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Assessment of 4VsW cod in 1994 with consideration of ecological indicators of stock status

by

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Abstract

There was no directed fishery for 4VsW cod in 1994 due to the continuing moratorium on fishing for this stock. The bycatch landings from other fisheries in the area amounted to 368t scattered throughout the year, split evenly between 4Vs and 4W and between fixed and mobile gear sectors. The foreign catch was limited to 2 t. Sampling of the catch was difficult because of the scattered, small landings and only 5 commercial samples were available for the year.

The sequential population analysis was calibrated using the same model as in recent years with two research vessel indices (July and March). The recent surveys have been the lowest on record and the population analysis reflects this. In 1994, when only a small bycatch was permitted, fishing mortality was estimated to be 0.02. The closure of the fishery in 1993, extended through 1994, has resulted in the only significant reduction in fishing mortality since the extension of jurisdiction in 1977.

Several biological and ecological indicators were examined in evaluating the status of this stock. These included trends in size at age and condition, distribution of spawning components and environmental predictors of recruitment, grey seal predation, and ecological and spatial correlations with yellowtail flounder and capelin. A synthesis of these indicators suggests that there has been a significant ecological shift since about 1982 which may be driven by, or exacerbated by, colder water temperatures, intense fishing, and increasing seal predation.

In the short term there are no reasonable prospects for a fishery on this stock and even in the longer term, until a number of yearclasses are seen to be of near average or larger size and there is evidence of continued reproductive success, this stock cannot safely sustain a directed fishery. It will require at least 8 years for these conditions to be satisfied after the first successful recruitment.

Résumé

Il n'y a pas eu de pêche sélective de la morue dans 4VsW en 1994, en raison de la poursuite du moratoire visant ce stock. Les prises accidentelles dans les autres pêches pratiquées dans la région atteignaient 368 t sur toute l'année. Elles étaient réparties également entre 4Vs et 4W et entre les flottilles de pêche aux engins mobiles et aux engins fixes. Les prises des navires étrangers se limitaient à 2 t. L'échantillonnage des prises s'est avéré difficile en raison de la dispersion et de la faiblesse de ces dernières, et on n'a obtenu que des échantillons pour l'année.

On a utilisé le modèle des dernières années pour étalonner l'analyse séquentielle de population d'après les indices des relevés de recherche de juillet et mars. Les données de ces deux relevés étaient les plus faibles jamais enregistrées, ce que reflète l'analyse de population. On a estimé la mortalité par pêche à 0,02. La fermeture de la pêche en 1993, maintenue en 1994, est à l'origine de la seule baisse importante de la mortalité par pêche depuis l'extension de la juridiction, en 1977.

On a examiné plusieurs indicateurs biologiques et écologiques pour évaluer l'état du stock, notamment les tendances de la taille selon l'âge et la condition, la distribution des reproducteurs et les prédicteurs environnementaux de recrutement, la prédation par le phoque gris, ainsi que les corrélations écologiques et spatiales avec la limande à queue jaune et le capelan. Une synthèse de ces indicateurs révèle l'existence d'un changement écologique important depuis environ 1982, qui pourrait être provoqué ou exacerbé par une baisse des températures de l'eau, une pêche intense et un accroissement de la prédation par les phoques.

À court terme, et même à plus long terme, il n'y a pas de perspectives raisonnables de pêche dans ce stock. Ce dernier ne peut alimenter sans danger une pêche sélective avant l'arrivée d'un certain nombre de classes d'âge d'un effectif moyen ou abondant et sans des indications de succès reproducteur continu. Il faudra au moins huit ans après le premier recrutement favorable pour que ces conditions soient réunies.

The Fishery

The fishery for cod was closed for the entire year in 1994 and strict by-catch restrictions were placed on those fisheries which were operating in the area, thus continuing the closure imposed in September of 1993. This resulted in a total reported landings of 368 t, the lowest on record (Table 1, Figure 1), taken entirely as bycatch in other fisheries e.g. redfish and halibut. The extension of jurisdiction in 1977 eliminated much of the foreign effort from the Scotian Shelf and the catches, almost entirely Canadian, rebuilt strongly and rapidly. From 1980 to 1993 the catches came predominantly from Subdiv. 4Vs in contrast to being relatively balanced between 4Vs and 4W prior to that time. In 1994 the catch was equally distributed between the two divisions, presumably reflecting the distribution of the directed effort on other stocks. The catch was taken predominantly by trawls in 4Vs and longline in 4W (Table 2) such that these two major gear components landed equal amounts of 4VsW cod overall.

Data

Catch at age

Because landings were limited to bycatch throughout the year the amounts of cod in individual landings were small and usually associated with larger landings of other species. The timing or location of these cod landings was unusual compared to the historical pattern. As a result samples from the commercial catch were difficult to obtain and only five samples were available for the entire year. Thus there are only 114 ages and 713 length measurements available and this, coupled with the drastic reduction in landings in each of the last two years means that the catch at age (Table 3) and associated information must be interpreted carefully. It was not possible in this assessment to follow the usual practice of constructing individual catches at age for gear and quarter strata and so a single age length key was used for all landings.

Although the mean individual weights from commercial samples up to age 7 (1987 yearclass) have increased over 1993 (Table 4), they are still low relative to long term means. Weights at ages greater than 7 are highly variable due to the small number of fish sampled.

In recent assessments (Mohn and MacEachern, 1993,1994) landings in the winter (Jan-Apr) from 4Vs have been adjusted downwards to account for the presence of 4T cod migrating out of 4Vn into 4Vs. This was not done for 1993-94 as there was nearly no landings from that area in the winter. Furthermore, the method depends on separating the length frequency at age into 4T (smaller) and 4Vs (larger) modes and the usually distinct bimodality was not apparent in 1994. However, the adjustments for the years 1986-92 were applied as in Mohn and MacEachern (1994).

Because of the lack of sampling of the commercial catch, additional sources of age-length data were investigated. In 1994 the International Observer Program (IOP) collected a substantial number of length measurements (19,276) and 135 otoliths from 4VsW cod. These data were

used to construct a separate catch at age for comparison, as well as being combined with the commercial sampling data. Comparing the three catches at age (Figure 2) indicated that the IOP sampling recorded significantly greater numbers of ages 3 and 4 as well as small numbers at lengths corresponding to age 11 to 15 which were not seen at all in the commercial samples. Virtually all of the age 3 and about 25% of the age 4 seen in the IOP data are less than the 42 cm minimum fish length suggesting that the differences at these ages are likely due to discarding of small fish before the commercial samples are taken. In the most important age groups for the fishery (age 5 to 9) the agreement between the two sampling sources is good except for age 6 (1988 yearclass) which is about 75% higher in the IOP sampling than in the commercial sampling. In contrast to the commercial samples the mean weight at age based on the IOP samples does not indicate any significant increases in weight for the ages up to 8 and, consistent with the commercial samples, the weights for older ages are variable.

Figure 3 displays the cumulative proportion of the catch in terms of ages (3a) and individual mean weights (3b). Each plot has the 10^{th}, 50^{th} (median) and 90^{th} percentiles from 1970 to 1994. The median age shifted by almost 2 years in the late 70s when the 200 mile limit was proclaimed. and has had a weak increasing trend since then. The 10^{th} and 90^{th} percentiles also reflect the exclusion of foreign effort in 1977. In the 1990s the distance between the 10^{th} and 90^{th} percentiles has decreased showing that there are fewer age classes in the landings. The pattern in the distribution of weights in the landings is similar although the median has not changed much since the shift in 1977. The 90^{th} percentile has fallen since the mid-80s showing the depletion of the largest fish in the landings.

Indices of Abundance

No commercial catch rate is available for 1994 as the fishery was closed and no cod-directed effort was recorded. This series has not been used for tuning in recent assessments because of inconsistencies between C/E based on IOP and ZIF data (Mohn and MacEachern, 1994).

