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Assessment of 4VsW Cod in 1991

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Abstract

The 1991 fishery for 4VsW cod took 32,698 t, a shortfall of about 2000 t from the TAC and 1400 t less than in 1989. This is the smallest catch since 1978. The proportion of the catch taken in Subdiv. 4Vs steadily declined from 88% in 1988 to 75% in 1991 perhaps indicating a return to the more equal division of catches seen prior to the mid-1980's.

The 1990 and 1991 catch at age in the 1st quarter indicated a significant amount of slow-growing fish (4400 t out of approximately 10000 t for Jan - Apr.) presumably from the 4TVn stock were being caught in 4Vs (J.M.Hanson & G. Nielson pers comm.). In some runs the catch at age and the total catch were adjusted for the slow growing fish to more accurately estimate the impact if these fish were not from 4VsW stock(s). This is not to suggest a problem with misreporting, but rather a more extensive migration by the 4TVn stock out of the Gulf of St. Lawrence.

The SPA was calibrated using both July and March RV indices in ADAPT. The retrospective trend that was previously reported (Fanning & MacEachern, 1991) is still evident in the results of the SPA. However, a bootstrap method (Mohn, In prep.) is shown to remove the retrospective patterns and produce stable estimates in the contemporaneous year. Both the point and bootstrap estimates for F_{1991} are well above $F_{0.1}$. On the other hand, the SPA's suggest that recent recruitments (especially the 1987 yearclass and perhaps that of 1989) have been above average.

A biological indices of the resource status based on RV and commercial trends suggest that the stock is in a degree of decline. Although not used in tuning the SPA, the 1992 March survey is more than an order of magnitude lower than the 1991 value. Meanwhile, the mean catch per tow (#'s) from the 1991 summer survey fell by more than factor of 2 from the 1990 level and is approximately half of the average since 1971 The indices were consistent in indicating that the stock size had declined from the mid-1980's. The 1986 yearclass is still estimated to be above average in size but the 1987 yearclass although average is much smaller than the 1990 estimate. Also, both commercial data and IOP catch rates fell from 1990 to 1991. As all indices are down in 1991-92 and the F_{1991} is well above target levels, this stock should be closely monitored to determine the severity of the situation.

Résumé

En 1991, les prises de morue de 4VsW se sont établies à 32 698 t, soit environ 2 000 t de moins que le TPA et 1 400 t de moins qu'en 1989. Ce sont là les prises les plus basses depuis 1978. La proportion des captures provenant de la subdivision 4Vs est en régression constante, étant passée de 88 p. 100 en 1988 à 75 p. 100 en 1991, ce qui pourrait être le signe d'un retour à la division plus équitable des prises qui existait avant le milieu des années 80.

Les données sur les prises selon l'âge des premiers trimestres de 1990 et de 1991 révélaient la présence d'une grande quantité de poissons à croissance lente, provenant apparemment du stock de 4TVn, parmi les captures provenant de 4Vs (4 400 t sur environ 10 000 t de janvier à avril) (Communication personnelle de J.M. Hanson et G. Nielson). Dans certains cas, on a modifié les prises selon l'âge et les prises totales, pour tenir compte des poissons à plus faible croissance, de manière à ce qu'elles reflètent plus précisément la situation si ces poissons ne proviennent pas du ou des stock(s) de 4VsW. Cette correction a été apportée non à cause d'un problème de fausses déclarations, mais plutôt en raison de migrations plus vastes du stock de 4TVn hors du golfe du Saint-Laurent.

L'ASP a été étalonnée au moyen des données des campagnes d'évaluation de juillet et mars, en suivant la méthode ADAPT. La tendance rétrospective des données, constatée dans les évaluations antérieures (Fanning et Mac Eachern, 1991), est encore manifeste dans les résultats de l'ASP. Toutefois, l'emploi d'une méthode fondée sur le principe boostrap (Mohn, 1992) élimine cet aspect rétrospectif et produit des estimations stables pour l'année considérée. Les deux, les estimations ponctuelles que celles obtenues par la méthode boostrap pour F_{1991} sont bien supérieures à $F_{0.1}$. Par ailleurs, l'ASP semble indiquer que le recrutement récent (en particulier dans la classe d'âge de 1987 et peut-être aussi dans celle de 1989) a été supérieur à la moyenne.

Des indices biologiques sur l'état de la ressource, fondés sur les données des campagnes d'évaluation et sur la pêche commerciale, révèlent un certain recul du stock. Quoiqu'on ne les ait pas utilisés pour mettre au point l'ASP, les résultats de la campagne d'évaluation de mars 1992 sont inférieurs de plus d'un ordre de grandeur à ceux de 1991. De plus, la quantité de prises moyennes par trait au cours de la campagne d'évaluation de l'été 1991 a été deux fois moindre qu'en 1990 et s'établit à la moitié environ de la moyenne depuis 1971. Tous les indices ont confirmé que l'abondance des stocks a diminué depuis le milieu des années 80. Du point de vue de la grosseur des classes d'âge, celle de 1986 est toujours jugée supérieure à la moyenne, mais celle de 1987, quoique se situant dans la moyenne, est bien inférieure à l'estimation effectuée en 1990. Les taux de prises établis en fonction des données de la pêche commerciale et ceux qui proviennent du Programme des observateurs internationaux ont aussi diminué de 1990 à 1991. Tous les indices étant en recul en 1991-1992 et le F_{1991} étant bien supérieur aux niveaux cibles, le stock devrait faire l'objet d'une étroite surveillance permettant de déterminer la gravité de la situation.

Description of the fishery

Catches of 4VsW cod (Tables 1-3, Figure 1) ranged from 40,000 t to 80,000 t in the years 1958 to 1974 and then declined rapidly to a low of 10,000 t in 1977. Subsequent to extension of jurisdiction the catches quickly climbed again and were at or above 50,000 t from 1980 to 1986. Under quota restrictions, the TAC's have been reduced and consequently the catches have declined in recent years to 32,698 t in 1991, the lowest catch since 1978. Since 1977 the foreign catch has only exceeded 1000 t once and in 1991 was approximately 200 t, primarily bycatch in the silver hake fishery. Anecdotal information suggests that there was a strong "river" of fish from the Gulf in 1991 that contributed to the January to April fishery in 4Vsb. In the same period in 1992 the "edge" fishery was not nearly as strong. Prior to 1980, the total catch was nearly equally split between Subdiv. 4Vs and Div. 4W however, since 1980 the percentage of the catch coming from Subdiv. 4Vs climbed from 60% to a high of 87% in 1988 (Figure 2). The percentage has declined for the last three years and was 75% in 1991, the lowest since 1983. The proportion of the catch taken by each gear type (Tables 2 and 3) is essentially unchanged from 1989 with over 70% of the catch taken by otter trawls, 25% taken by longline and handline and the remainder taken primarily by seines and gillnets. The catches were close to the final allocations for all gears except the FG 45-64 ' (870 t shortfall), MG <65' (400 t shortfall) and the vessels >100' which were about 1000 t short of their final allocation (2500 t short of their initial allocation). The CFSAC advice, TAC and nominal catches (kt), with and without correction for 4TVn contributions, are summarized in the following text table. Details of the resource management in 1991 are given in Table 4.

Year	1986	1987	1988	1989	1990	1991	1992
CAFSAC Advice	35	44	38	33.2[b]	35[b]	35.2[c]	35.2[c]
TAC (nominal)	48	44	38	35.2	35.2	35.2	35.2
Catch (Total)	51.5	45.5	38.4	36.8[a]	34.3[a]	32.9[a]	
Catch (Corrected)	48.1	43.5	35.9	34.2	29.7	26.6	

[a] Preliminary
[b] 50% rule
[c] Advised that constant catch would not be detrimental

The proportion of the total 4VsW catch taken by otter trawls in 4Vs in the first quarter has increased in recent years, Figure 3. The increase in the 1st quarter fishery will likely affect the amount of 4TVn caught in the nominal 4VsW fishery.

Data

Catch and weight at age

The 1990 catch at age was constructed by using six separate keys (Tables 5 and 6), mobile gears (trawlers and seines) for Quarter 1, Quarter 2 and Quarters 3+4 (H2), fixed gears (longline and handline) for first and second halves of the year (H1 and H2), and gillnets for the full year. The parameters of the length/weight relationships were estimated from the 1991 March and July RV surveys and applied to the keys for the appropriate time periods. The keyed catch accounted for more than 98% of the total catch and was pro-rated to the total. The catch at age is given in Table 7.

Examination of the age compositions resulting from each key and for each half year showed that the mobile gear catch at age for the 1st Quarter (Q1-OTB), which accounted for over half the total catch in numbers, had substantially higher proportions of fish at ages 8+ than the other keys, except the small gillnet sample. Inspection of the mean weights at age for each key indicated that the Q1-OTB key also estimated mean weights at age substantially below any of the other keys and which were inconsistent with other years.

The mean size at age in southern Gulf (4TVn) cod is substantially smaller than in 4VsW cod and they are known to migrate into 4Vn in the winter to the degree that catches from the 4Vn (Jan.- Apr.) fishery are considered part of the 4TVn spawning group for management purposes. There have also been industry reports in the past that indicate parts of the 4TVn migration may extend southward into 4Vb and perhaps even 4Vc, however, as this usually involves small quantities of catch, the impact has been assumed negligible. However in the most recent years, the Q1-OTB catch accounted for over 15,000 t out of less than 35,000 t (45%) in 1990, and the 1991 quota reports indicate that the Q1-OTB catch was 14,500 t (41%) of the 35,200 t TAC. The change in the fishery over the last decade can be seen in Figures 4 and 5 which compare 1981 and 1989 surveillance sightings of Canadian vessels that were fishing for the first four months of the year and IOP observations for 1981 and 1991. The shift from the shelf to the edge is quite pronounced. Corrections for the proportion of the catch that are slower growing, and presumably to a large degree from 4T, were estimated for 1986-1991 (J.M.Hanson & G. Nielson pers comm.) and are given in Table 8. When the corrected catch is used in subsequent analyses is will be specified otherwise the uncorrected catch has been employed.

The commercial mean weights at age (Figure 6 and Table 9) in 1991 continue the recent trend to smaller weights at age. The mean weights at age peaked in the early eighties and have slowly fallen since that time.

Commercial catch rates

The data for the years 1968-1988 were extracted from the NAFO data base and 1989-1991 were extracted from the Interzonal (ZIFF) database and aggregated into the same the gear/area/month categories previously defined by Sinclair and Smith (1987). Selection criteria removed catch or landings of less than 10 units. Throughout the 1980's the C/E remained higher than the 1970's and relatively stable, with the exception of 1985-86 which were the highest observed. The 1991 value fell about 25% from the 1990 value. See Table 10 and Figure 6.

The Canadian OTB (TC 4-5) catch rates from the IOP were calculated for the years 1982-1991. (Table 11, Figure 7) The observed catch has varied between 7% and 17% of the total OTB catch during 1982-89, however, in 1990 the IOP observed 34% of the OTB catch. When standardized to the same basis, the C/E based on the IOP was significantly higher than that based on the commercial statistics in 1984-89 but nearly equal in 1982, 83 and 90 and 1991. A possible explanation for this pattern is discussed in Fanning & MacEachern (1991) and is attributed to changes induced by the practice of fishing to "shopping lists". Until the poor agreement in the two CPUE series is resolved they will not be included in tuning SPA's.

Research vessel surveys

The July stratified random trawl survey of 4VsW has been conducted annually since 1970, however the 1970 estimates of abundance are not used in the assessment of this stock because of variations in gear and survey protocol. Tow means and variances are given in Tables 12 and 13. In addition, the survey estimates for 1970 were deemed inconsistent

with the SPA estimates in previous assessments. The research vessel conducting the survey was changed in 1982 and 1983 due to the retirement of the A.T. Cameron, the temporary use of the Lady Hammond (in 1982) and the advent of the Alfred Needler in 1983. The catches from the A.T. Cameron and the Lady Hammond were adjusted by a cod conversion factor of 0.8 to account for the change in the survey vessel. Because of differences in age composition, the stratified estimates of mean catch per tow and coefficients of variation were calculated for 4Vs and 4W separately, and combined by weighting by strata areas. Due to vessel failure of the Needler, the 1991 July survey was completed by the Lady Hammond. The conversion factor had then to be applied on a set by set basis in the construction of the survey estimates. The 3+ numbers are shown in Figure 8.

A second survey has been conducted in March from 1979 to 1992 with the exception of 1985 (Tables 14 and 15). The same conversion factor was applied to the March surveys for the years 1979-83 when the Lady Hammond was the survey vessel. See Figure 8 for 3+ numbers from this survey. From time to time the estimation of abundance from the March survey has been complicated by missing strata due to the presence of ice in the survey area. However, in 1991 and 1992 there were no missing strata although a number of strata contained only 1 set. The CV's associated with the March survey estimates are generally larger than in the July survey, probably reflecting the more aggregated distribution of fish in the winter. Also, parameters related to this survey have lower levels of significance when fit to SPA's.

