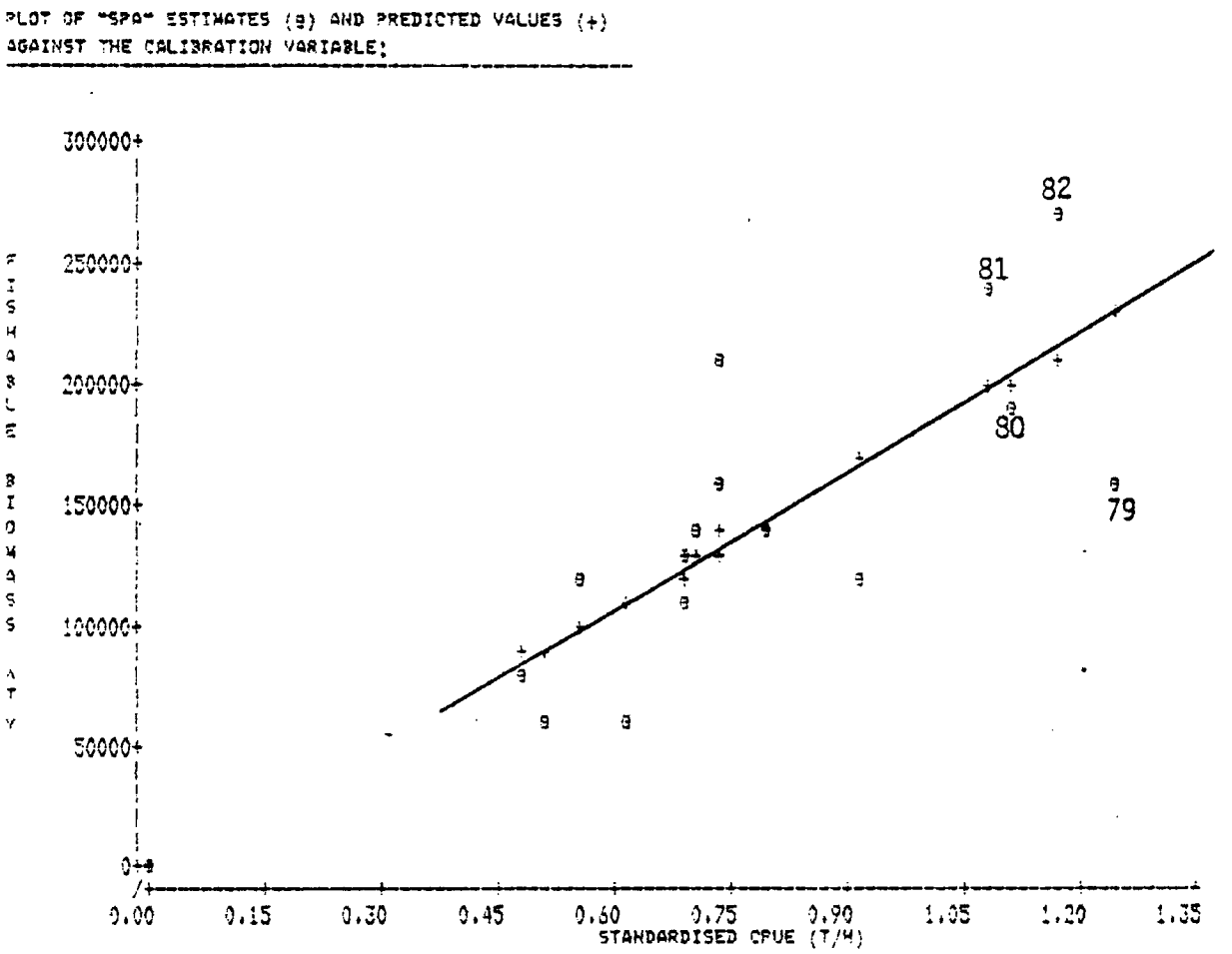


Figure 9. Relationship between fishable biomass and the standardised commercial catch rate; F_t = 0.25.

PLOT OF RATIOS (BASE=MEAN, THE LAST FOUR YEARS BEING EXCLUDED)
"SPA" ESTIMATES (@) AND CALIBRAT. VAR.(+).