There are two research vessel groundfish trawl survey series available for this stock, a July series (Table 5) which started in 1970 and a March series (Table 6) since 1979 except 1985. Both series utilize stratified random sampling designs. The research vessel conducting the surveys has changed over this time period. In the July series the A.T. Cameron operated from 1970 to 1981, the Lady Hammond in 1982 and the Alfred Needler from 1984 to the present. Comparative fishing experiments were conducted among the three vessels during the transition years and the resulting catch conversion factor derived. The catches of first two vessels were reduced by a factor of 0.8 to be equivalent to those of the Alfred Needler (Fanning, 1985). The March series was conducted by the Lady Hammond from 1979 to 1984 and the Alfred Needler from 1986 to the present and the same conversion is used as in the July series. The stratification scheme used in the March survey was also revised in 1986 to improve the statistical efficiency of the estimates.

Both survey series (Figure 4) have tracked substantial declines in abundance since the late 1980's and estimates of adult (ages 6+) numbers are now at or near record lows. Perhaps of more

concern, neither survey indicates any sign of even average incoming recruitment. In each series, yearclasses were estimated as the average of the mean of mean catch per tow of a cohort at age 2 and a year later at age 3 (Figure 5). The most recent yearclasses are the lowest in their respective series (i.e. 92 yearclass in both series and 93 yearclass in March only) The legend notation 'only 1 age' refers to means where one of the two age groups being averaged for a cohort is missing.

Stock Assessment

The age-based population analysis accepted for the last assessment was used as the primary estimate of the current status of the stock. The estimated population numbers (Table 7) for ages 4-11 (which contribute most in the fishery) in 1993 and 1994 are the lowest observed in the 25 year series. Since 1987 there has been a steady decline in the abundance of fish over 10 years of age and the 1987 yearclass was the last one to even approach the average recruitment at age 1. The historical total numbers and age 1 recruitment from long term SPA, based on assumed F=0.5 at age 15 prior to 1970, are given for comparison in Figure 6. Estimates of biomass at age (Table 8, Figure 7) have declined even more than numbers due to the significant reductions in size at age seen since the early 1980's (see Stock Biology section below).

This analysis continued to suffer from a severe retrospective problem in that estimates of population size (Figure 8a) in a given terminal year are consistently higher, or F's (Figure 8b) consistently lower than when estimated with additional data available in subsequent years. However, given that the fishery is closed and that the current assessment is already extremely pessimistic, the assessment and subsequent management decisions are unlikely to be seriously affected by overly optimistic errors caused by the retrospective effect.

Fishing mortality in 1994 was the lowest on record (Table 9). The fully recruited F (age 7-9), in 1994 was estimated at 0.02 due solely to bycatch removals (Figure 9). The fully recruited F in 1993 is now estimated as 0.36 and in 1992 was 1.99. The early closure of the fishery in 1993 continued as a moratorium in 1994, resulted in the first significant decrease in exploitation levels since the removal of foreign effort in 1977 and the first time ever that F did not exceed $F_{0.1}$ by a significant margin.

The stock-recruitment relationship from VPA (Figure 10a) and survey (Figure 10b) are consistent in the location and trajectory of the most recent years. Recruitment is numbers at age 1 and the age 6+ population biomass is used as a proxy for spawning stock biomass. In both views the population since 1987 has been rapidly approaching the origin as both spawning stock biomass and recruitment decline. In the RV survey figure, the recruitment estimates, with a few exceptions, tend to be clustered in a fairly narrow range, regardless of the spawning stock biomass. The VPA based figure shows a much greater spread in recruitment and also indicates a significant split in the data points with most of the data from the 1970's clustered in a zone substantially higher than those from the 1980's and 90's.

Stock Biology

Trends in Growth and Condition

Length at age declined in this stock from the mid 1980's to about 1992 in both the RV data and the commercial catch data (Table 10). Since about 1992 the pattern of declining size at age across all ages seems to have changed in that some ages showed increases in one or more years. Overall, however, sizes remain near record lows. At the same time that mean length at age was declining there was also a steady decline in the condition i.e. the relative weight of the fish for their length. The index of condition used here is the predicted weight of fish of a given length based on the length/weight relationship derived from the annual July surveys. An earlier study on the condition of cod in 4VsW (Fanning, unpublished manuscript) up to 1989 had found a highly significant ($p<.0001$, $R^2=82\%$) negative relationship between population biomass (age 3+) and the condition of the fish which was suggestive of density-dependent effects on the weight at length (Figure 11). Extending that analysis to include from 1990 to the present substantially reduces the correlation suggesting that another mechanism has been responsible or at least influential since that time. Since 1989 the population biomass has declined substantially however the condition index has continued to fall rather than increase as would have been expected under density-dependent regulation. This suggests that the current factors regulating condition in 4VsW cod are not related to the population density but may be due to a less favourable environmental or ecological regime.

Spawning Components

The cod resource on the Eastern Scotian Shelf is a complex of spawning components including at least two major offshore groups (Western/Sable and Banquereau), several smaller offshore groups (Middle Bank, Canso Bank) and a chain of small coastal spawning groups. The situation is complicated by the presence of both spring and fall spawning in several of the spawning components (Sable/Western offshore and various inshore areas). A recent study of the production of cod eggs and larvae in 4W (OPEN, 1991-93) found that fall-spawned production accounted for over 90% of the total. This is in contrast to the findings of a major program in 1977-82 (SSIP) in which egg and larval production was nearly equal between the spring and fall spawning components. The disappearance of eggs and larvae from the spring spawning period in 4W would suggest that either the adult 4W spawning component had been eliminated or that, for whatever reason, it's reproduction was unsuccessful. Elimination of the spring 4W spawning component is consistent with a shift observed in the distribution of fishing effort in the spring spawning period over the same years. In 1981 fishing effort during the spring spawning period, Jan-Apr, was distributed widely over the entire 4VsW area and in the vicinity of all the major offshore banks. During the mid to late 80's this had contracted to the eastward (Sinclair and Smith, 1987) and since then virtually all the fishing effort during the spring spawning period was concentrated on the slope of the Laurentian Channel in 4Vs.

Ecosystem Considerations

Grey seal predation

Estimates of grey seal predation on 4VsW cod presented last year were based on information on the composition of grey seal diets collected between 1989 and early 1993. The model was revised to incorporate new data on the seal dynamics and metabolism. Consequently the estimate for seal consumption in 1993 was revised downward from 17,300 (Mohn and Bowen, 1994) to about 14,000 t of cod mostly less than 4 years old. The proportion of cod in the diet of grey seals in these samples did not indicate a trend over this time period. However, given the low and declining cod biomass, it was possible that grey seals might reduce predation on cod in favour of more abundant prey. Samples collected from Sable Island between the summer of 1993 and the fall of 1994 show that the proportion of cod in the grey seal diet, although variable among samples, has remained at about 15%. Given the continued increase in the grey seal population, consumption of 4VsW cod by grey seals is estimated to be 15,400t in 1994. Because of the revisions in the model described above this represents an increase over the previous year despite being less than previously reported.

Environment-Based Recruitment Models

Frank et al. (1994) tested a number of environmental signals as regression predictors of 4VsW cod recruitment. These models were re-examined using the recruitment series adjusted for seal predation. The St. Lawrence River discharge (RIVSUM) correlation fits better in the recent years than for the unadjusted recruitment however the overall correlation is relatively low. The Emerald Basin 200 m temperature series showed the strongest correlation accounting for approximately half of the measured recruitment variability in 4VsW cod (Figure 12). Although the actual mechanism is not understood in either case (RIVSUM or temperature), it has been suggested that the temperature series reflects conditions in the upper water layers near the spawning locations during the time the eggs and larvae are in the water. Whatever the mechanism may be, it is noteworthy that the temperature based predictions for recent years (1992-94), although low relative to the predictions for earlier years, are consistently over the VPA estimate of recruitment.