The July survey mean catch per tow in recent years, 1987-90, was higher than all years prior to 1982 except for 1973, but well below the peak of 1982-84. The 1991 point was beneath the long term average. The general trend in the March surveys was similar although 1986 and 1990 seemed to be extremely high and low, respectively, relative to the July estimates. The March survey estimate for ages 4+ was very low in 1990. However, in 1991 the estimate, which includes the strong 1987 yearclass, is comparable to the early 1980's. The March 1992 numbers are the lowest on record for this survey.

Both surveys series have indicated that the 1986 and 1987 yearclasses are above average. The 1987 yearclass has constituted 44% to 49% of the mean catch per tow (in numbers) in 4 of the 5 surveys available for 1989 to 1991, and it was 30% of the total numbers in the fifth survey (July 1989).

The efficiency of the both surveys for 1991 and the March 1992 survey have been calculated (Gavaris & Smith, 1987). The 1991 surveys both had efficiencies greater than 50% showing that the design were advantageous. The 1992 March survey had an efficiency of 14%.

Estimation of parameters

This stock has displayed a retrospective pattern of such severity that recent SPA's were not accepted. Mohn (In prep.) investigated this problem and showed that by applying conditioned bootstrapping the converged values of terminal F could be well estimated in the contemporaneous year. The procedure is unfortunately computer intensive. The basic formulation is:

Parameters:

Terminal F estimates --	$F_{i,1991}$, i=3 to 8
Calibration coefficients --	$K_{1,i}$, i=3 to 8 for July RV survey
--	$K_{2,i}$, i=3 to 9 for March RV survey

Structure Imposed:

Error in catch assumed negligible
Partial recruitment fixed for ages 1, 2, and 9+
F on oldest age (15) set to 95% of the average F ages 7-9
No intercept was fitted
M=0.2

Input:

$C_{i,t}$, i=1 to 15; t=1971 to 1991 - Full year catch at age
$J_{i,t}$, i=3 to 9; t=1971 to 1991 - July RV index
$M_{i,t}$, i=3 to 9; t=1979 to 1991 - March RV index (excluding 1985)

Objective function: Minimize

$$\Sigma\,\Sigma\,\{\ln J_{i,t} - K_{i,t}\,N_{i,t}\}^2 - \Sigma\,\Sigma\,\{\ln M_{i,t} - K_{i,t}\,N_{i,t}\}^2$$

Summary:

Number of observations: 132 July RV
84 March RV

Number of parameters 19

The SPA results are not used because of the strong retrospective pattern which was produced. This pattern has also been seen in previous years for this stock. Table 16 shows 5 years consecutive estimates of average F ages 7-9 using data from 1970-1988, 1970-1989 etc. Looking down a column (eg. 1987) it is seen that successive estimates are increasing considerably as more data are accumulated.

Retrospective Analysis and Bootstrapping.

All the ADAPT formulations investigated for this stock continue to show the retrospective pattern that has been of concern in this assessment for the last few years. Mohn (In prep.) has shown that for this stock if conditioned bootstrapping is performed with the research survey data that the mean of the estimates does not display the retrospective pattern. In the Table 17 the same formulation as given above has been repeated 75 times for each of the 5 data series. Residuals from the survey are resampled with replacement (conditioned bootstrapping) for the replicate SPA's. The means of the bootstrapped runs are seen to be much more stable than the point estimates and the "converged" value is well estimated in the contemporaneous year. The bootstrap estimate for the 1991 for average F is 0.97 as opposed to the point estimate of 0.69. Due to the dissimilarity of the average F's between the bootstrap and point estimates, estimates from the bootstrap mean are used as an indication of stock status (Tables 18-20 and Figures 9-11) and for projections.

ADAPT was run with the above formulation also when the estimated Gulf contribution to the catch was removed for 1990 and 1991. The solution gives a lower F in 1991 (0.88 vs. 0.92) and earlier estimates are unaffected. The removal of these fish does not significantly affect ones interpretation of the status of this stock, particularly when one recalls the approximate 50% CV on the estimates of standing stock in 1991.

Prognosis

The numbers are projected ahead from base run of ADAPT with a GM recruitment of 69 million. The weights are the average commercial weights for the last 5 years and the selectivity is the average from the SPA results for 1989-1991. Due to the instability in the

bootstrap estimates, probably due to the low number of replicates (75), another technique was also used to estimate recruitment in recent years (A. Sinclair pers. comm.). A multiplicative model was used to estimate yearclass strength at age 3. See Figure 10. The estimates for the 1987-1989 yearclasses were aged ahead using the cohort equation to 1992 and the results are in the column N_{model} Values used in stock projections are:

Age	N_{1992}	Weight	Selectivity		N_{model}
1	68800	.000	.000[a]	.000[b]	68800
2	56300	.223	.000	.000	56300
3	46100	.685	.012	.014	32737
4	18482	.953	.132	.156	30136
5	72660	1.229	.404	.480	35990
6	15803	1.527	.623	.740	15803
7	4346	1.832	.801	.951	4346
8	1246	2.267	.934	1.000	1246
9	325	2.664	.924	1.000	325
10	311	3.252	.789	1.000	311
11	148	4.704	1.000	1.000	148
12	285	5.518	.825	1.000	285
13	37	7.055	.875	1.000	37
14	58	11.156	.560	1.000	58
15	25	10.203	.833	1.000	25

[a] average of 1988 to 1990

[b] smoothed and used for projections

Projections with the SPA data were done assuming a 35200 t TAC for 1992 and 50% rule for 1993 and 1994

Year	1992	1993	1994
Yield	35.2	28.7	24.2
Biomass 3+	148	147	153
Biomass 6+	36.2	84.2	73.3
F_{7-9}	0.57	0.40	0.30

and with a constant 35.2 kt TAC for the 3 year period:

Year	1992	1993	1994
Biomass 3+	148	147	141
Biomass 6+	36.2	84.2	67.5
F_{7-9}	0.57	0.51	0.51

The same projections were performed using the model based 1987-1989 yearclass estimates. This was done to check the sensitivity of the projections to the strong 1987 SPA estimated year class. The following projections are considered conservative estimates of these yearclasses. With constant TAC's

Year	1992	1993	1994
Yield	35.2	35.2	35.2
Biomass 3 Jan1	112	108	106
Biomass 6+	36.2	45.1	37.7
F_{7-9}	0.82	0.86	0.98

and with the 50% rule for 1993-4.

Year	1992	1993	1994
Yield	35.2	19.0	17.2
Biomass 3+	112	108	122
Biomass 6+	36.2	45.1	51.9
F_{7-9}	0.82	0.40	0.30

The 1987 yearclass was identified in the last assessment as being above average. The addition of new surveys and the 1990 catch at age 3 enhances this view and indicates that the 1987 yearclass is comparable to the largest since 1971. The 1986 yearclass is also above average in the surveys and these two yearclasses may be important in the 1991 and 1992 fisheries.

The 6+ biomass and yield for 1993 as a function of increasing fishing mortality are shown in Figure 12. The impacts of dropping from the 1991 fully recruited fishing mortality to a level near F0.1 are considerable. The yield would fall to about a third while the survivors in terms of 6+ biomass would almost double.

Recruitment estimates from either the SPA or the SPA-multiplicative model series (Figure 10) show that only 1 recruitment since 1982 has been above the GM average. The 6+ biomass has fallen steadily since 1986. Furthermore both the 1991 catch rate series and 1991 summer survey and the 1992 spring survey fell in the most recent year. The 1992 point is the lowest observed but its reliability is not yet established. Industry has been complaining of a lack of fish in the first few months of 1992 although they reached their catch cap. If F_{Max} were applied to 1992 the resultant catch would be of the order of 20 kt, an amount that may be attained by mid-year. Some portion of the 1992 catch is attributable to 4TVn, presumably a few thousand tons. The problem of accounting for 4TVn fish in the assessment and subsequent advice

References

Fanning, L.P. and W.J. MacEachern. 1991. Assessment of 4VsW cod in 1990. CAFSAC Res Doc. 91/44. 42p.

Gavaris, S. and S.J. Smith. 1987. Effect of allocation and stratification strategies on precision of survey abundance estimates for Atlantic cod (*Gadus morhua*) of the eastern Scotian Shelf. J. Northw. Atl. Fish. Sci. 8:137-145.

Hanson, J.M. and G.A. Nielson. Pers. Comm. 1992. DFO, Moncton, N.B.

Mohn, R. In prep.. Bootstrap estimates of ADAPT parameters, their projection in risk analysis and their retrospective patterns. Submitted to Can J. Fish. Aquat. Sci.

Sinclair, A. Pers. Comm. 1992. DFO, Mont Joli, P.Q.

Sinclair, A. and S.J. Smith. 1987. Assessment of 4VsW cod. CAFSAC Res. Doc. 87/92. 62p.

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

YEAR	CANADA	FRANCE	PORTUGAL	SPAIN	USSR	OTHERS	TOTAL	SUBDIV. 4Vs	DIV. 4W	TAC
1958	17938	4577	1095	14857	-	124	38591	23790	14801	-
1959	20069	16378	8384	19999	-	1196	66026	47063	18963	-
1960	18389	1018	1720	29391	-	126	50645	27689	22956	-
1961	19697	3252	2321	40884	113	42	66309	34237	32072	-
1962	17579	2645	341	42146	2383	60	65154	26350	38804	-
1963	13144	72	617	44528	9505	307	68173	27566	40607	-
1964	14330	1010	-	39690	7133	1094	63257	25496	37761	-
1965	23104	536	88	39280	7856	122	70986	36713	34273	-
1966	17690	1494	-	43157	5473	711	68525	27177	41348	-
1967	18464	77	102	33934	1068	513	54158	26607	27551	-
1968	24888	225	-	50418	4865	32	80428	48781	31647	-
1969	14188	217	-	32305	2783	672	50165	22316	27849	-
1970	11818	420	296	41926	2521	453	57434	28639	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	2592	54093	23401	30692	60500
1974	10700	35	1464	27384	3097	1061	43741	19611	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
1979	39219	18	-	2	683	108	40030	15393	24637	30000
1980	48821	17	5	5	338	66	49252	31378	17874	45000
1981	53053	-	-	-	630	35	53718	32107	21611	50000
1982	55675	-	-	-	45	34	55754	40110	15644	55600
1983	50898	-	1230	-	190	62	52380	33170	19210	64000
1984	52104	-	303	-	110	29	52546	42578	9968	55000
1985	56553	-	870	-	21	11	57455	48189	9266	55000
1986	51467	-	-	-	28	34	51529	44028	7501	48000
1987	45430	-	-	-	25	48	45503	39755	5748	44000
1988	38215	-	-	-	106	35	38356	33729	4627	38000
1989	36574[1]	-	-	-	168[2]	49[2]	36791	29330	7461	35200
1990	34136[1]	-	-	-	127[2]	71[2]	34334	26340	7994	35200
1991	32698[1]	-	-	-	159[2]	58[2]	32915	24451	8464	35200
1992										35200

[1] Preliminary Catch Statistics (ZIFF)

[2] IOP

Table 2. Total catch of 4VsW cod by gear[1] and (Sub)Division from NAFO.

	4Vs					4W					4VsW				
YEAR	TRAWLS	LL	SDN	MIS	TOTAL	TRAWLS	LL	SDN	MIS	TOTAL	TRAWLS	LL	SDN	MIS	TOTAL
1964	25452	42	2	0	25496	32855	708	88	4110	37761	58307	750	90	4110	63257
1965	36607	84	22	0	36713	28931	1416	159	3767	34273	65538	1500	181	3767	70986
1966	27006	143	14	14	27177	36460	1474	38	3376	41348	63466	1617	52	3390	68525
1967	26481	99	27	0	26607	22407	2405	71	2668	27551	48888	2504	98	2668	54158
1968	48715	48	18	0	48781	24686	2970	89	3902	31647	73401	3018	107	3902	80428
1969	22265	43	7	1	22316	21946	3567	13	2323	27849	44211	3610	20	2324	50165
1970	28617	21	1	0	28639	23655	3817	62	1261	28795	52272	3838	63	1261	57434
1971	24088	40	0	0	24128	22006	4819	26	1584	28435	46094	4859	26	1584	52563
1972	33570	595	4	2364	36533	15888	3793	7	5424	25112	49458	4388	11	7788	61645
1973	21654	82	3	1662	23401	25144	3748	20	1780	30692	46798	3830	23	3442	54093
1974	19105	337	0	169	19611	18931	2969	5	2225	24130	38036	3306	5	2394	43741
1975	10522	444	0	728	11694	16336	3185	11	1291	20823	26858	3629	11	2019	32517
1976	10068	68	0	1417	11553	8021	2913	14	1906	12854	18089	2981	14	3323	24407
1977	2819	50	4	0	2873	2305	3487	68	1657	7517	5124	3537	72	1657	10390
1978	10044	294	19	0	10357	8277	4552	839	1380	15048	18321	4846	858	1380	25405
1979	14869	438	86	0	15393	14579	5825	3245	988	24637	29448	6263	3331	988	40030
1980	28941	2116	321	0	31378	6729	6588	3440	1117	17874	35670	8704	3761	1117	49252
1981	27662	4274	171	0	32107	9813	8229	2433	1136	21611	37475	12503	2604	1136	53718
1982	32247	7069	794	0	40110	6431	6655	1943	615	15644	38678	13724	2737	615	55754
1983	28024	4475	671	0	33170	11555	5052	1936	667	19210	39579	9527	2607	667	52380
1984	37576	4123	879	0	42578	3839	3512	2144	473	9968	41415	7635	3023	473	52546
1985	39978	7449	718	44	48189	3768	3386	1229	883	9266	43746	10835	1947	927	57455
1986	35514	8277	237	0	44028	2758	3075	600	1068	7501	38272	11352	837	1068	51529
1987	33157	6276	311	11	39755	1803	2666	538	741	5748	34960	8942	849	752	45503
1988	26964	6097	612	56	33729	1240	2163	382	842	4627	28204	8260	994	898	38356
1989[2]	22563	6324	402	41	29330	3539	2990	323	609	7461	26102	9314	725	650	36791
1990[2]	22272	3840	224	4	26340	2997	4027	532	438	7994	25269	7867	756	442	34334
1991[2]	20371	3827	253	0	24451	3956	3511	429	568	8464	24327	7338	682	568	32915

[1] Gear designations include the following: TRAWLS - Side/stern bottom, side/stern midwater, pair trawls and shrimp trawls; LL - Set/drift longlines, Hand lines, jigs, dory vessel lines; SDN - Scottish, danish and pair seines; MIS - Miscellaneous gears not included above.