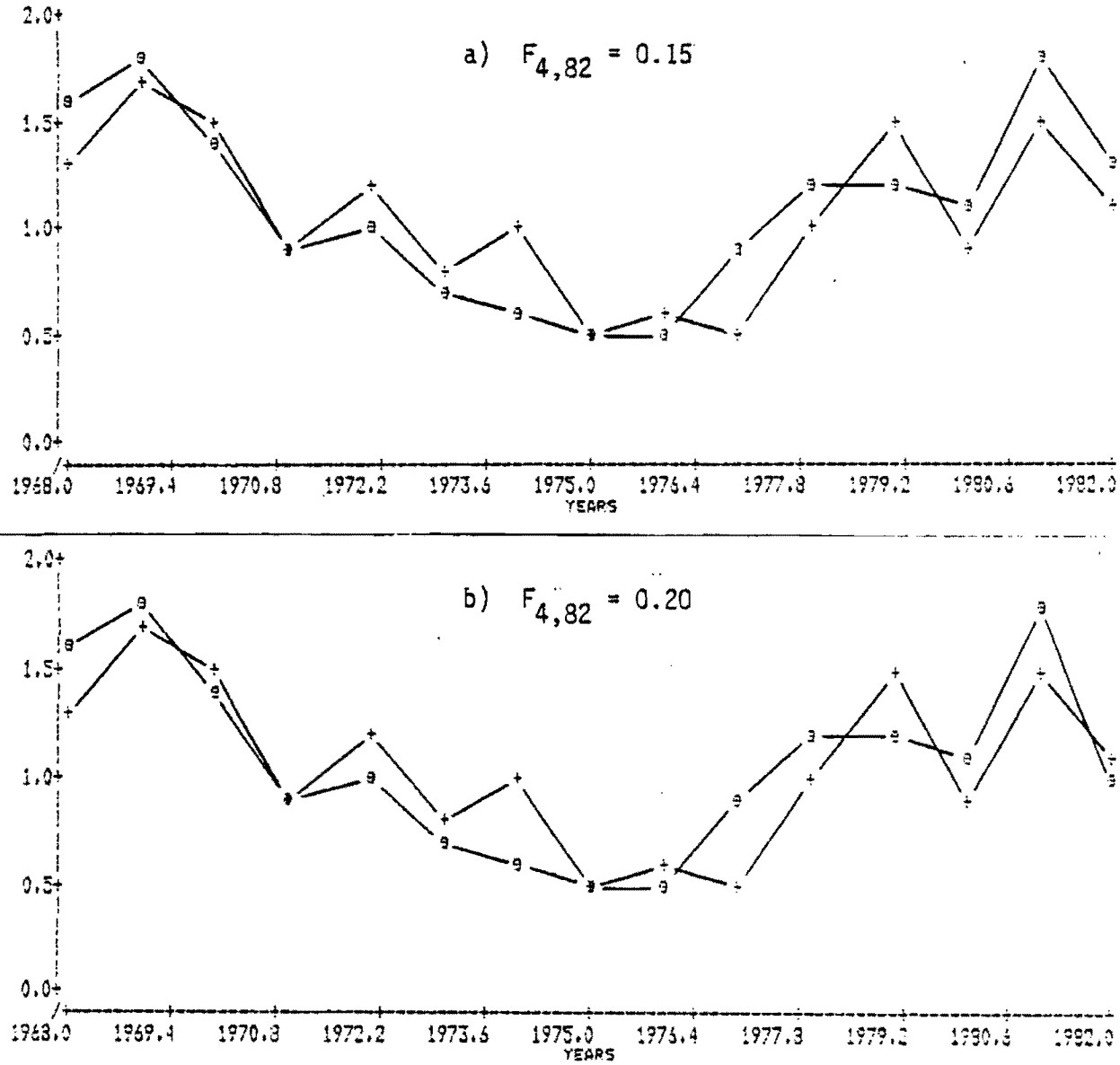


Figure 10. Comparison of the annual trends of the fishable biomass at age 4 and the standardised CPUE at age 4 (F_t = 0.25).

APPENDICES

Table A1. Results of the calibration of cohort 5+ numbers (mid-year) with R.V. 5+ population estimates (high catches of 1973 and 1982 winsorised).

Year	R.V. 5+ Population Estimates	COHORT	Pred.	P/C	COHORT	Pred.	P/C	COHORT	Pred.	P/C	COHORT	Pred.	P/C	COHORT	Pred.	P/C
1971	27621	54198	60929	1.12	53898	53681	1.00	53698	48850	0.91	53621	46992	0.88	53555	45400	0.85
1972	14617	38932	39467	1.01	38527	36007	0.94	38256	33701	0.88	38152	32814	0.86	38063	32054	0.84
1973	3037	31336	20355	0.65	30647	20268	0.66	30187	20211	0.67	30011	20188	0.67	29860	20169	0.68
1974	5660	25759	24684	0.96	24876	23833	0.96	24287	23266	0.96	24060	23048	0.96	23867	22861	0.96
1975	5260	20364	24024	1.18	19373	23290	1.20	18711	22800	1.22	18456	22612	1.22	18237	22451	1.23
1976	11029	18398	33545	1.82	17109	31130	1.82	16248	29521	1.82	15917	28902	1.82	15633	28371	1.82
1977	18672	23122	46159	2.00	21294	41518	1.95	20078	38424	1.91	19610	37235	1.90	19210	36215	1.88
1978	14273	39882	38899	0.98	36755	35539	0.97	34673	33300	0.96	33874	32439	0.96	33189	31701	0.96
1979	31396	57344	67159	1.17	52056	58812	1.13	48533	53247	1.10	47180	51108	1.08	46020	49274	1.07
1980	36256	67824	75180	1.11	59272	65417	1.10	53572	58909	1.10	51380	56406	1.10	49502	54262	1.10
1981	28016	72799	61581	0.85	61094	54218	0.89	53288	49310	0.92	50286	47422	0.94	47713	45805	0.96
1982	24208	97320	55296	0.57	77856	49042	0.63	64880	44874	0.69	59889	43271	0.72	55611	41897	0.75
r			0.74			0.77			0.78			0.79			0.78	
r^2			0.55			0.60			0.62			0.62			0.61	
B_o			15342			16140			16672			16877			17052	
F_t			0.200			0.250			0.300			0.325			0.350	

Table A2. Research survey biomass estimates (t). The very high catches of 1973 and 1982 have been winsorised.

Year	4Vs	4W	4VsW
		A.T. Cameron	
1970	19919	23798	43717
1971	48893	26986	75879
1972	58389	13842	72231
1973	20634	23007	43641
1974	12808	30418	43226
1975	17589	14766	32355
1976	24893	27303	52196
1977	45274	44227	89501
1978	20269	94318	114587
1979	45252	50768	96020
1980	64982	37631	102613
1981	96762	33016	129778
		Lady Hammond	
1982	79299	28096	107395