Yellowtail-Cod Correlation

An analysis of spatial association (Zwanenberg, pers. comm.) based on July RV surveys revealed that cod and yellowtail flounder had a consistent spatial correlation in the 1970's that has essentially disappeared since that time. The distribution of yellowtail flounder appears unchanged over the entire time series with the fish concentrated on top of the offshore banks of the eastern Scotian shelf. The gross distribution of cod has shifted in the past 10-15 years from being widely distributed in 4Vs and 4W primarily on the bank tops, to being more concentrated on the slopes in the northeastern shelf area. Yellowtail flounder are considered to be relatively restricted in their movements and do not appear to migrate in response to changes in water conditions such as

temperature. Cod, on the other hand, have been shown to have certain water mass associations, albeit changing with age. This change in spatial association suggests that the community structure has been changed as well.

Capelin Abundance

Capelin have been present in both the July and March RV surveys in increasing numbers since 1984 and the large numbers occurring since 1990 are unprecedented (Table 11). Capelin are a cold-water species generally restricted to temperatures less than 4°C. Consequently, they occur in this area only in periods of colder than normal bottom water and are generally restricted to 4Vs when they are present. The pattern of capelin abundance in the surveys indicates that two colonization events occurred, one in the early 1970's and a second one since about 1987. In each case the initial years were characterized by small numbers of adult capelin which were followed in subsequent years by increasing numbers of adults and the appearance of younger fish as well. The 1970's capelin colonization ended abruptly in 1975 when none were observed in the survey. Their continuing presence in 4VsW suggests the cold conditions that are persisting throughout the year in the area since about 1984 have effected a significant ecological change in this area. The results, in terms of cod ecology, of such a change are difficult to predict. Although capelin are an important forage species in their normal range, supporting seabird, groundfish and marine mammal populations, it cannot be said whether their presence in 4Vs would indicate an enhanced forage base or a displacement of the normal forage species in the area.

Synthesis

The period since about 1986 has been one of significant cooling in the 4VsW area, particularly in 4Vs. The mean temperatures on the bottom declined by 1-2°C during this time. The effect this has had on the biology and ecology of cod in the area is not known, however a number of the biological observations noted above can be interpreted plausibly, if somewhat speculatively, in terms of changes in the ecosystem dynamics of the area. For example, individual fish are now shorter at age and in lower condition; there is a lack of recruitment and there has been an apparent disappearance of a major 4W spring spawning component. Each of these effects may be due to changes in the environmental conditions e.g. low temperature or lack of food, or to fishery effects e.g. selective removal by the fishery of large or highly aggregated fish.

Whether environmentally or fishery induced (or both), there are clear changes in the ecological communities in 4VsW, particularly in 4Vs. The establishment of a capelin population in 4Vs is, by itself, an ecological shift with respect to the period prior to 1986. This comes at about the same time that a previously consistent correlation between cod and yellowtail flounder appears to have broken down. These two changes in cod associations coincide with the onset of the colder environmental conditions and may in fact be in response to them. However, there has also been a coincidental increase in a significant cod predator (grey seals) in a period of low production and reproduction for cod, thus increasing the ecological pressure on the cod population.

Outlook

Projections

Population and catch projections for the years 1995 to 1997 were calculated using the same mean weights and selectivity pattern as in the last assessment (Mohn and MacEachern, 1994). The GM recruitment for the years 1984-92 (27.6 million) was used. This is appropriate as it represents the average recruitment during the recent years of consistent poor recruitment. Given that the most recent years appear even lower than in the late 1980's this may still be too high. This should have little effect as the 3 year projection period is relatively insensitive to recruitment inputs. Two fishery options were considered; the fishery remains closed with bycatch landings of 400 t each year and secondly, $F_{0.1}$ (0.22) fishing mortality in each year.

Option 1: Closed fishery at 400t bycatch

Year	F	Yield	Population Biomass	Adult (6+) Biomass
1995	0.025	400	40903	13957
1996	0.017	400	52588	19280
1997	0.012	400	64687	28159

Option 2: $F_{0.1}$ fishing mortality

Year	F	Yield	Population Biomass	Adult (6+) Biomass
1995	0.22	3318	40903	13957
1996	0.22	4314	49667	16645
1997	0.22	5537	57761	21662

The short-term prospects for this stock remain dismal. The adult population is at historic low levels; there is no indication of any significant recruitment; both growth and condition of the fish are poor; and there is a significant and increasing predation by seals contributing to natural mortality. The last noticeable recruitments were the 1986 and 1987 yearclasses, both of which were well below the long-term average; the last average yearclasses were in 1981 and 1982. The spawning stock biomass is about 25% of the long term mean. It is less than 50% of the minimum spawning stock biomass threshold and well below the dangerous spawning stock biomass threshold as defined in the 1994 Spring RAP report (O'Boyle and Zwanenburg, 1994). If the environmental and ecological conditions discussed above persist there seems little likelihood of recruitment of a large yearclass from the current 4VsW cod population and thus even bycatch in other fisheries may pose a serious threat to the eventual recovery of this stock.

In the longer term, until a number of yearclasses are seen to be of near average or larger size and have reached maturity i.e. age 5 or 6 and the stock demonstrates continued reproductive success, this stock cannot safely sustain a directed fishery. It will require at least 8 years for these conditions to be satisfied after the first successful recruitment.

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

YEAR	CANADA	FRANCE	PORTUGAL	SPAIN	USSR	OTHERS	TOTAL	SUBDIV. 4Vs	DIV. 4W	TAC
1958	17938	4577	1095	14857	-	124	38591	23790	14801	
1959	20069	16378	8384	19999	-	1196	66026	47063	18963	
1960	18389	1018	1720	29391	-	126	50644	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	36619	-	-	-	84	40	36743	29378	7365	35200
1990	34172	-	-	-	150	81	34403	26274	8129	35200
1991	32804	-	-	-	-	-	32804	24596	8208	35200
1992	29724 [1]	3 [2]	-	-	36 [2]	42 [2]	29805	21317	8488	35200
1993	3434 [1]	-	-	-	15 [2]	25 [2]	3474	2316	1158	11000
1994	366 [1]	-	-	-	- [2]	2 [2]	368	180	188	
1995										

[1] Preliminary Catch Statistics (ZIFF)

[2] International Observer Program

Table 2. Canadian catch of 4VsW cod by gear 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	23800	28595	6263	3331	988	39177
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	4511	28083	8240	994	898	38215
1989	22608	6324	400	40	29372	3332	2983	323	609	7247	25940	9307	723	649	36619
1990	22218	3825	224	4	26271	2839	4080	530	452	7901	25057	7905	754	456	34172
1991	20529	3838	229	.	24596	3579	3675	371	583	8208	24108	7513	600	583	32804
1992	17941	3203	170	.	21314	3596	4098	506	210	8410	21537	7301	676	210	29724
1993	1189	1071	56	.	2316	174	798	87	59	1118	1363	1869	143	59	3434
1994	144	32	4	.	180	32	142		12	186	176	174	4	12	366

Table 3. Commercial 4VsW cod catch at age (000's). (4TVn component included)

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Age													
1	1293	1984	2046	1218	1273	1538	513	1	34	12	31	3	3
2	8631	12824	15865	10221	7321	8571	2866	23	94	93	92	258	138
3	8886	9643	11801	8001	13324	7402	2860	532	1168	1762	1765	3200	2473
4	14802	5125	11989	5803	11695	3163	4707	1229	4078	6559	4873	9136	7667
5	13673	6612	7384	9634	6854	4788	3900	1591	4817	9525	6937	7281	10123
6	4539	5128	6527	3324	2247	3297	2085	845	2582	5056	6177	4651	3681
7	1942	3419	3308	3370	669	2943	1287	490	767	1210	3050	2957	2568
8	759	1963	1880	4732	1008	623	447	199	247	377	1121	1421	1315
9	236	704	347	1684	196	497	136	118	107	76	313	397	679
10	72	367	466	389	153	686	53	33	75	23	92	135	318
11	137	159	68	551	13	172	12	42	31	10	50	69	153
12	56	173	8	8	2	123	47	44	27	4	26	32	65
13	9	156	36	21	0	41	0	11	28	3	4	22	54
14	12	80	0	21	0	6	4	3	10	0	0	2	55
15	4	40	3	18	0	6	0	2	1	0	1	5	19
16	4	52	7	47	0	19	2	6	2	0	7	2	19
1+	55055	48429	61735	49042	44755	33875	18919	5169	14068	24710	24539	29571	29330
3+	45131	33621	43824	37603	36161	23766	15540	5145	13940	24605	24416	29310	29189
6+	7770	12241	12650	14165	4288	8413	4073	1793	3877	6759	10841	9693	8926