[2] Preliminary Interzonal and International Observer Program data.

Table 3. Canadian catch of 4VsW cod by gear[1] and (sub) Division (from NAFO).

	4Vs					4W					4VsW				
YEAR	TRAWLS	LL	SDN	MIS	TOTAL	TRAWLS	LL	SDN	MIS	TOTAL	TRAWLS	LL	SDN	MIS	TOTAL
1964	2056	42	2	-	2100	7324	708	88	4110	12230	9380	750	90	4110	14330
1965	7366	84	22	-	7472	10290	1416	159	3767	15632	17656	1500	181	3767	23104
1966	6374	143	14	-	6531	6614	1472	38	3035	11159	12988	1615	52	3035	17690
1967	6735	99	27	-	6861	6460	2405	71	2667	11603	13195	2504	98	2667	18464
1968	9501	48	18	-	9567	8360	2970	89	3902	15321	17861	3018	107	3902	24888
1969	3540	43	7	-	3590	4695	3567	13	2323	10598	8235	3610	20	2323	14188
1970	3054	21	1	-	3076	3602	3817	62	1261	8742	6656	3838	63	1261	11818
1971	5827	40	-	-	5867	4768	4819	26	1584	11197	10595	4859	26	1584	17064
1972	9856	115	4	-	9975	4732	3793	7	1480	10012	14588	3908	11	1480	19987
1973	6392	82	3	-	6477	4723	3748	20	961	9452	11115	3830	23	961	15929
1974	4644	56	-	-	4700	1335	2969	5	1691	6000	5979	3025	5	1691	10700
1975	1824	63	-	-	1887	3566	3185	11	1290	8052	5390	3248	11	1290	9939
1976	3755	42	-	-	3797	937	2913	14	1906	5770	4692	2955	14	1906	9567
1977	2751	50	4	-	2805	1873	3487	68	1657	7085	4624	3537	72	1657	9890
1978	9561	294	19	-	9874	7997	4552	839	1380	14768	17558	4846	858	1380	24642
1979	14853	438	86	-	15377	13742	5825	3245	988	23842	28637	6263	3331	988	39219
1980	28941	2116	321	-	31378	6298	6588	3440	1117	17443	35239	8704	3761	1117	48821
1981	27662	4274	171	-	32107	9148	8229	2433	1136	20946	36810	12503	2604	1136	53053
1982	32247	7069	794	-	40110	6352	6655	1943	615	15565	38599	13724	2737	615	55675
1983	26817	4475	671	-	31963	11280	5052	1936	667	18935	38097	9527	2607	667	50898
1984	37290	4123	879	-	42292	3683	3512	2144	473	9812	40973	7635	3023	473	52104
1985	39098	7449	718	44	47309	3746	3386	1229	883	9244	42844	10835	1947	927	56553
1986	35482	8277	237	-	43996	2728	3075	600	1068	7471	38210	11352	837	1068	51467
1987	33139	6276	311	11	39737	1748	2666	538	741	5693	34887	8942	849	752	45430
1988	26959	6077	612	56	33704	1124	2163	382	842	4453	28083	8240	994	898	38215
1989[2]	22563	6324	402	41	29330	3322	2990	323	609	7244	25885	9314	725	650	36574
1990[2]	22272	3840	224	4	26340	2799	4027	532	438	7796	25071	7867	756	442	34136
1991[2]	20371	3827	253	-	24451	3739	3511	429	568	8247	24110	7338	682	568	32698

[1] Gear designations include the following: TRAWLS - Side/stern bottom, side/stern midwater, pair trawls and shrimp trawls; LL - Set/drift longlines, Hand lines, jigs, dory vessel lines; SDN - Scottish, danish and pair seines; MIS - Miscellaneous gears not included above.

[2] Preliminary Interzonal data.

Table 4. Resource management of 4VsW cod - 1991 domestic allocations and catches from quota reports.

Gear Sector	Allocations at Specific Dates						Total Catches to Specific Dates			
	Jan 1	May 15	July 10	Oct 9	Dec 31		May 15	July 10	Oct 9	Dec 31
Vessels >100'	23160	22405	22077	21827	21653		16755	16961	18187	20797
MG 65-100'	625	901	991	991	991		799	849	850	936
FG 65-100'	520	999	1237	1487	1661		879	997	1271	1625
MG <65' ITQ Fishery	3963	3963	3963	3963	3963		1039	1464	2274	3527
MG <65' Quota Reserve	47	47	47	47	47		--	--	--	--
MG 45-64' 4T, 3Pn Vessels	40	40	40	40	40		--	--	--	--
FG 45-64'	1985	1985	1985	1985	1985		301	575	888	1115
FG <45'	4860	4860	4860	4860	4860		625	1301	3101	4778
Totals	35200				35200	% of TAC	57.9	62.9	75.5	93.1

Table 5. Data used to calculate 4VsW cod commercial catch at age.

Key	Gear	Period	Length/weight coefficients a	b	Source	Lengths	Aged	Catch
1	OTB, PTB, SNU	Q1	.00633	3.07234	March 4Vs	6395	673	14661
2	OTB, PTB, SNU	Q2	.00951	2.98771	July 4Vs	3042	365	4075
3	OTB, PTB, SNU	H2	.01003	2.97557	July 4VsW	4975	473	6274
4	LL, LHP	H1	.01003	2.97557	July 4VsW	3240	367	3143
5	LL, LHP	H2	.01003	2.97557	July 4VsW	5421	567	4196
6	GN	FY	.01002	2.97704	July 4W	1003	134	566

Table 6. 4VsW cod catch at age ('000) by key for each half of 1991.

	OTB, PTB, SNU			LL, LHP		GN	
Age	Q1	Q2	H2	H1	H2	FY	Total
1	0	0	0	0	0	0	0
2	0	0	0	1	0	0	1
3	14	11	193	22	31	0	271
4	697	307	1731	260	402	4	3401
5	2466	588	2058	673	989	14	6788
6	2247	500	733	447	587	31	4545
7	2268	365	261	204	265	28	3391
8	907	169	74	77	100	22	1349
9	944	156	96	62	77	22	1357
10	677	54	13	72	27	14	857
11	354	32	8	36	10	14	454
12	98	16	3	13	11	9	150
13	34	14	0	4	9	4	65
14	0	5	2	3	1	0	11
15	0	1	0	2	2	0	5
16	4	0	0	1	0	0	5
Total	10710	2218	5172	1877	2511	162	22650

Table 7. Catch at age for 4VsW cod in thousands (4TVn component included)

	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	1293	1984	2046	1218	1273	1538	513	1	34
2	8631	12824	15865	10221	7321	8571	2866	23	94
3	8886	9643	11801	8001	13324	7402	2860	532	1168
4	14802	5125	11989	5803	11695	3163	4707	1229	4078
5	13673	6612	7384	9634	6854	4788	3900	1591	4817
6	4539	5128	6527	3324	2247	3297	2085	845	2582
7	1942	3419	3308	3370	669	2943	1287	490	767
8	759	1963	1880	4732	1008	623	447	199	247
9	236	704	347	1684	196	497	136	118	107
10	72	367	466	389	153	686	53	33	75
11	137	159	68	551	13	172	12	42	31
12	56	173	8	8	2	123	47	44	27
13	9	156	36	21	0	41	0	11	28
14	12	80	0	21	0	6	4	3	10
15	4	40	3	18	0	6	0	2	1
3+	45127	33569	43817	37556	36161	23747	15538	5139	13938
6+	7766	12189	12643	14118	4288	8394	4071	1787	3875

	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	12	31	3	3	0	0	0	0	0
2	93	92	258	138	6	1	4	3	0
3	1762	1765	3200	2473	3507	430	156	124	38
4	6559	4873	9136	7667	8679	5778	2253	4210	877
5	9525	6937	7281	10123	7484	9101	8151	7640	5694
6	5056	6177	4651	3681	6278	5678	7523	9221	5885
7	1210	3050	2957	2568	1905	3829	4284	3589	6049
8	377	1121	1421	1315	1012	1250	2430	1571	2733
9	76	313	397	679	625	544	1063	1123	1105
10	23	92	135	318	224	290	452	447	604
11	10	50	69	153	149	153	284	285	233
12	4	26	32	65	52	63	173	105	131
13	3	4	22	54	24	34	68	66	61
14	0	0	2	55	15	17	20	11	11
15	0	1	5	19	6	8	17	19	14
3+	24605	24409	29308	29170	29960	27175	26874	28411	23435
6+	6759	10834	9691	8907	10290	11866	16314	16437	16826

	1988	1989	1990	1991
1	0	0	0	0
2	8	7	0	1
3	185	671	332	271
4	1512	2544	2569	3401
5	2399	4111	4162	6788
6	4531	3334	3763	4545
7	4075	3669	2300	3391
8	3295	1796	3276	1349
9	1731	2018	1695	1357
10	626	590	1914	857
11	260	251	335	454
12	153	156	139	150
13	64	29	56	65
14	9	15	17	11
15	10	58	15	5
3+	18850	19242	20573	22644
6+	14754	11916	13510	12184

Table 8. Estimated contribution of 4TVn fish in the catch at age (Thousands)

	1986	1987	1988	1989	1990	1991
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	8	0	0	0	2
4	121	62	5	0	65	92
5	542	294	391	45	94	371
6	1637	518	611	201	1082	645
7	221	584	579	353	602	1972
8	213	97	513	552	276	506
9	201	177	277	664	709	731
10	108	112	155	106	828	576
11	96	13	0	49	5	17
12	24	9	1	118	0	61
13	0	0	0	0	0	0
14	0	0	0	0	0	0
15	0	0	0	0	0	0
1+	3163	1874	2532	2088	3661	4973

Table 9. Weights at age from commercial landings (kgs)

	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.53	.53	.79	.49	.43	.00	.00	.00	.61
3	.76	.76	1.01	.96	.79	.71	.79	.80	.97
4	1.08	1.08	1.15	.94	1.19	.85	1.05	1.11	1.21
5	1.45	1.45	1.39	1.17	1.74	1.36	1.50	1.72	1.63
6	1.80	1.80	1.84	1.64	2.17	1.88	2.26	2.40	2.33
7	2.28	2.28	2.29	2.29	2.59	2.34	3.33	3.15	3.39
8	3.50	3.50	2.88	2.28	2.47	2.94	4.37	4.48	4.76
9	4.87	4.87	4.82	2.64	3.24	3.69	4.85	4.05	5.34
10	5.70	5.70	4.56	4.27	3.62	3.72	5.57	5.29	6.19
11	5.70	5.70	7.57	3.85	4.87	4.79	7.39	4.73	7.91
12	8.74	8.74	11.56	9.48	9.58	5.46	3.38	4.92	8.57
13	6.77	6.77	6.31	7.05	.00	8.24	14.23	6.57	9.61
14	5.92	5.92	.00	9.06	.00	12.10	11.54	8.85	10.30
15	9.27	9.27	14.49	10.98	.00	12.78	22.97	10.52	8.37
Ave	1.19	1.30	1.27	1.27	1.11	1.06	1.33	1.97	1.82

	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.57	.59	.60	.55	.47	.54	.68	.27	.00
3	.69	.81	.81	.77	.78	.74	.71	.68	.48
4	.96	1.16	1.12	1.04	1.04	1.06	1.03	.95	.93
5	1.57	1.60	1.68	1.53	1.53	1.50	1.45	1.26	1.28
6	2.30	2.22	2.13	2.33	2.13	2.06	1.97	1.65	1.54
7	3.08	3.10	2.96	2.73	3.09	2.69	2.39	2.38	1.88
8	3.72	4.26	3.90	3.99	3.55	3.64	3.10	2.74	2.61
9	4.90	5.38	5.69	5.34	4.38	4.03	3.84	3.67	3.58
10	6.39	6.96	7.02	6.84	5.79	5.19	5.03	4.99	4.31
11	7.25	7.42	7.68	8.53	6.84	7.09	6.32	5.30	6.49
12	10.11	10.01	9.45	8.88	9.16	8.44	6.13	6.87	6.32
13	13.95	8.75	12.05	10.90	10.64	9.28	9.88	10.18	7.23
14	10.26	10.53	8.48	10.43	11.73	10.58	11.12	9.57	11.68
15	11.97	13.97	9.80	13.34	14.07	12.63	11.12	11.89	12.69
Ave	1.61	2.00	1.82	1.89	1.74	1.93	2.12	1.80	1.93