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Age												
1	0	0	0	0	0	0	0	0	0	0	0	0
2	6	1	4	3	0	8	7	0	1	2	0	0
3	3507	430	156	124	38	185	671	291	277	571	32	0
4	8679	5778	2253	4210	877	1512	2544	2329	3365	2541	427	4
5	7484	9101	8151	7640	5694	2399	4111	3983	6790	9251	605	68
6	6278	5678	7523	9221	5885	4531	3334	3659	4486	6080	758	29
7	1905	3829	4284	3589	6049	4075	3669	2208	3348	2125	513	72
8	1012	1250	2430	1571	2733	3295	1796	3212	1332	1401	129	15
9	625	544	1063	1123	1105	1731	2018	1600	1356	521	44	5
10	224	290	452	447	604	626	590	1879	861	471	8	1
11	149	153	284	285	233	260	251	328	457	231	7	0
12	52	63	173	105	131	153	156	135	154	178	4	0
13	24	34	68	66	61	64	29	55	65	33	2	0
14	15	17	20	11	11	9	15	15	10	7	1	0
15	6	8	17	19	14	10	58	14	6	6	0	0
16	11	5	15	18	12	11	35	13	5	7	0	0
1+	29977	27181	26893	28432	23447	18869	19284	19721	22513	23425	2530	194
3+	29971	27180	26889	28429	23447	18861	19277	19721	22512	23423	2530	194
6+	10301	11871	16329	16455	16838	14765	11951	13118	12080	11060	1466	122

Table 4. 4VsW cod weights at age from commercial landings.

Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Age													
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	0.53	0.79	0.49	0.43	.	.	.	0.61	0.57	0.59	0.60	0.55	0.47
3	0.76	1.01	0.96	0.79	0.71	0.79	0.80	0.96	0.69	0.81	0.81	0.77	0.78
4	1.08	1.15	0.94	1.19	0.85	1.05	1.11	1.21	0.96	1.16	1.12	1.04	1.04
5	1.45	1.39	1.17	1.74	1.36	1.50	1.72	1.63	1.57	1.60	1.68	1.53	1.53
6	1.80	1.84	1.64	2.17	1.88	2.26	2.40	2.33	2.30	2.22	2.12	2.33	2.13
7	2.28	2.29	2.29	2.59	2.34	3.33	3.15	3.39	3.08	3.10	2.96	2.73	3.09
8	3.50	2.88	2.28	2.47	2.94	4.37	4.47	4.76	3.72	4.26	3.90	3.99	3.55
9	4.87	4.82	2.64	3.24	3.69	4.85	4.04	5.34	4.90	5.38	5.69	5.34	4.38
10	5.70	4.56	4.27	3.62	3.72	5.57	5.29	6.19	6.39	6.96	7.02	6.84	5.79
11	5.70	7.57	3.85	4.87	4.79	7.39	4.73	7.91	7.25	7.42	7.68	8.53	6.84
12	8.74	11.56	9.48	9.58	5.46	3.38	4.92	8.57	10.11	10.01	9.45	8.88	9.16
13	6.77	6.31	7.05	.	8.24	14.23	6.57	9.61	13.95	8.75	12.05	10.90	10.64
14	5.92	.	9.06	.	12.10	11.54	8.85	10.30	10.26	10.53	8.48	10.43	11.73
15	9.27	14.49	10.98	.	12.78	22.97	10.52	8.37	11.97	13.97	9.80	13.34	14.07
16	6.03	8.73	9.61	.	8.13	15.50	12.27	12.04	12.89	17.80	17.77	14.92	13.55

Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Age											
1	.	.	.	.	.	.	.	.	.	.	.
2	0.54	0.68	0.27	.	0.35	0.29	.	0.46	0.19	.	.
3	0.74	0.71	0.68	0.48	0.63	0.77	0.76	0.77	0.63	0.57	0.69
4	1.06	1.03	0.95	0.93	0.97	1.01	1.00	0.88	0.79	0.86	1.28
5	1.50	1.45	1.26	1.28	1.26	1.28	1.23	1.14	1.01	1.05	1.53
6	2.06	1.97	1.65	1.54	1.73	1.56	1.40	1.46	1.31	1.39	1.83
7	2.69	2.38	2.38	1.87	1.92	2.19	1.68	1.57	1.76	1.79	1.80
8	3.64	3.10	2.74	2.61	2.37	2.21	2.27	1.96	1.84	2.21	2.12
9	4.03	3.84	3.67	3.58	2.79	2.50	2.18	2.37	1.96	4.05	2.70
10	5.19	5.03	4.99	4.31	3.67	3.93	2.17	2.29	2.72	3.71	2.85
11	7.09	6.32	5.30	6.49	4.92	5.10	4.38	2.89	2.49	7.75	.
12	8.44	6.13	6.87	6.32	7.06	5.16	6.19	3.53	2.60	4.78	.
13	9.28	9.88	10.18	7.23	7.65	8.55	8.49	4.14	5.67	11.02	.
14	10.58	11.12	9.57	11.68	11.17	12.28	12.33	12.98	13.53	13.44	.
15	12.63	11.12	11.89	12.69	12.16	7.87	10.38	9.18	12.83	14.27	.
16	13.21	14.49	14.52	13.19	14.76	15.38	11.41	10.75	12.97	16.01	.

Table 5. 4VsW cod July survey mean catch at age per tow.

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Age													
0	0.03	0.01	.	.	0.25	0.02	.	.	0.05	0.29	0.01	0.02	.
1	0.42	0.44	1.78	1.84	1.48	0.95	0.67	0.21	0.88	0.35	0.20	1.33	0.73
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	62.94
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	52.60
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	18.37
5	1.28	4.53	1.67	6.44	0.58	0.86	1.65	2.82	2.71	5.18	4.98	3.22	4.12
6	0.42	1.66	1.72	0.53	0.64	0.19	0.32	1.24	1.00	2.59	3.47	2.31	2.23
7	0.50	0.99	0.46	0.83	0.11	0.23	0.15	0.27	0.25	0.77	1.37	1.19	1.20
8	0.16	0.42	0.16	0.26	0.13	0.06	0.26	0.18	0.05	0.29	0.37	0.44	0.51
9	0.03	0.18	0.14	0.12	0.06	0.12	.	0.04	0.03	0.12	0.10	0.14	0.11
10	0.07	0.02	0.04	0.15	0.05	0.01	0.18	.	0.02	0.02	0.08	0.16	0.12
11	0.08	0.04	.	0.05	0.02	.	0.02	0.03	.	0.01	0.03	0.04	0.06
12	0.03	0.02	.	.	0.02	0.02	.	0.02	.	.	.	0.01	.
13	0.05	0.06	.	.	.	.	0.04	.	.	0.01	.	0.01	.
14	.	.	.	0.06	.	.	.	.	.	.	.	.	.
15	.	.	.	0.01	0.02	.	.	.	.	.	.	0.01	.
16	.	.	.	.	.	.	.	.	0.02	.	.	.	.
0+	12.04	23.09	21.19	58.74	19.96	10.41	13.81	19.06	27.52	22.03	20.87	26.50	142.99
3+	6.86	20.44	16.64	44.31	8.78	7.01	9.44	16.10	22.84	18.35	18.65	21.50	79.32
6+	1.34	3.39	2.52	2.01	1.05	0.63	0.97	1.78	1.37	3.81	5.42	4.31	4.23

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Age												
0	0.02	0.07	.	0.03	0.04	0.07	0.03	.	.	.	0.01	0.06
1	13.72	0.41	1.29	0.36	0.64	0.06	0.25	0.13	0.47	1.69	0.09	0.11
2	13.31	7.27	1.68	1.32	1.51	4.70	8.86	5.06	1.82	5.02	1.00	1.30
3	44.47	12.82	7.88	1.53	4.97	7.29	7.38	18.22	3.38	6.60	6.36	2.81
4	19.25	19.09	9.56	6.16	4.83	5.89	5.01	8.64	6.97	4.08	7.18	2.39
5	9.88	12.94	9.32	3.89	8.86	3.27	3.47	3.83	4.91	2.59	5.66	1.11
6	4.42	6.01	5.12	3.26	3.61	3.41	1.35	1.41	1.63	0.88	3.16	0.49
7	0.99	4.13	2.56	1.15	2.71	1.95	2.00	0.60	0.43	0.15	1.10	0.51
8	0.55	0.41	1.01	0.55	1.47	0.98	0.47	0.29	0.19	0.07	0.27	0.06
9	0.14	0.33	0.48	0.24	0.34	0.22	0.32	0.11	0.24	0.04	0.00	0.04
10	0.08	0.10	0.11	0.15	0.02	0.05	0.01	0.07	0.07	0.02	0.02	0.04
11	0.04	0.23	0.11	0.04	0.08	0.12	.	.	0.05	.	.	0.02
12	0.02	0.01	0.07	.	0.04	0.02	0.02	.	0.02	.	.	.
13	0.02	0.01	.	0.02	0.01	.	0.01	.	.	.	.	.
14	.	0.01	.	.	.	0.02	.	.	.	0.01	.	.
15	.	.	0.01	.	0.03	.	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.	.	.	.	.
0+	106.91	63.84	39.20	18.70	29.16	28.05	29.18	38.35	20.17	21.14	24.85	8.93
3+	79.86	56.09	36.23	16.99	26.97	23.22	20.04	33.16	17.88	14.44	23.75	7.46
6+	6.26	11.24	9.47	5.41	8.31	6.77	4.18	2.47	2.63	1.16	4.55	1.16

Table 6. 4VsW cod Spring survey mean catch at age per tow.

Year	1979	1980	1981	1982	1983	1984	1985	1986	1987
Age									
0	.	.	.	.	.	.	.	.	.
1	0.26	0.86	8.25	2.65	0.85	0.22	.	0.19	0.35
2	2.12	2.71	3.80	22.22	3.17	1.49	.	10.88	0.92
3	0.89	2.04	5.29	17.91	42.14	1.85	.	19.44	2.87
4	0.60	1.67	7.79	11.84	25.52	9.37	.	23.58	4.50
5	1.37	2.52	4.87	7.24	4.96	6.21	.	11.67	10.14
6	1.02	2.90	5.76	1.99	5.85	2.92	.	13.13	4.82
7	0.47	1.43	3.20	1.36	1.32	2.53	.	6.27	3.32
8	0.29	0.30	1.53	1.08	0.62	0.77	.	1.34	1.20
9	0.07	0.06	0.18	0.28	0.29	0.50	.	0.73	0.24
10	0.10	0.03	0.14	0.14	0.10	0.20	.	0.28	0.10
11	0.08	0.01	0.03	0.06	0.04	0.02	.	0.04	0.04
12	0.02	.	0.02	0.03	0.04	0.09	.	0.05	0.03
13	0.03	0.01	.	0.01	0.01	.	.	0.01	0.03
14	0.01	.	.	.	0.04	0.01	.	0.01	0.01
15	0.01	.	.	0.01	.	.	.	.	.
16	.	.	.	0.01	.	0.02	.	0.01	.
0+	7.33	14.55	40.86	66.83	84.94	26.19	.	87.62	28.56
3+	4.95	10.98	28.81	41.96	80.92	24.48	.	76.55	27.30
6+	2.10	4.74	10.86	4.97	8.31	7.06	.	21.87	9.79

Year	1988	1989	1990	1991	1992	1993	1994	1995
Age								
0	.	.	.	.	.	.	.	.
1	0.60	0.58	0.12	0.02	0.07	0.03	0.10	0.23
2	7.96	17.96	1.60	3.50	0.52	2.86	0.16	0.39
3	9.49	10.40	5.08	12.15	0.25	5.62	0.30	0.63
4	4.26	4.23	2.56	21.92	0.25	3.83	0.83	1.19
5	4.32	4.80	0.86	5.09	0.49	2.43	0.46	2.05
6	4.88	1.68	0.31	1.49	0.31	1.08	0.68	0.48
7	1.43	0.70	0.19	0.35	0.11	0.16	0.33	0.25
8	1.87	0.22	0.36	0.02	0.05	0.08	0.26	0.12
9	0.46	0.25	0.13	0.10	0.02	0.01	0.03	0.00
10	0.19	0.05	0.12	.	.	.	0.02	0.01
11	0.18	0.03	0.04	0.01	0.01	.	.	.
12	0.04	0.02	0.03	.	0.03	.	.	.
13	0.02	.	0.01	0.02	0.01	.	.	.
14	.	0.01	.	0.01	.	.	.	.
15	0.03	0.02	.	.	.	.	.	.
16	.	.	.	.	.	.	.	.
0+	35.75	40.94	11.42	44.69	2.14	16.10	3.17	5.35
3+	27.18	22.41	9.69	41.16	1.55	13.21	2.91	4.73
6+	9.10	2.98	1.19	2.00	0.54	1.33	1.32	0.86

Table 7. SPA estimates of population numbers (Thousands) for 4VsW cod.

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Age													
1	84,967	84,749	66,999	61,754	74,328	84,665	70,855	66,551	101,959	90,245	106,032	112,028	63,253
2	80,064	68,395	67,592	53,003	49,458	59,702	67,926	57,547	54,486	83,447	73,875	86,784	91,718
3	40,548	57,741	44,394	40,984	34,147	33,869	41,125	53,020	47,095	44,524	68,236	60,401	70,819
4	47,459	25,158	38,549	25,668	26,315	15,901	21,032	31,082	42,928	37,501	34,859	54,270	46,556
5	39,971	25,463	15,960	20,713	15,765	10,963	10,157	12,960	24,336	31,456	24,768	24,131	36,166
6	17,292	20,353	14,864	6,386	8,241	6,705	4,644	4,787	9,171	15,566	17,136	14,002	13,169
7	6,583	10,050	12,024	6,264	2,220	4,714	2,507	1,915	3,154	5,173	8,170	8,440	7,255
8	3,843	3,632	5,135	6,851	2,079	1,213	1,197	888	1,125	1,889	3,140	3,929	4,235
9	902	2,460	1,198	2,503	1,328	790	429	575	547	697	1,205	1,557	1,931
10	375	525	1,377	667	526	910	197	228	364	351	502	703	915
11	487	242	98	706	194	292	124	114	157	230	266	328	454
12	321	274	54	19	79	147	83	91	55	100	180	173	206
13	126	212	68	37	8	63	9	26	34	21	79	123	113
14	114	95	32	23	11	7	14	7	11	3	14	61	81
15	9	83	5	26	.	9	.	8	3	.	2	12	48

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Age												
1	62,629	25,980	26,671	34,200	45,102	44,161	23,542	16,942	24,532	7,201	.	.
2	51,784	51,276	21,271	21,836	28,000	36,926	36,156	19,274	13,871	20,085	5,896	.
3	74,967	42,392	41,981	17,411	17,875	22,925	30,226	29,596	15,780	11,356	16,442	4,827
4	55,744	58,205	34,319	34,230	14,143	14,608	18,602	24,139	23,967	12,672	8,783	13,433
5	31,180	37,786	42,426	26,059	24,325	10,842	10,596	12,928	17,715	16,694	8,200	6,805
6	20,450	18,756	22,702	27,360	14,913	15,030	7,060	4,997	7,066	8,808	6,219	6,166
7	7,451	11,063	10,218	11,780	15,538	7,353	8,758	2,945	1,759	2,537	1,876	4,406
8	3,617	4,377	5,593	4,490	6,597	7,777	2,857	4,170	958	890	548	1,071
9	2,277	2,045	2,452	2,380	2,447	3,016	3,850	1,214	758	215	139	332
10	967	1,299	1,182	1,046	1,115	1,164	1,154	1,927	187	324	9	74
11	462	589	801	559	550	467	527	507	627	98	8	.
12	233	243	343	399	287	251	147	248	122	122	4	.
13	110	144	142	125	253	124	68	86	81	38	2	.
14	43	68	87	55	42	152	44	29	21	8	1	.
15	17	22	40	53	35	25	116	22	10	8	.	.