	1988	1989	1990	1991
1	.00	.00	.00	.00
2	.35	.29	.00	.47
3	.63	.77	.78	.77
4	.97	1.01	.97	.88
5	1.26	1.28	1.18	1.15
6	1.73	1.56	1.35	1.46
7	1.92	2.19	1.62	1.56
8	2.37	2.21	2.21	1.94
9	2.79	2.50	2.10	2.35
10	3.67	3.93	2.11	2.25
11	4.92	5.10	4.15	2.87
12	7.06	5.16	5.64	3.41
13	7.65	8.55	7.69	4.16
14	11.17	12.28	9.37	11.29
15	12.16	7.87	8.96	9.34
ave	2.03	1.86	1.66	1.45

Table 10. Standarized catch and effort for 4VsW cod from NAFO and ZIFF data.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... .588
MULTIPLE R SQUARED..... .345

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	1.798E0002	1.798E0002	
REGRESSION	45	3.499E0002	7.776E0000	21.269
TYPE 1	10	1.691E0002	1.691E0001	46.264
TYPE 2	1	9.914E0000	9.914E0000	27.116
TYPE 3	11	8.961E0001	8.146E0000	22.280
TYPE 4	23	1.768E0002	7.686E0000	21.022
RESIDUALS	1814	6.632E0002	3.656E-001	
TOTAL	1860	1.193E0003		

PREDICTED CATCH RATE

STANDARDS USED VARIABLE NUMBERS: 5 1 1

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	CATCH RATE S.E.	EFFORT
68	80428	0.779	1.045	0.095	76973
69	50165	0.731	1.047	0.105	47905
70	57434	0.803	1.061	0.101	54110
71	52563	0.715	0.759	0.070	69273
72	61645	0.652	0.830	0.072	74254
73	54093	0.741	0.852	0.073	63507
74	43741	0.728	0.706	0.063	61921
75	32517	0.603	0.507	0.048	64103
76	24407	0.588	0.669	0.062	36484
77	10390	0.292	0.706	0.079	14717
78	25405	0.597	1.357	0.126	18725
79	40030	0.653	1.723	0.160	23227
80	49252	0.605	1.266	0.112	38909
81	53718	0.591	1.335	0.114	40250
82	55754	0.645	1.644	0.138	33913
83	52380	0.657	1.576	0.135	33232
84	52546	0.722	1.737	0.153	30254
85	57455	0.614	2.138	0.186	26873
86	51529	0.581	2.227	0.195	23143
87	45503	0.599	1.546	0.139	29436
88	38356	0.592	1.431	0.128	26809
89	36791	0.555	1.478	0.137	24884
90	34334	0.542	1.846	0.171	18596
91	32915	0.638	1.338	0.121	24600

AVERAGE C.V. FOR THE MEAN: .091

Table 10 (continued).

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	5	INTERCEPT	0.318	0.084	1860
2	1				
3	1				
4	82				
1	0	1	¯0.030	0.061	142
	1	2	¯0.197	0.048	284
	2	3	¯0.844	0.068	111
	3	4	¯0.410	0.056	185
	4	5	¯0.200	0.052	226
	6	6	¯0.314	0.079	74
	7	7	¯0.036	0.095	47
	8	8	0.003	0.063	132
	9	9	0.559	0.061	191
	10	10	0.842	0.079	93
2	2	11	¯0.161	0.031	739
3	2	12	0.173	0.068	189
	3	13	0.039	0.065	235
	4	14	¯0.234	0.066	223
	5	15	¯0.427	0.068	193
	6	16	¯0.525	0.075	130
	7	17	¯0.570	0.080	105
	8	18	¯0.393	0.077	119
	9	19	¯0.374	0.076	124
	10	20	¯0.368	0.074	139
	11	21	¯0.086	0.074	136
	12	22	¯0.127	0.075	127
4	68	23	¯0.453	0.095	71
	69	24	¯0.450	0.105	55
	70	25	¯0.437	0.099	64
	71	26	¯0.772	0.096	69
	72	27	¯0.683	0.092	86
	73	28	¯0.657	0.090	98
	74	29	¯0.844	0.094	83
	75	30	¯1.175	0.100	67
	76	31	¯0.898	0.096	76
	77	32	¯0.842	0.116	38
	78	33	¯0.191	0.094	71
	79	34	0.048	0.092	74
	80	35	¯0.261	0.089	83
	81	36	¯0.208	0.084	103
	83	37	¯0.042	0.086	94
	84	38	0.055	0.088	85
	85	39	0.263	0.087	88
	86	40	0.304	0.088	87
	87	41	¯0.061	0.091	77
	88	42	¯0.138	0.092	75
	89	43	¯0.105	0.095	67
	90	44	0.117	0.095	67
	91	45	¯0.205	0.092	75

Table 11. Standardized catch and effort for 4VsW cod from IOP data.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... .672
MULTIPLE R SQUARED..... .452

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	1.077E0000	1.077E0000	
REGRESSION	21	7.100E0001	3.381E0000	6.637
TYPE 1	9	1.489E0001	1.654E0000	3.247
TYPE 2	11	5.523E0001	5.021E0000	9.857
TYPE 3	1	1.151E0000	1.151E0000	2.259
RESIDUALS	169	8.609E0001	5.094E-001	
TOTAL	191	1.582E0002		

PREDICTED CATCH RATE

STANDARDS USED VARIABLE NUMBERS: 1 5

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	S.E.	EFFORT
82	55754	0.075	1.570	0.366	35523
83	52380	0.081	1.431	0.320	36614
84	52546	0.125	2.673	0.603	19656
85	57455	0.102	3.023	0.681	19009
86	51529	0.053	2.588	0.609	19911
87	45503	0.073	2.402	0.561	18943
88	38356	0.123	2.002	0.452	19161
89	36791	0.114	2.679	0.628	13734
90	34334	0.241	1.721	0.390	19956
91	32915	0.153	1.339	0.323	24582

AVERAGE C.V. FOR THE MEAN: .230

Table 11. (continued).

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	82	INTERCEPT	0.222	0.236	191
2	1				
3	5				
1	83	1	¯0.095	0.223	23
	84	2	0.531	0.225	22
	85	3	0.654	0.228	21
	86	4	0.501	0.246	16
	87	5	0.426	0.242	17
	88	6	0.242	0.228	21
	89	7	0.535	0.247	16
	90	8	0.090	0.231	20
	91	9	¯0.157	0.245	16
2	2	10	0.587	0.229	20
	3	11	0.443	0.229	20
	4	12	¯0.510	0.235	18
	5	13	¯0.704	0.243	16
	6	14	¯0.830	0.253	14
	7	15	¯0.919	0.259	13
	8	16	¯0.691	0.265	12
	9	17	¯0.831	0.258	13
	10	18	¯1.079	0.239	17
	11	19	¯0.266	0.239	17
	12	20	¯0.133	0.266	12
3	4	21	¯0.163	0.109	77

Table 12. 4VsW cod July RV survey mean catch at age per tow.
3/ 7/92

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	.03	.01	.00	.00	.25	.02	.00	.00	.05	.29	.01	.02
1	.42	.44	1.78	1.84	1.48	.95	.67	.21	.88	.35	.20	1.33
2	4.73	2.20	2.77	12.59	9.45	2.43	3.70	2.75	3.75	3.04	2.01	3.65
3	1.66	10.22	3.41	19.79	5.53	3.76	4.22	6.97	8.96	4.60	5.31	5.53
4	2.58	2.30	9.04	16.07	1.62	1.76	2.60	4.53	9.80	4.76	2.94	8.44
5	1.28	4.53	1.67	6.44	.58	.86	1.65	2.82	2.71	5.18	4.98	3.22
6	.42	1.66	1.72	.53	.64	.19	.32	1.24	1.00	2.59	3.47	2.31
7	.50	.99	.46	.83	.11	.23	.15	.27	.25	.77	1.37	1.19
8	.16	.42	.16	.26	.13	.06	.26	.18	.05	.29	.37	.44
9	.03	.18	.14	.12	.06	.12	.00	.04	.03	.12	.10	.14
10	.07	.02	.04	.15	.05	.01	.18	.00	.02	.02	.08	.16
11	.08	.04	.00	.05	.02	.00	.02	.03	.00	.01	.03	.04
12	.03	.02	.00	.00	.02	.02	.00	.02	.00	.00	.00	.01
13	.05	.06	.00	.00	.00	.00	.04	.00	.00	.01	.00	.01
14	.00	.00	.00	.06	.00	.00	.00	.00	.00	.00	.00	.00
15	.00	.00	.00	.01	.02	.00	.00	.00	.00	.00	.00	.01
16	.00	.00	.00	.00	.00	.00	.00	.00	.02	.00	.00	.00
0+	12.04	23.09	21.19	58.74	19.95	10.40	13.82	19.05	27.51	22.04	20.87	26.50
1+	12.01	23.08	21.19	58.74	19.70	10.38	13.82	19.05	27.46	21.74	20.85	26.47
2+	11.59	22.64	19.41	56.90	18.22	9.44	13.15	18.84	26.59	21.40	20.66	25.15
3+	6.86	20.44	16.63	44.31	8.77	7.01	9.45	16.09	22.84	18.35	18.64	21.49
4+	5.20	10.22	13.23	24.53	3.24	3.24	5.22	9.12	13.89	13.76	13.33	15.96

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	.00	.02	.07	.00	.03	.04	.07	.03	.00	.00
1	.73	13.72	.41	1.29	.36	.64	.06	.25	.13	.47
2	62.94	13.31	7.27	1.68	1.32	1.51	4.70	8.86	5.06	1.44
3	52.60	44.47	12.82	7.88	1.53	4.97	7.29	7.38	18.22	2.73
4	18.37	19.25	19.09	9.56	6.16	4.83	5.89	5.01	8.64	5.58
5	4.12	9.88	12.94	9.32	3.89	8.86	3.27	3.47	3.83	3.90
6	2.23	4.42	6.01	5.12	3.26	3.61	3.41	1.35	1.41	1.32
7	1.20	.99	4.13	2.56	1.15	2.71	1.95	2.00	.60	.39
8	.51	.55	.41	1.01	.55	1.47	.98	.47	.29	.20
9	.11	.14	.33	.48	.24	.34	.22	.32	.11	.18
10	.12	.08	.10	.11	.15	.02	.05	.01	.07	.05
11	.06	.04	.23	.11	.04	.08	.12	.00	.00	.05
12	.00	.02	.01	.07	.00	.04	.02	.02	.00	.00
13	.00	.02	.01	.00	.02	.01	.00	.01	.00	.00
14	.00	.00	.01	.00	.00	.00	.02	.00	.00	.00
15	.00	.00	.00	.01	.00	.03	.00	.00	.00	.00
16	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
0+	143.01	106.91	63.82	39.21	18.69	29.17	28.04	29.19	38.35	16.31
1+	143.00	106.89	63.75	39.21	18.67	29.13	27.97	29.17	38.35	16.31
2+	142.27	93.16	63.35	37.92	18.31	28.48	27.92	28.92	38.22	15.84
3+	79.33	79.86	56.08	36.24	16.99	26.98	23.21	20.06	33.16	14.40
4+	26.74	35.39	43.26	28.36	15.45	22.00	15.92	12.68	14.94	11.67

Table 13. 4VsW cod July RV survey coefficients of variation.
3/ 7/92

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
0	.514	1.000	.000	.000	.000	1.000	.000	.000	.471	.552	.644	.760
1	.277	.363	.747	.649	.135	.341	.370	.276	.147	.226	.292	.395
2	.063	.303	.295	.771	.032	.266	.165	.174	.425	.257	.397	.316
3	.210	.589	.661	.622	.073	.347	.119	.197	.396	.260	.368	.385
4	.097	.466	.844	.785	.080	.253	.252	.247	.230	.220	.243	.293
5	.078	.582	.677	.708	.313	.187	.227	.397	.292	.191	.233	.256
6	.105	.549	.820	.775	.384	.236	.216	.504	.172	.164	.266	.224
7	.251	.520	.806	.679	.269	.333	.198	.514	.097	.169	.256	.269
8	.291	.344	.624	.327	.457	.402	.000	.492	.318	.177	.339	.271
9	.760	.695	.633	.784	.355	.464	.000	.421	.263	.187	.484	.450
10	.536	.730	.781	.523	.190	1.000	.000	.000	.670	.522	.611	.518
11	.000	.600	.000	.443	1.000	.000	1.000	.471	.000	.404	.688	.662
12	1.000	1.000	.000	.000	.000	1.000	.000	.541	.000	1.000	.000	1.000
13	.000	.723	.000	.000	.000	.000	.000	.000	.000	.885	.000	1.000
14	.000	.000	.000	.676	.000	.000	.000	.000	.000	.000	.000	.000
15	.000	.000	.000	.713	1.000	.000	.000	.000	.000	.000	.000	1.000
16	.000	.000	.000	.000	.000	.000	.000	.000	1.000	.000	.000	.000