Table 8. Population biomass for 4VsW cod from SPA estimates (kt).

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Age													
1	3691	3681	2384	2790	3584	5708	4777	4487	4128	3780	4365	4574	2697
2	35436	15746	18998	11733	10256	8855	10075	8536	13457	19923	17944	21258	21510
3	25851	36646	32480	35692	21245	18714	17145	22243	21643	28886	46365	41755	48136
4	44235	22792	36039	25011	28127	13030	18159	29106	42235	36001	31187	51691	42730
5	52019	31864	19555	24026	20162	13947	11468	17417	32734	43356	30697	33687	47343
6	27656	32882	24279	9641	13132	12128	8141	9082	18360	30139	31991	25788	26054
7	12114	20360	24412	12858	4576	10623	6272	5110	8997	13857	21814	21636	17454
8	11403	10261	13158	15655	4945	3346	3827	3425	4355	6707	11374	13661	14553
9	4062	10155	4919	6902	3608	2386	1620	2417	2671	3368	5391	7663	8812
10	2138	2768	6488	3024	1625	3158	895	1156	1822	2049	2932	4323	5709
11	2240	1379	644	2957	884	1215	650	583	1016	1543	1834	2397	3512
12	3184	1937	440	159	481	757	335	547	350	899	1530	1448	1701
13	913	1629	506	335	68	560	79	121	237	225	740	1356	1143
14	540	602	230	175	98	63	141	82	91	28	171	523	910
15	68	612	51	240	0	108	0	91	28	0	28	118	510

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Age												
1	2889	1118	1023	2081	3041	2360	1382	1142	1144	522	.	.
2	11227	11916	5547	3588	4153	6908	6157	2859	2975	2769	874	.
3	49102	25001	25994	11840	6435	8535	15691	13894	6495	6113	5411	1881
4	49884	52925	29962	28112	11247	9968	14838	21182	19601	9883	6465	11474
5	39331	47195	52598	29687	26824	11736	11807	14409	18915	15738	7468	7806
6	36918	33298	39025	42320	20773	22365	9898	6689	9468	10764	7369	8547
7	19993	26481	22626	25507	27294	12644	17047	4768	2608	4067	2872	6969
8	11259	14678	16151	11465	16442	16372	5885	9298	1739	1513	1081	2087
9	9520	7736	9168	8029	7664	8138	9371	2664	1757	422	379	811
10	5374	6193	5323	4578	4433	4219	3820	4488	419	824	24	251
11	3157	3771	4588	2886	3127	2152	2279	2102	1569	235	36	0
12	2060	1847	2265	2628	1659	1698	743	1396	481	335	15	0
13	1068	1326	1297	985	1785	864	527	571	411	169	12	0
14	490	724	883	532	462	1367	425	301	219	58	10	0
15	203	266	439	611	384	295	1092	252	111	104	0	0

Table 9. Fishing mortality at age in 4VsW cod.

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Age													
1	0.02	0.03	0.03	0.02	0.02	0.02	0.01	.	.	.	.	.	.
2	0.13	0.23	0.30	0.24	0.18	0.17	0.05	.	.	.	.	.	.
3	0.28	0.20	0.35	0.24	0.56	0.28	0.08	0.01	0.03	0.04	0.03	0.06	0.04
4	0.42	0.26	0.42	0.29	0.68	0.25	0.28	0.04	0.11	0.21	0.17	0.21	0.20
5	0.47	0.34	0.72	0.72	0.65	0.66	0.55	0.15	0.25	0.41	0.37	0.41	0.37
6	0.34	0.33	0.66	0.86	0.36	0.78	0.69	0.22	0.37	0.44	0.51	0.46	0.37
7	0.39	0.47	0.36	0.90	0.40	1.17	0.84	0.33	0.31	0.30	0.53	0.49	0.50
8	0.25	0.91	0.52	1.44	0.77	0.84	0.53	0.28	0.28	0.25	0.50	0.51	0.42
9	0.34	0.38	0.39	1.36	0.18	1.19	0.43	0.26	0.24	0.13	0.34	0.33	0.49
10	0.24	1.48	0.47	1.04	0.39	1.79	0.35	0.17	0.26	0.08	0.23	0.24	0.48
11	0.37	1.30	1.45	1.99	0.08	1.05	0.11	0.53	0.25	0.05	0.23	0.26	0.47
12	0.21	1.19	0.18	0.64	0.03	2.60	0.98	0.77	0.78	0.04	0.17	0.23	0.43
13	0.08	1.68	0.88	0.98	.	1.27	.	0.64	2.29	0.18	0.06	0.22	0.76
14	0.12	2.66	.	5.25	.	3.99	0.36	0.60	4.51	.	.	0.04	1.38
15	0.65	0.75	0.91	1.33	1.03	1.19	0.89	0.31	0.40	0.50	0.63	0.64	0.57

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Age												
1	.	.	.	.	.	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.	.	.	.	.	.
3	0.05	0.01	.	0.01	.	0.01	0.02	0.01	0.02	0.06	<.01	<.01
4	0.19	0.12	0.08	0.14	0.07	0.12	0.16	0.11	0.16	0.24	0.06	<.01
5	0.31	0.31	0.24	0.36	0.28	0.23	0.55	0.40	0.50	0.79	0.09	0.01
6	0.41	0.41	0.46	0.37	0.51	0.34	0.67	0.84	0.82	1.35	0.14	0.01
7	0.33	0.48	0.62	0.38	0.49	0.75	0.54	0.92	0.48	1.33	0.36	0.02
8	0.37	0.38	0.65	0.41	0.58	0.50	0.66	1.51	1.29	1.66	0.30	0.02
9	0.36	0.35	0.65	0.56	0.54	0.76	0.49	1.67	0.65	2.99	0.43	0.02
10	0.30	0.28	0.55	0.44	0.67	0.59	0.62	0.92	0.45	3.54	4.28	0.02
11	0.44	0.34	0.50	0.47	0.58	0.95	0.55	1.22	1.44	2.90	4.15	0.02
12	0.28	0.34	0.81	0.25	0.64	1.11	0.34	0.92	0.97	3.81	3.59	0.02
13	0.28	0.30	0.75	0.88	0.31	0.84	0.64	1.22	2.15	3.33	2.90	0.02
14	0.48	0.32	0.29	0.25	0.34	0.07	0.47	0.83	0.75	4.15	2.20	0.02
15	0.50	0.51	0.61	0.50	0.58	0.58	0.78	1.14	0.98	1.62	0.28	0.02

Table 10. Mean length at age in 4Vs and 4W cod from July RV surveys.