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0	1.000	1.000	.534	.000	.698	1.000	.588	1.000	1.000	1.000
1	.299	.905	.563	.667	.368	.346	.449	.226	.548	.420
2	.854	.395	.285	.326	.490	.293	.458	.620	.514	.180
3	.822	.501	.566	.175	.286	.376	.509	.485	.373	.160
4	.744	.424	.478	.262	.341	.274	.319	.325	.298	.150
5	.362	.390	.491	.341	.347	.240	.307	.241	.346	.130
6	.076	.221	.481	.337	.312	.286	.483	.233	.307	.130
7	.046	.135	.540	.263	.290	.304	.444	.267	.301	.130
8	.025	.184	.357	.214	.286	.281	.393	.250	.308	.120
9	.097	.214	.526	.198	.300	.257	.268	.285	.388	.130
10	.000	.000	.311	.242	.291	.394	.347	.676	.351	.240
11	.000	.000	.713	.469	.542	.395	.358	1.000	.000	.220
12	.000	.000	1.000	.290	.000	.531	.425	.631	.000	.000
13	.000	.000	.740	.000	1.000	1.000	.000	.733	.000	.000
14	.000	.000	.736	.000	.000	.000	.638	.000	.000	.000
15	.000	.000	.000	1.000	.000	.585	.000	.000	.000	.000
16	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

Table 14. 4VsW cod Spring RV survey mean catch at age per tow.
3/ 7/92

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
1	.26	.86	8.25	2.65	.85	.22	.00	.19	.35	.60	.58	.12
2	2.12	2.71	3.80	22.22	3.17	1.49	.00	10.88	.92	7.96	17.96	1.60
3	.89	2.04	5.29	17.91	42.14	1.85	.00	19.44	2.87	9.49	10.40	5.08
4	.60	1.67	7.79	11.84	25.52	9.37	.00	23.58	4.50	4.26	4.23	2.56
5	1.37	2.52	4.87	7.24	4.96	6.21	.00	11.67	10.14	4.32	4.80	.86
6	1.02	2.90	5.76	1.99	5.85	2.92	.00	13.13	4.82	4.88	1.68	.31
7	.47	1.43	3.20	1.36	1.32	2.53	.00	6.27	3.32	1.43	.70	.19
8	.29	.30	1.53	1.08	.62	.77	.00	1.34	1.20	1.87	.22	.36
9	.07	.06	.18	.28	.29	.50	.00	.73	.24	.46	.25	.13
10	.10	.03	.14	.14	.10	.20	.00	.28	.10	.19	.05	.12
11	.08	.01	.03	.06	.04	.02	.00	.04	.04	.18	.03	.04
12	.02	.00	.02	.03	.04	.09	.00	.05	.03	.04	.02	.03
13	.03	.01	.00	.01	.01	.00	.00	.01	.03	.02	.00	.01
14	.01	.00	.00	.00	.04	.01	.00	.01	.01	.00	.01	.00
15	.01	.00	.00	.01	.00	.00	.00	.00	.00	.03	.02	.00
16	.00	.00	.00	.01	.00	.02	.00	.01	.00	.00	.00	.00
0+	7.33	14.55	40.86	66.83	84.94	26.19	.00	87.62	28.56	35.75	40.94	11.42
1+	7.33	14.55	40.86	66.83	84.94	26.19	.00	87.62	28.56	35.75	40.94	11.42
2+	7.07	13.68	32.62	64.18	84.09	25.97	.00	87.43	28.22	35.15	40.37	11.29
3+	4.95	10.98	28.81	41.96	80.92	24.48	.00	76.55	27.30	27.18	22.41	9.69
4+	4.06	8.93	23.52	24.05	38.78	22.63	.00	57.11	24.43	17.69	12.01	4.62

	1991	1992
0	.00	.00
1	.02	.07
2	3.50	.52
3	12.15	.25
4	21.92	.25
5	5.09	.49
6	1.49	.31
7	.35	.11
8	.02	.05
9	.10	.02
10	.00	.00
11	.01	.01
12	.00	.03
13	.02	.01
14	.01	.00
15	.00	.00
16	.00	.00
0+	44.69	2.14
1+	44.69	2.14
2+	44.66	2.07
3+	41.16	1.55
4+	29.02	1.30

Table 15. 4VsW cod Spring RV survey coefficients of variation.
3/ 7/92

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
0	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
1	.287	.306	.000	.000	.402	.208	.000	.000	.201	.153	.582	.375
2	.142	.457	.528	.000	.580	.166	.000	.000	.081	.700	.758	.408
3	.181	.400	.200	.000	.709	.140	.000	.000	.038	.804	.489	.444
4	.250	.307	.198	.000	.516	.259	.000	.000	.011	.508	.484	.471
5	.174	.376	.266	.000	.368	.389	.000	.000	.011	.541	.440	.340
6	.166	.485	.245	.000	.309	.455	.000	.000	.018	.434	.380	.314
7	.383	.550	.192	.000	.297	.380	.000	.000	.104	.368	.338	.334
8	.309	.639	.223	.000	.296	.370	.000	.000	.129	.392	.578	.647
9	.088	.343	.174	.000	.364	.549	.000	.000	.172	.434	.381	.468
10	.274	.769	.333	.000	.641	.400	.000	.000	.094	.355	.293	.516
11	.275	.401	.630	.000	.888	.527	.000	.000	.000	.050	.438	.526
12	.211	1.000	.455	.000	.492	.315	.000	.000	.000	.426	.651	.000
13	.702	.826	.000	.000	.768	.000	.000	.000	.000	.000	1.000	.407
14	.000	1.000	.000	.000	.564	1.000	.000	.000	.000	.000	.857	.000
15	.000	.000	.000	.000	.000	.000	.000	.000	.000	.273	.857	.000
16	.000	.000	.000	.000	.000	1.000	.000	.000	.000	.000	.000	.000

	1991	1992
0	.000	.000
1	.543	.429
2	.672	.231
3	.915	.440
4	.868	.440
5	.740	.429
6	.573	.419
7	.519	.455
8	.453	.400
9	.483	.500
10	1.000	1.000
11	.407	1.000
12	1.000	.667
13	.597	.000
14	.029	.000
15	.000	.000
16	.000	.000

Table 16. Successive annual patterns of point estimates of average F's (ages 7-9) from base run from 1986 to 1990. Each row contains one more year's data using NAFO SA 4VsW cod data with 4T culled.

Terminal Data Year	Estimate Year 1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1987	.40	.37	.37	.26	.27	.35	.17	.14				
1988	.43	.42	.42	.30	.29	.42	.24	.23	.19			
1989	.45	.42	.43	.31	.38	.60	.42	.44	.46	.27		
1990	.45	.43	.45	.32	.37	.58	.39	.44	.45	.29	.37	
1991	.45	.44	.46	.35	.40	.63	.43	.50	.60	.46	.91	.69

Table 17. Successive annual patterns of bootstrap mean estimates of average F's (ages 7-9) from base run from 1980 to 1991. Each row contains one more year's data .

Terminal Data Year	Estimate Year 1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1987	.44	.43	.46	.35	.38	.60	.38	.40				
1988	.45	.45	.48	.36	.38	.62	.43	.50	.51			
1989	.46	.44	.47	.35	.40	.66	.48	.61	.73	.61		
1990	.45	.44	.46	.35	.39	.63	.44	.54	.62	.47	.94	
1991	.45	.44	.46	.35	.40	.63	.43	.51	.61	.47	.98	.97

Table 18. Numbers at age from averaged bootstrap parameters.

	1970	1971	1972	1973	1974	1975	1976	1977
1	84984	84789	67068	61806	74394	85165	71022	66570
2	80074	68409	67624	53060	49500	59757	68335	57683
3	40571	57749	44405	41011	34193	33903	41169	53355
4	47463	25176	38556	25678	26337	15939	21060	31119
5	39971	25466	15975	20719	15773	10981	10188	12983
6	17292	20354	14867	6398	8246	6712	4658	4812
7	6583	10050	12024	6266	2231	4718	2512	1927
8	3845	3633	5135	6852	2081	1221	1200	892
9	902	2461	1198	2503	1328	792	436	578
10	376	525	1378	667	526	910	199	234
11	487	242	98	706	194	292	124	115
12	322	274	55	19	80	147	83	91
13	126	213	68	37	8	64	9	26
14	117	95	33	23	12	7	15	8
15	9	85	6	27	0	10	0	9
1+	323123	299523	268491	225771	214901	220615	221009	230400

	1978	1979	1980	1981	1982	1983	1984	1985
1	102263	90955	106261	113720	65581	64407	27743	31333
2	54502	83695	74457	86971	93103	53691	52732	22714
3	47206	44537	68439	60877	70972	76102	43953	43173
4	43202	37592	34870	54436	46946	55869	59133	35596
5	24366	31681	24843	24140	36302	31499	37889	43186
6	9190	15590	17320	14063	13176	20562	19017	22786
7	3175	5188	8189	8591	7305	7457	11154	10432
8	1134	1906	3153	3945	4358	3658	4381	5668
9	550	705	1219	1567	1944	2378	2079	2456
10	366	354	509	715	924	977	1382	1210
11	162	232	269	333	463	468	598	869
12	56	104	181	175	210	241	249	351
13	35	21	82	125	114	113	150	147
14	11	3	15	63	82	45	71	92
15	3	0	2	12	50	17	23	43
1+	286221	312564	339808	369732	341532	317485	260554	220055

	1986	1987	1988	1989	1990	1991
1	41446	64791	168912	34118	68800	68800
2	25653	33933	53047	138293	27934	56300
3	18593	21000	27782	43424	113219	22870
4	35206	15110	17167	22579	34945	92395
5	27105	25124	11634	12691	16184	26345
6	27983	15769	15684	7708	6712	9570
7	11848	16048	8055	9294	3476	3069
8	4665	6653	8194	3431	4609	1309
9	2441	2591	3062	4191	1684	1059
10	1049	1165	1281	1191	2206	486
11	582	552	508	623	537	824
12	454	305	253	181	327	141
13	131	299	139	70	114	142
14	59	47	189	56	31	42
15	57	38	29	147	32	10
1+	197272	203426	315936	277998	280810	283363

Table 19. F at age from averaged bootstrap parameters.

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	.02	.03	.03	.02	.02	.02	.01	.00	.00	.00	.00	.00
2	.13	.23	.30	.24	.18	.17	.05	.00	.00	.00	.00	.00
3	.28	.20	.35	.24	.56	.28	.08	.01	.03	.04	.03	.06
4	.42	.25	.42	.29	.67	.25	.28	.04	.11	.21	.17	.21
5	.47	.34	.72	.72	.65	.66	.55	.15	.25	.40	.37	.41
6	.34	.33	.66	.85	.36	.78	.68	.22	.37	.44	.50	.45
7	.39	.47	.36	.90	.40	1.17	.84	.33	.31	.30	.53	.48
8	.25	.91	.52	1.44	.77	.83	.53	.28	.28	.25	.50	.51
9	.34	.38	.39	1.36	.18	1.18	.42	.26	.24	.13	.33	.33
10	.24	1.48	.47	1.03	.39	1.79	.35	.17	.26	.07	.22	.23
11	.37	1.29	1.45	1.98	.08	1.05	.11	.52	.24	.05	.23	.26
12	.21	1.19	.18	.64	.03	2.58	.98	.77	.77	.04	.17	.23
13	.08	1.66	.88	.96	.00	1.25	.00	.64	2.26	.17	.06	.22
14	.12	2.63	.00	5.25	.00	3.99	.35	.58	4.51	.00	.00	.04
15	.62	.72	.87	1.27	.98	1.14	.85	.30	.38	.47	.60	.61
7-9	.33	.59	.42	1.23	.45	1.06	.60	.29	.28	.22	.45	.44
3-13	.31	.77	.58	.95	.37	1.07	.44	.31	.46	.19	.28	.31

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
3	.04	.05	.01	.00	.01	.00	.01	.02	.00	.01
4	.20	.19	.11	.07	.14	.06	.10	.13	.08	.04
5	.37	.30	.31	.23	.34	.27	.21	.44	.33	.31
6	.37	.41	.40	.45	.36	.47	.32	.60	.58	.59
7	.49	.33	.48	.60	.38	.47	.65	.50	.78	.70
8	.41	.36	.38	.64	.39	.58	.47	.51	1.27	1.19
9	.49	.34	.34	.65	.54	.50	.74	.44	1.04	1.03
10	.48	.29	.26	.53	.44	.63	.52	.60	.79	.99
11	.45	.43	.33	.45	.45	.58	.83	.44	1.14	.86
12	.42	.27	.33	.79	.22	.58	1.09	.26	.63	1.14
13	.74	.27	.29	.72	.82	.26	.71	.62	.79	.69
14	1.35	.46	.31	.27	.23	.30	.05	.35	.95	.33
15	.54	.47	.48	.58	.46	.53	.51	.63	.87	.82
7-9	.46	.35	.40	.63	.44	.52	.62	.49	1.03	.97
3-13	.40	.30	.29	.47	.37	.40	.52	.41	.67	.69

Table 20. Biomass at age from averaged bootstrap parameters.

	1970	1971	1972	1973	1974	1975	1976	1977	1978
1	3.7	3.7	2.4	2.8	3.6	8.5	7.1	6.7	4.1
2	35.4	15.7	19.0	11.7	10.3	6.0	6.8	5.8	13.5
3	25.9	36.7	32.5	35.7	21.3	18.7	11.6	15.1	14.7
4	44.2	22.8	36.0	25.0	28.2	13.1	18.2	29.2	42.5
5	52.0	31.9	19.6	24.0	20.2	14.0	11.5	17.5	32.8
6	27.7	32.9	24.3	9.7	13.1	12.1	8.2	9.1	18.4
7	12.1	20.4	24.4	12.9	4.6	10.6	6.3	5.1	9.1
8	11.4	10.3	13.2	15.7	4.9	3.4	3.8	3.4	4.4
9	4.1	10.2	4.9	6.9	3.6	2.4	1.6	2.4	2.7
10	2.1	2.8	6.5	3.0	1.6	3.2	.9	1.2	1.8
11	2.2	1.4	.6	3.0	.9	1.2	.7	.6	1.0
12	3.2	1.9	.4	.2	.5	.8	.3	.5	.4
13	.9	1.6	.5	.3	.0	.6	.1	.1	.2
14	.6	.6	.0	.2	.0	.0	.1	.1	.1
15	.1	.6	.1	.0	.0	.0	.0	.1	.0
1+	225.6	193.4	184.4	151.1	112.8	94.5	77.2	96.9	145.6
6+	64.4	82.6	74.9	51.8	29.3	34.2	22.0	22.8	38.1

	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	3.8	4.4	4.6	2.8	3.0	1.2	1.2	2.5	6.5
2	20.0	18.1	21.3	21.9	11.6	12.3	5.9	4.2	3.4
3	29.0	46.3	42.1	48.3	49.8	25.9	26.7	12.6	7.5
4	36.1	31.3	51.7	42.9	50.2	53.5	31.1	28.8	12.0
5	43.6	30.7	33.7	47.5	39.7	47.3	53.6	30.9	27.6
6	30.1	32.3	25.9	26.1	37.1	33.7	39.1	43.3	22.0
7	13.9	21.9	22.0	17.6	20.0	26.7	23.1	25.6	28.2
8	6.8	11.4	13.7	15.0	11.4	14.7	16.4	11.9	16.6
9	3.4	5.5	7.7	8.9	9.9	7.9	9.2	8.2	8.1
10	2.1	3.0	4.4	5.8	5.4	6.6	5.4	4.6	4.6
11	1.6	1.9	2.4	3.6	3.2	3.8	5.0	3.0	3.1
12	.9	1.5	1.5	1.7	2.1	1.9	2.3	3.0	1.8
13	.2	.8	1.4	1.2	1.1	1.4	1.3	1.0	2.1
14	.0	.2	.5	.9	.5	.8	.9	.6	.5
15	.0	.0	.1	.5	.2	.3	.5	.7	.4
1+	191.5	209.1	233.1	244.7	245.3	237.9	221.7	180.9	144.4
6+	59.0	78.3	79.7	81.2	91.1	97.7	103.2	101.9	87.4

	1988	1989	1990	1991
1	9.0	2.0	6.9	3.2
2	10.0	23.6	2.8	12.2
3	7.0	22.6	53.8	6.4
4	11.7	18.0	30.1	76.7
5	12.6	14.1	17.7	27.8
6	23.3	10.8	8.8	12.5
7	13.9	18.1	5.5	4.4
8	17.3	7.1	10.1	2.3
9	8.3	10.2	3.6	2.4
10	4.6	3.9	5.1	1.1
11	2.3	2.7	2.2	2.0
12	1.7	.9	1.8	.5
13	1.0	.5	.7	.7
14	1.7	.5	.3	.4
15	.3	1.4	.3	.1
1+	124.6	136.5	149.7	152.7
6+	74.4	56.2	38.4	26.5

Figure 1. Total catch, catch with estimated 4T component culled and TAC.

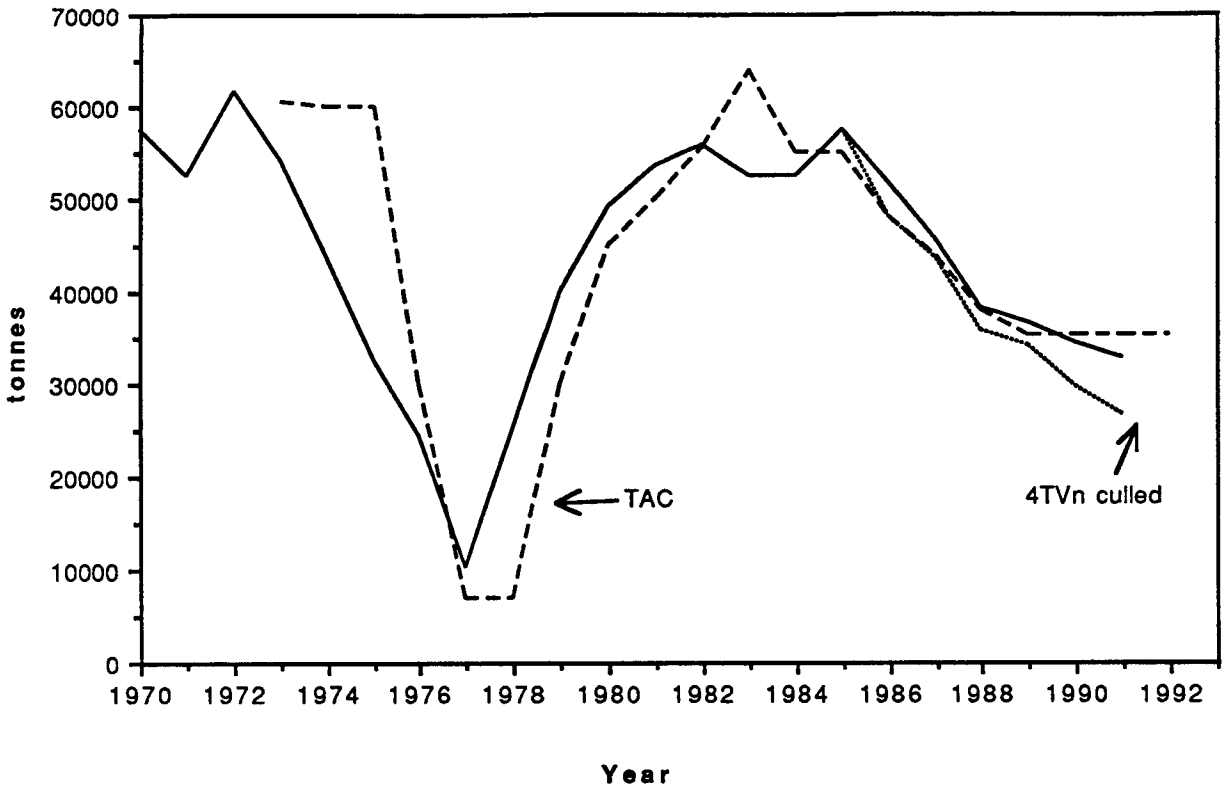


Figure 2. Percent of 4VsW cod landings taken in 4Vs.

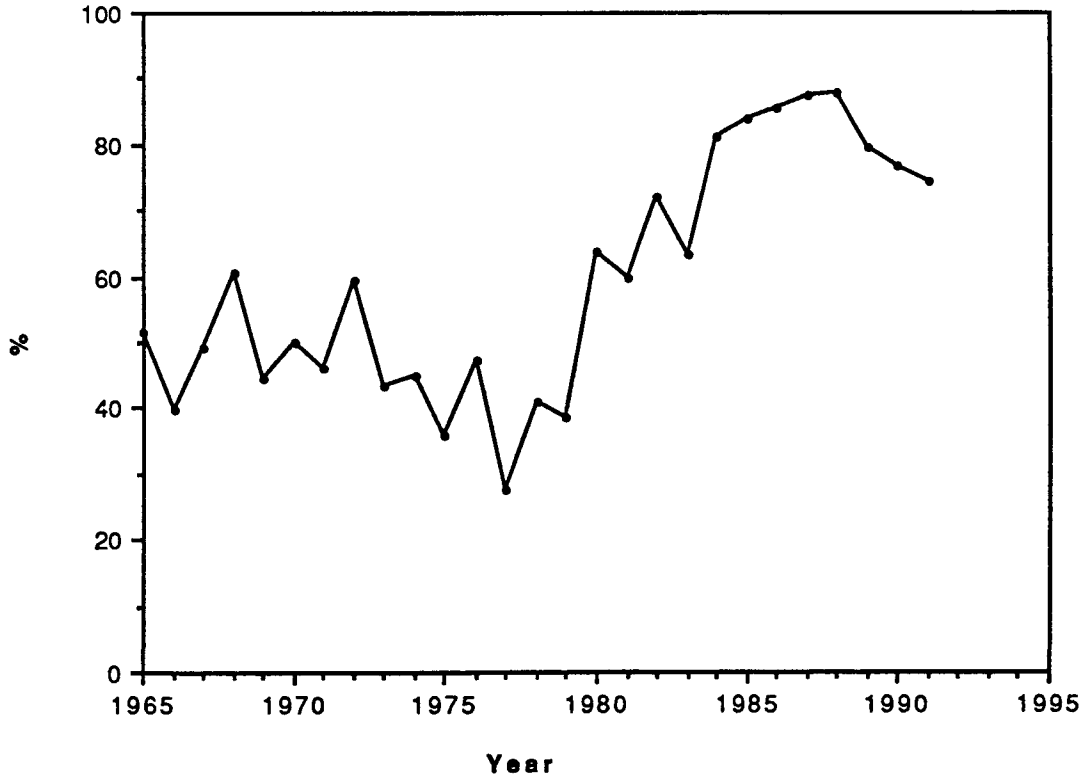
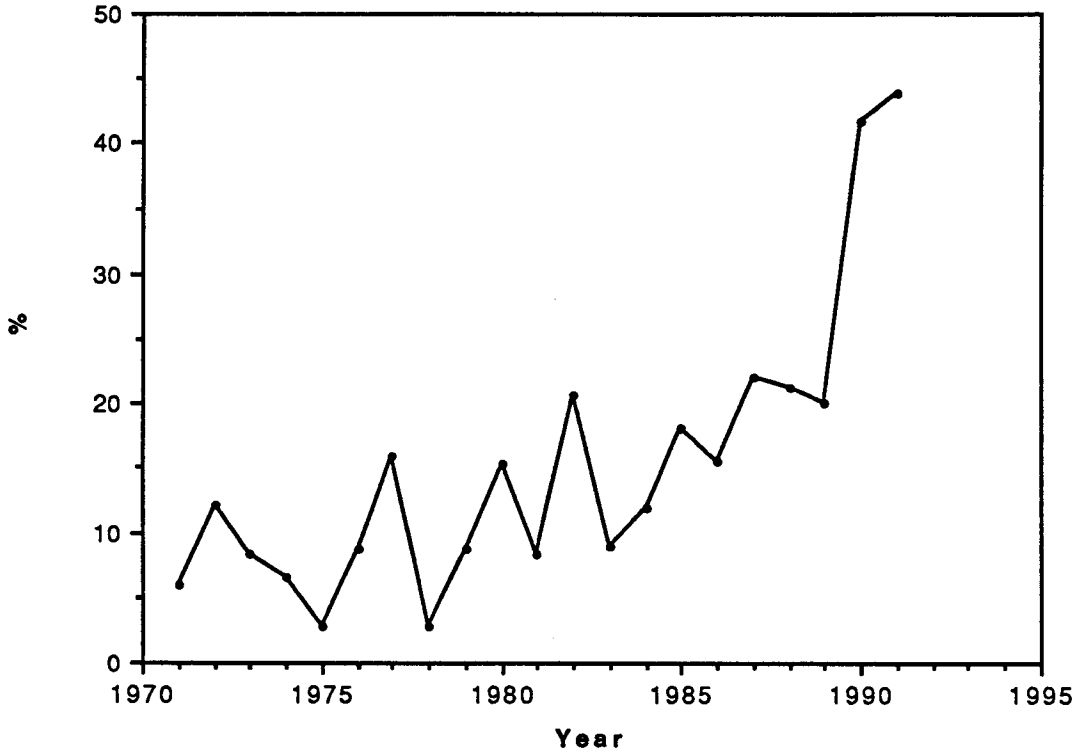
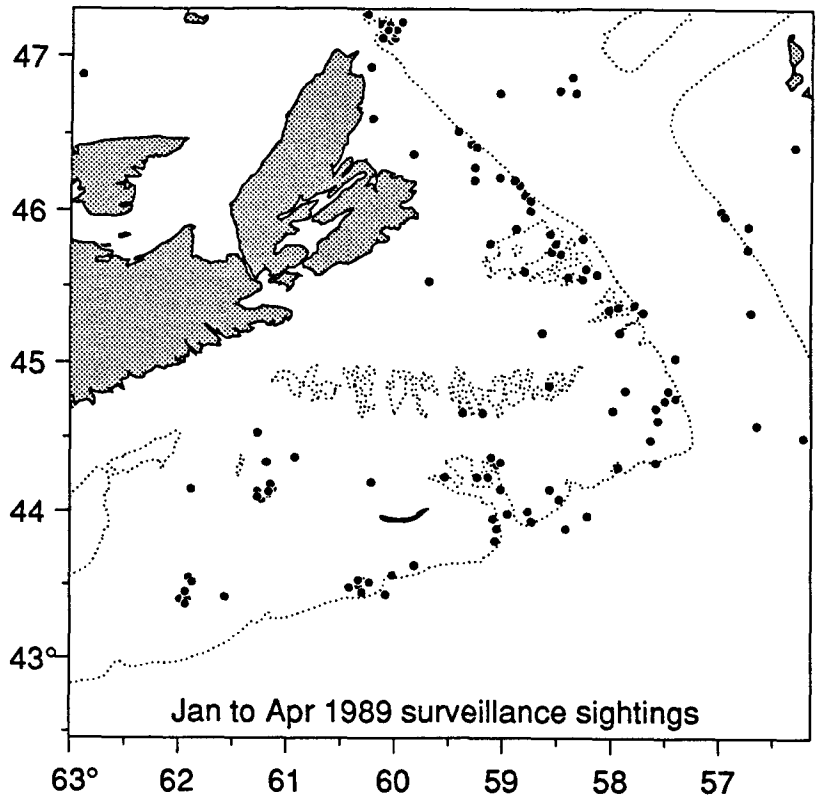


Figure 3. Percent of total 4VsW landings taken by OTB's in 4Vs in 1st quarter.