SubDivision 4Vs

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Year																
70	7.00	16.78	26.63	42.89	48.68	53.87	59.25	64.05	65.09	97.00	82.00	70.06		73.51		
71	.	.	29.20	35.70	45.02	52.38	56.31	56.69	63.40	70.00	70.00			67.00		
72	.	22.99	32.21	42.65	44.51	52.52	56.69	57.33	64.24	89.79	60.15					
73	.	21.56	31.66	40.04	46.93	53.01	65.46	67.12	62.55	82.00	.	79.43		.	.	82.00
74	.	21.11	30.94	38.72	47.84	54.20	58.83	62.67	68.71	68.37	82.92	97.00		.	.	115.00
75	.	20.84	32.87	40.89	47.31	54.52	60.69	67.09	70.45	75.76	88.00					
76	.	19.56	29.62	35.95	45.43	56.34	64.57	71.60	70.11	.	81.27			100.00		
77	.	25.01	28.88	40.21	48.18	56.80	65.70	72.13	81.80	82.12		83.68				
78	.	20.58	36.42	43.13	49.59	58.05	68.39	75.71	79.00	85.00	88.00			.	.	.
79	.	16.72	31.14	37.44	47.08	53.96	63.27	75.38	84.39	88.77	97.00	93.53	112.00	94.00		
80	.	16.00	26.04	41.68	48.09	55.72	63.96	71.75	78.33	98.89	96.88	105.20				
81	.	19.62	34.78	40.89	51.07	58.02	63.36	71.31	84.58	91.98	100.83	100.00	112.00	109.00	.	115.00
82	.	14.06	30.36	37.17	44.78	55.69	62.69	66.07	71.95	81.69	86.92	96.49		.	103.00	
83	.	16.41	25.64	39.59	48.34	54.76	62.68	71.41	73.06	84.81	79.00	100.29	109.00	109.00		
84	.	19.63	31.10	39.60	47.71	55.95	59.43	62.92	76.27	67.76	72.00	100.46	115.00	91.00	109.00	
85	.	18.21	26.72	35.98	43.44	50.35	56.78	61.71	68.42	72.49	77.39	92.92	71.27	.	.	133.00
86	10.00	13.00	26.65	35.78	45.08	51.60	56.44	61.68	64.56	74.97	83.17	92.55		106.00		
87	.	14.53	27.83	36.57	43.78	51.46	55.23	58.90	62.82	68.13	78.00	87.97	95.14	112.00	.	113.60
88	7.00	.	28.12	36.09	42.27	52.56	56.16	57.85	64.45	69.23	84.00	86.84	91.00	.	106.14	
89	.	25.00	28.69	36.24	44.33	50.20	54.25	62.03	65.56	63.59	91.60	106.00	107.20	100.00		
90	10.00	14.74	29.02	33.66	41.63	51.64	55.32	65.34	71.08	69.85	70.85					
91	.	19.00	27.36	37.16	42.77	49.43	56.67	61.59	72.16	76.41	73.03	88.18	103.00			
92	.	.	29.41	36.09	43.18	49.87	56.54	55.12	65.15	67.37	94.00				94.00	
93	.	12.52	26.93	34.31	42.38	49.79	52.32	56.49	78.55							

Division 4W

Age	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Year																
70	10.00	20.32	35.79	46.32	53.34	61.95	72.50	77.98	79.67	79.00	83.46	.	112.00			
71	7.00	17.05	25.69	37.76	51.80	56.00	59.65	67.77	69.36	73.14	.	67.00	100.00			
72	.	19.72	31.45	43.15	55.27	60.47	67.77	82.00	79.00	98.00						
73	.	21.64	29.66	40.61	48.28	52.06	60.65	57.98	69.40	61.00	95.74	.	.	.	97.00	
74	9.05	24.87	32.21	38.94	48.65	55.85	64.83	75.70	74.59	63.46	73.00	.	88.00			
75	10.00	21.74	29.30	37.98	46.67	56.13	66.96	80.05	.	88.07	.	.	100.00			
76	.	21.07	30.66	38.14	46.84	52.25	60.09	69.34	.	.	.	88.00				
77	.	23.96	32.48	41.43	48.16	59.06	64.24	71.45	85.03	.	.	.	76.00			
78	9.55	20.15	34.72	42.18	50.73	57.98	66.52	67.39	79.36	100.00	118.00	.	.	.	.	.
79	9.05	17.15	29.70	37.00	46.41	52.20	60.04	68.00	75.00	69.41						
80	8.29	19.62	32.40	38.98	46.15	52.06	58.35	61.84	81.35	71.50						
81	7.89	20.67	29.31	40.57	47.06	54.88	57.39	61.10	64.72	80.55	79.00	94.00				
82	7.00	18.68	31.55	37.19	42.30	49.57	55.39	60.66	65.71	64.77						
83	7.00	19.80	29.39	37.91	47.04	51.64	58.22	61.72	61.46	64.00						
84	11.01	21.24	28.69	37.93	44.22	52.90	56.77	59.56	65.49	72.98	70.00	68.52				
85	.	18.24	23.70	34.98	42.26	49.65	54.71	60.04	66.74	77.81	.	88.00	100.00			
86	10.00	20.41	29.99	37.03	42.90	53.74	59.87	63.47	71.87	74.90	72.51					
87	7.00	17.31	25.71	36.01	41.63	48.02	53.40	58.35	58.44	97.00						
88	9.23	19.60	30.04	34.84	42.19	50.64	56.22	58.69	61.57	59.74						
89	7.00	17.77	31.86	38.18	43.68	50.98	52.39	75.78	74.30	85.00						
90	.	20.50	29.51	36.58	42.57	47.81	54.78	55.18	64.00							
91	.	11.17	29.55	35.31	41.06	46.06	48.08	51.25	55.81	.	.	55.00				
92	.	18.55	22.87	32.89	36.80	43.23	45.28	52.92	50.41	94.00						
93	7.00	14.36	27.62	32.78	40.26	44.50	45.57	49.80	51.62	94.00	70.00					
94	10.02	22.40	29.29	33.15	37.05	40.80	46.41	48.49	52.00	.	73.00					

Table 11. Capelin total numbers at length caught in 4VW from RV surveys in July.

Length (cm)	Year 71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6
7	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	12
8	.	.	.	16	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8	139
9	.	.	.	32	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	32	22	398
10	.	.	.	14	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3	1	754	54	1,227
11	.	.	.	5	.	.	.	.	.	.	.	.	.	.	.	.	.	1	6	3	1,787	48	1,649
12	.	.	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	26	26	959	37	459
13	.	.	5	11	.	.	.	.	.	.	.	.	.	.	.	.	.	9	76	69	23	145	436
14	.	1	11	8	.	.	.	.	1	.	.	.	.	.	.	2	3	156	77	134	12	763	1,207
15	1	.	8	1	.	.	.	.	.	.	.	.	1	.	.	.	4	401	38	98	21	4,350	1,130
16	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1	10	90	67	40	37	11,399	1,099
17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	5	38	7	21	5,329	560
18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	4	1	244	111
19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	7
20	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.
21	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Total	1	1	27	90	0	0	0	0	1	0	0	0	1	0	0	3	18	665	332	388	3647	22399	8440
6-11cm	0	0	0	68	0	0	0	0	0	0	0	0	0	0	0	0	0	3	9	4	2573	132	3431
12+ cm	1	1	27	22	0	0	0	0	1	0	0	0	1	0	0	3	18	662	323	384	1074	22267	5009

Figure 1. Landings and TAC for 4VsW cod.

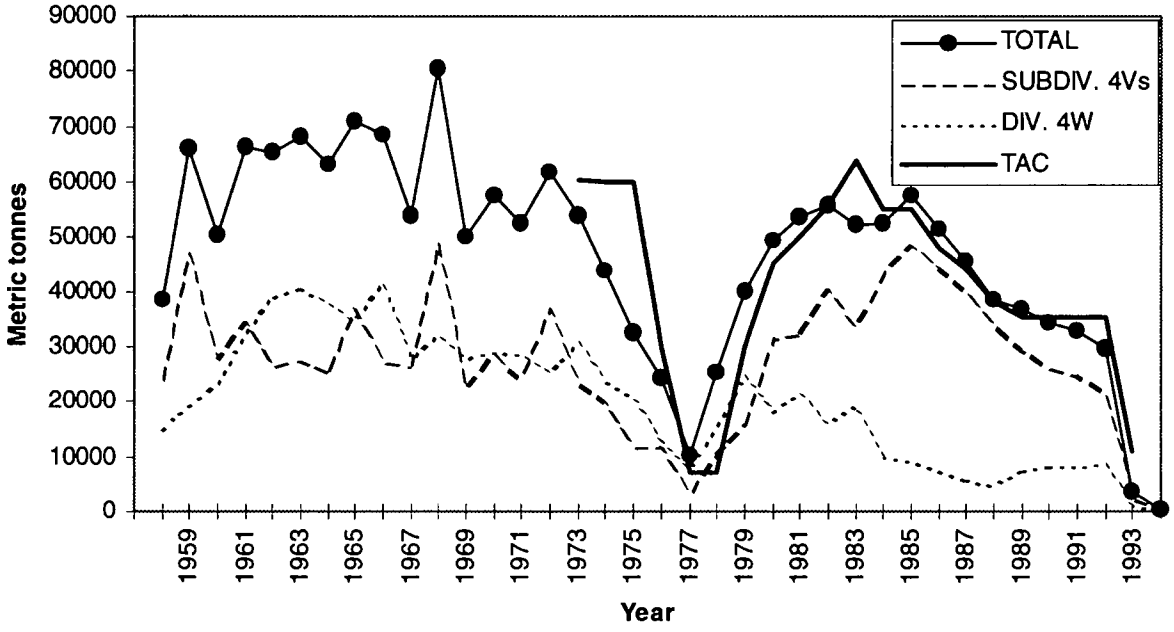

Figure 2. Comparison of numbers at age in 1994 from commercial and IOP sampling.