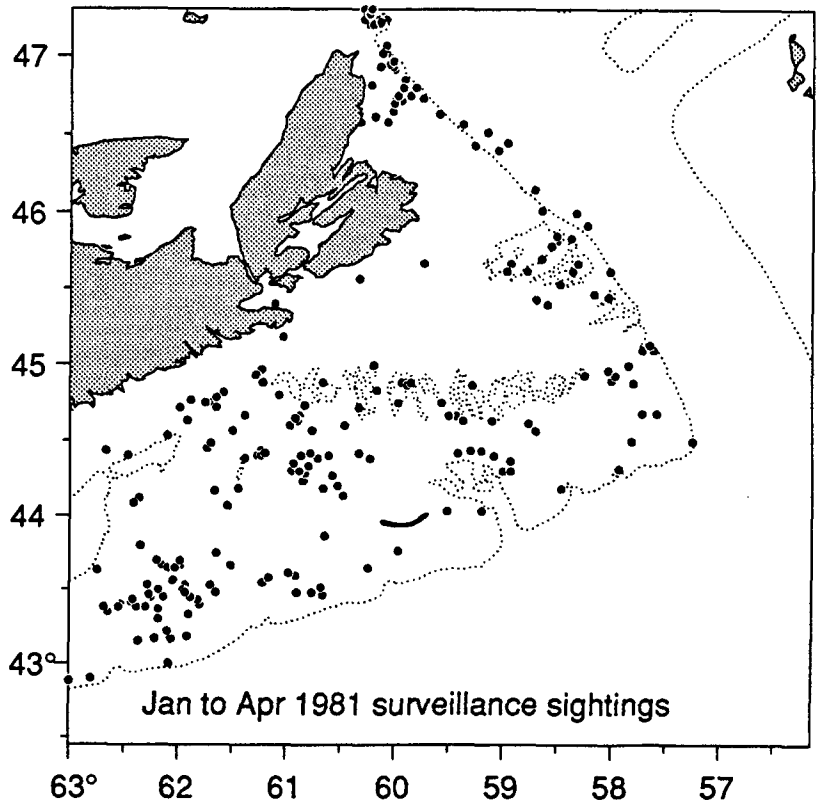


Figure 4. Comparison of 1981 and 1989 surveillance sightings of vessels fishing.

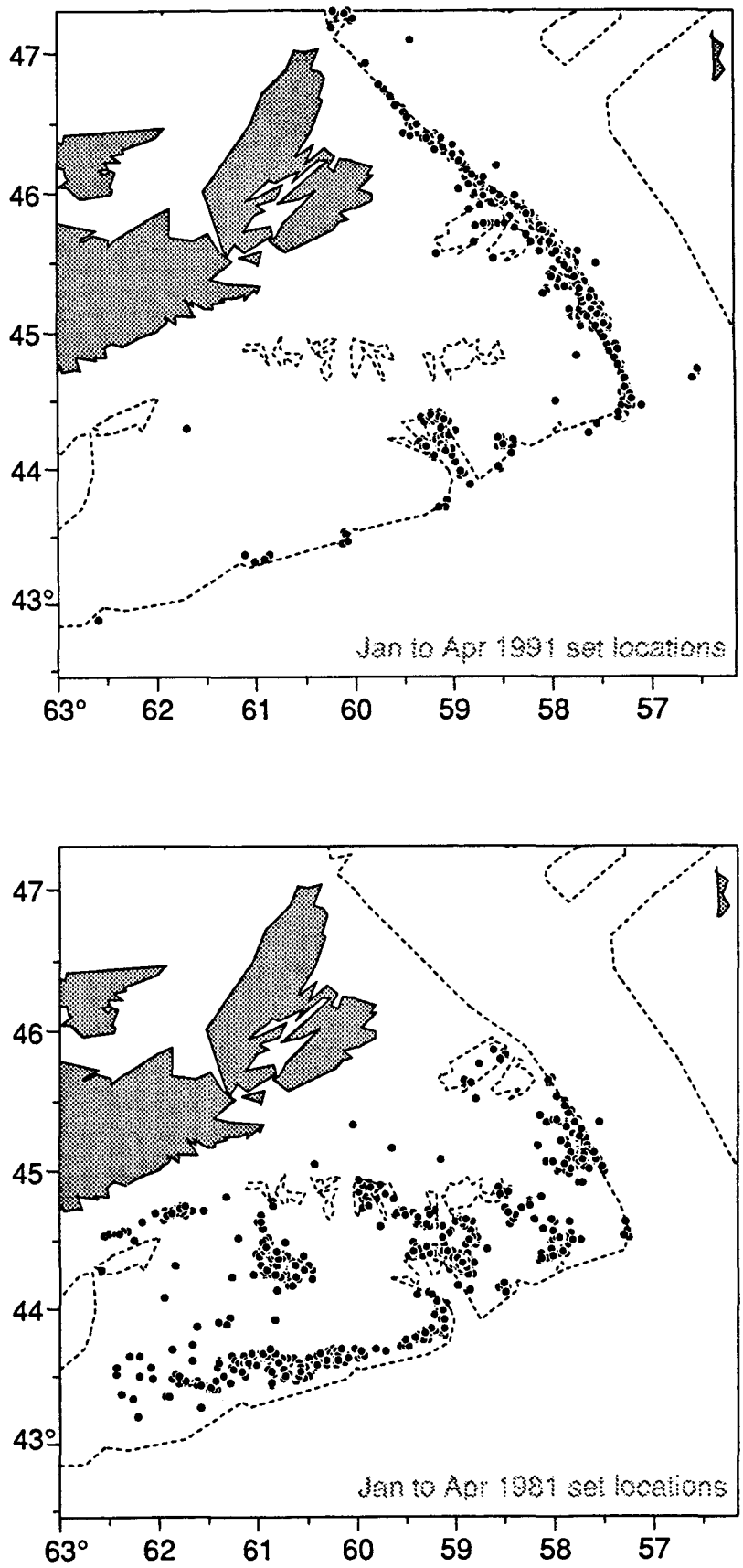


Figure 5. Comparison of 1981 and 1991 IOP set locations for directed cod catch by Canadian vessels.

Figure 6. 4VsW cod commercial mean weight at ages 5-11.

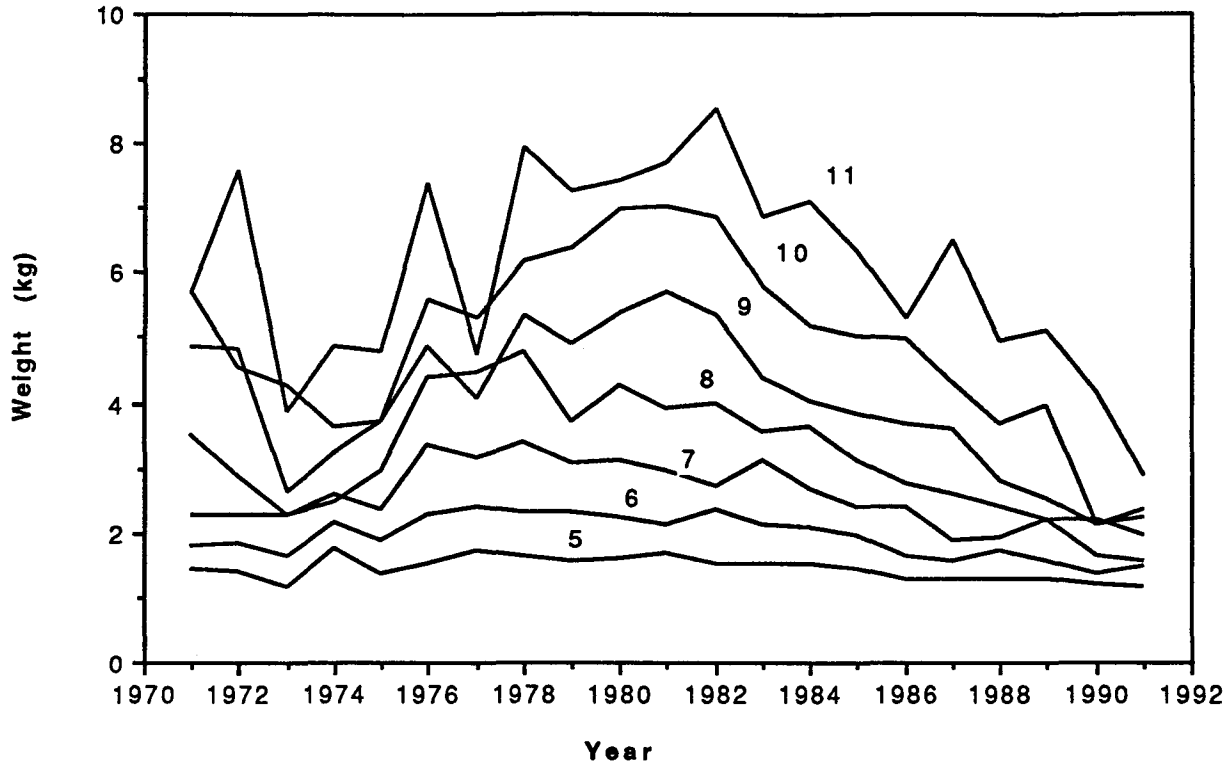


Figure 7. Landings statistics and IOP catch rates for 4VsW cod.

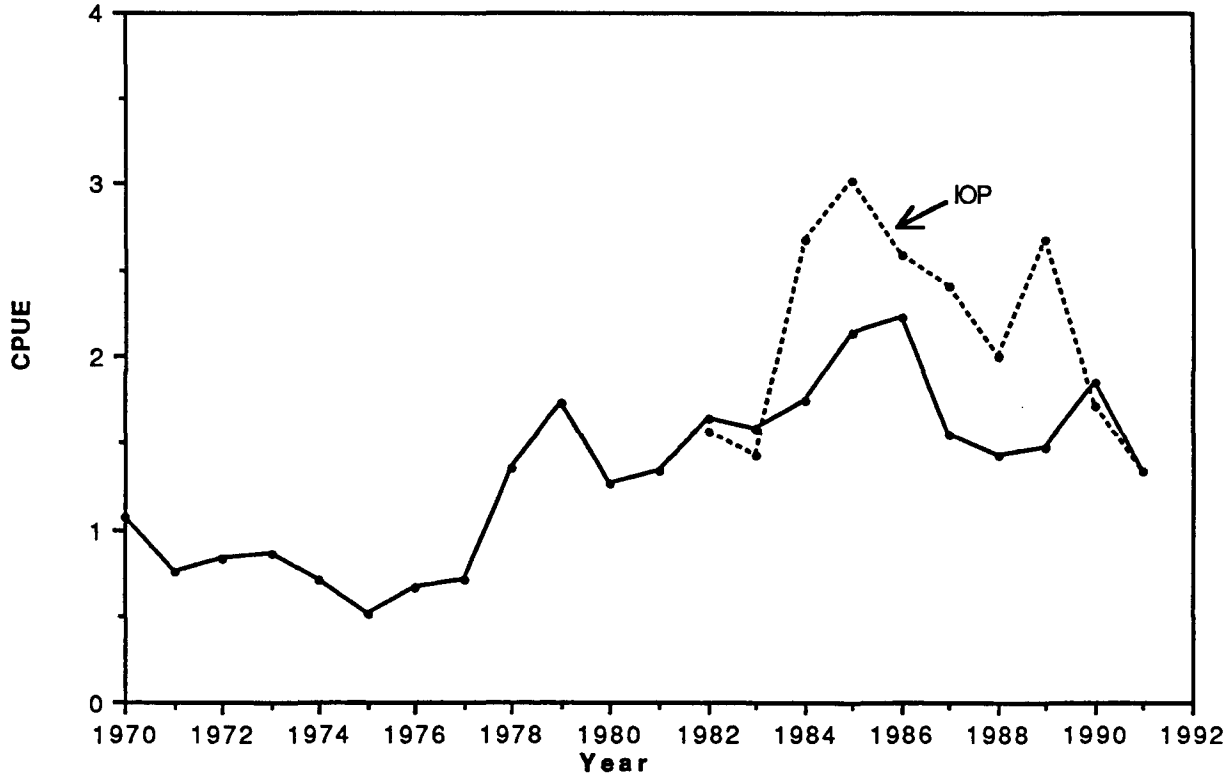


Figure 8. RV survey 3+ catch rates.

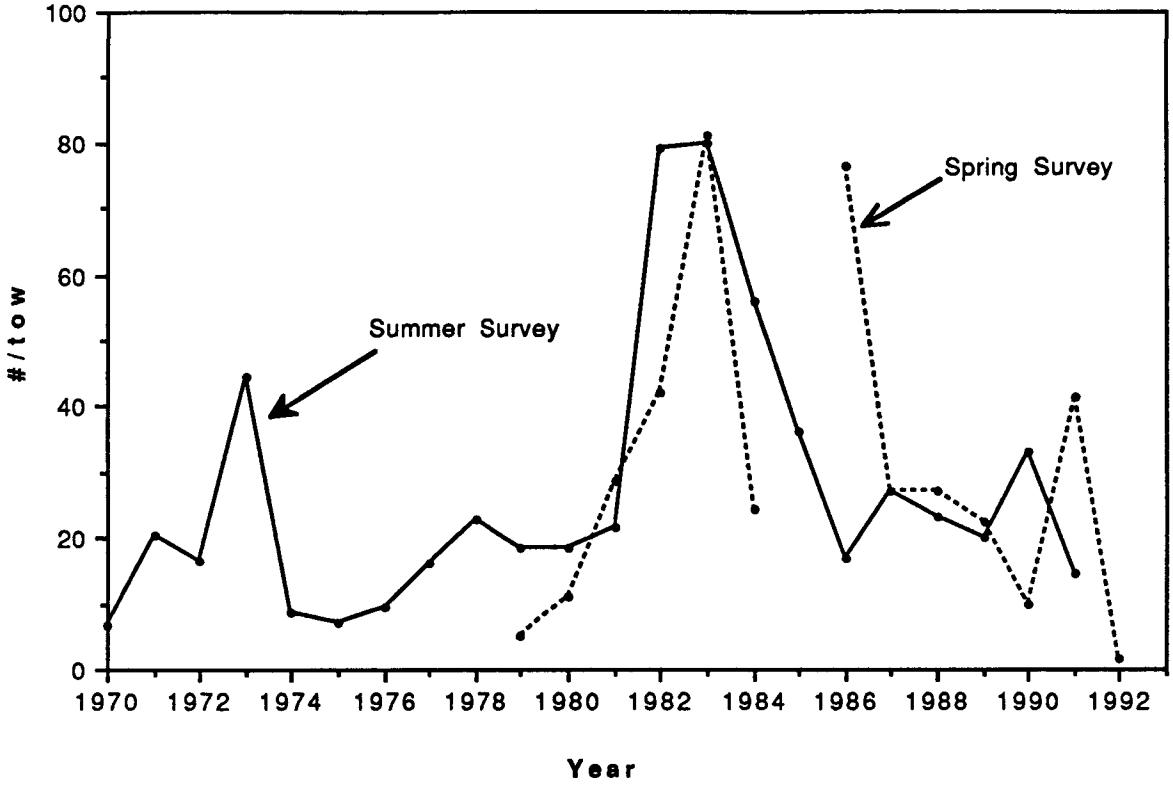


Figure 9. Biomass estimates for 4VsW cod.
Dashed line is 1+ using multiplicative model 87-89 yearclasses

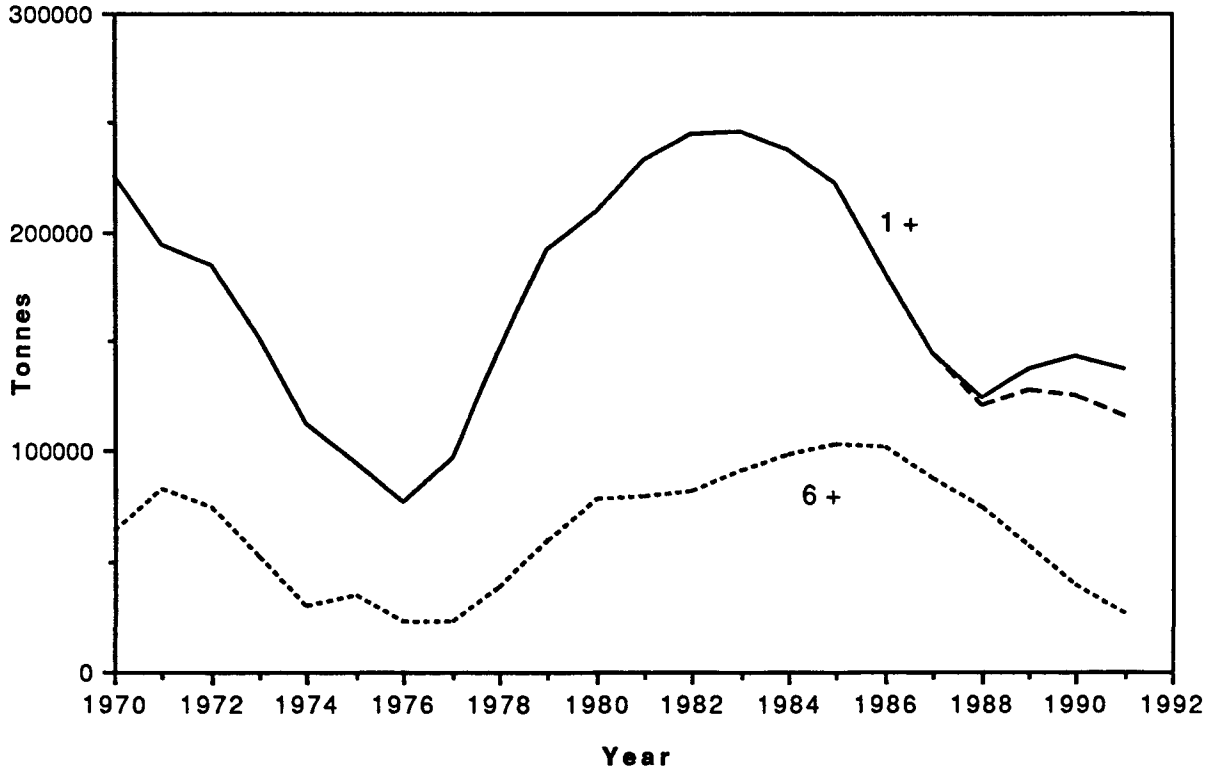


Figure 10. Recruitment series (Age 1) for 4VsW cod.
Dashed line is multiplicative model estimates.

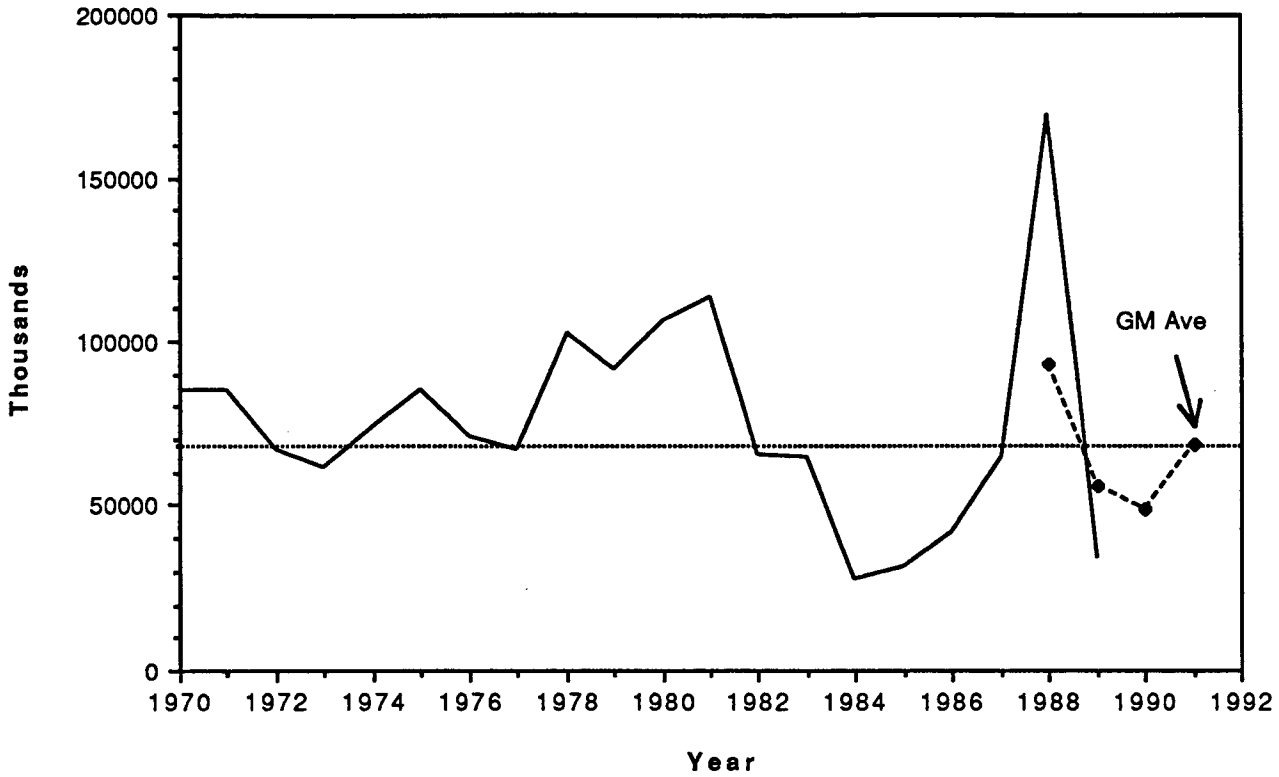


Figure 11. Estimates of average fishing mortality for 4VsW cod.

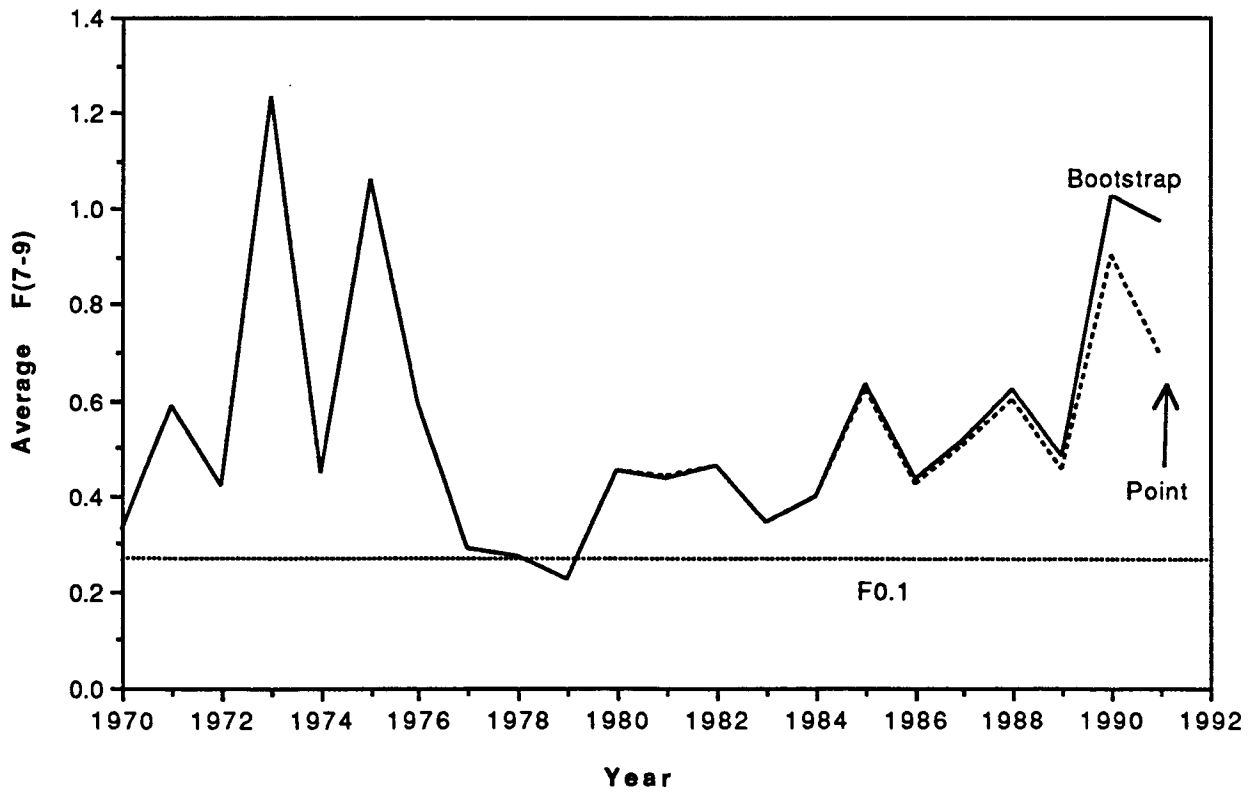


Figure 12. 4VsW Cod yield and 6+ biomass projections (SPA).