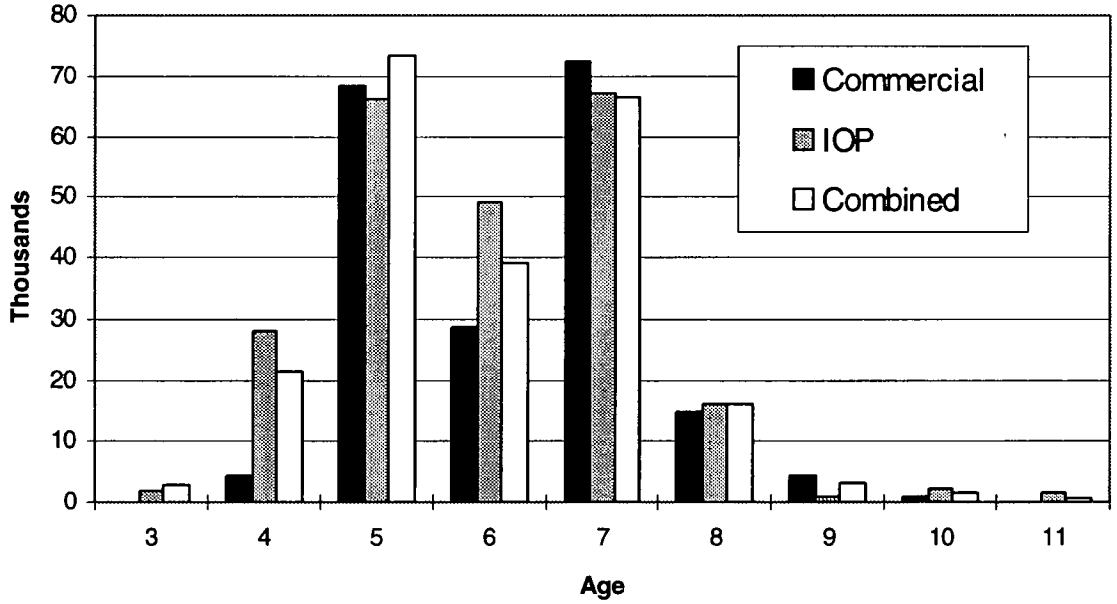

Figure 3a. Major quantiles of the cumulative age in the landings by year in 4VsW cod.

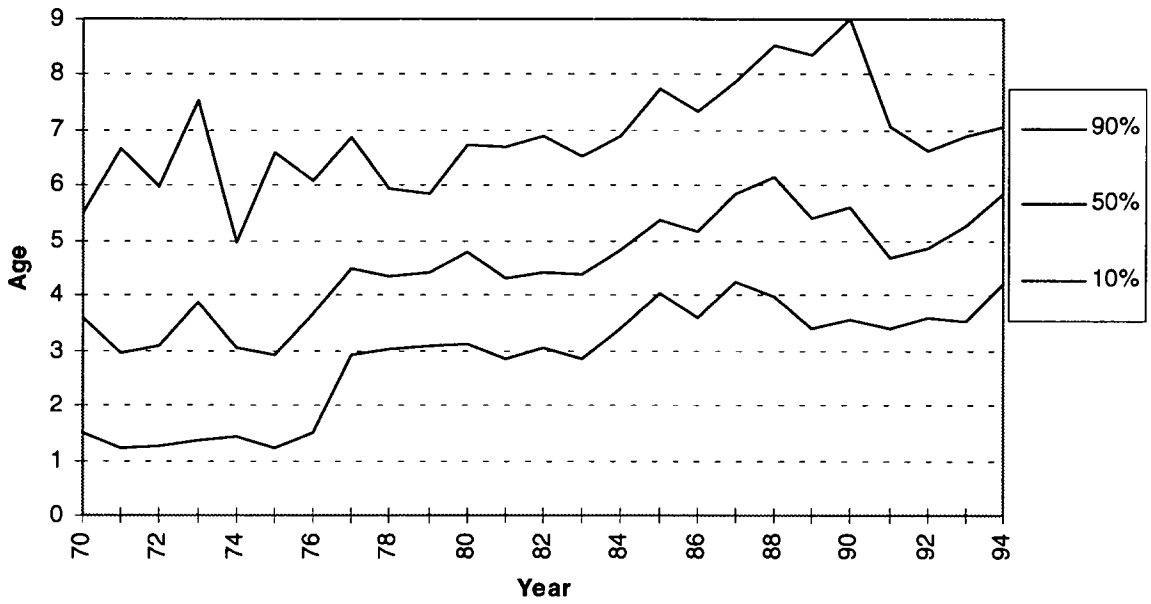

Figure 3b. Major quantiles of the cumulative weight in the landings by year in 4VsW cod.

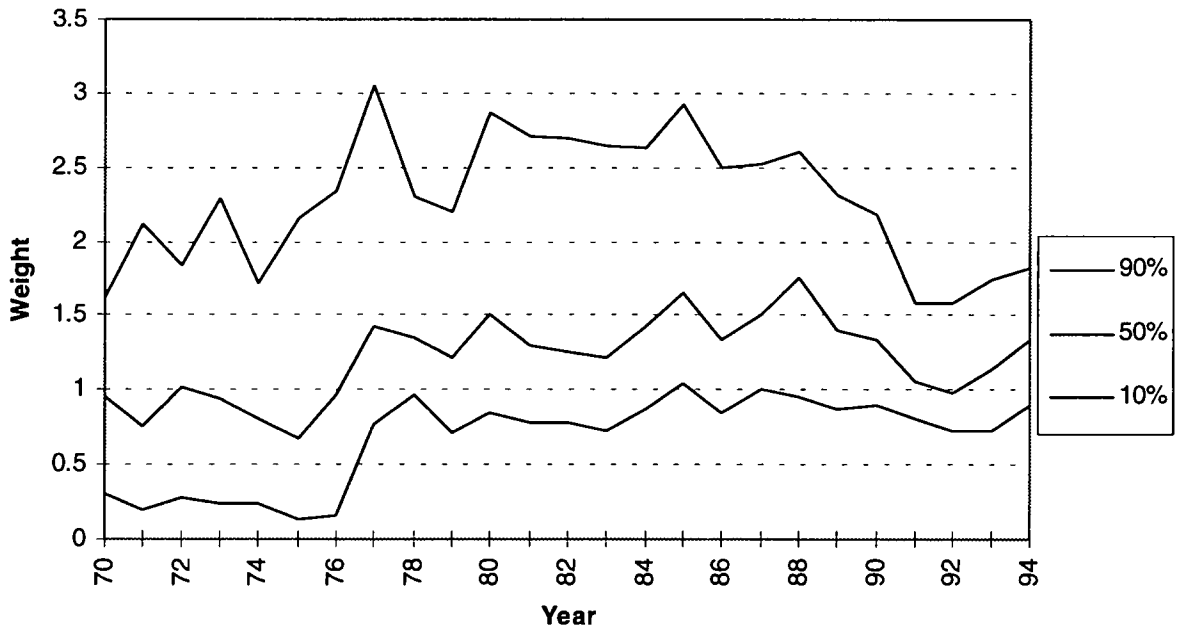

Figure 4. Research vessel survey abundance for adult (ages 6+) 4VsW cod.

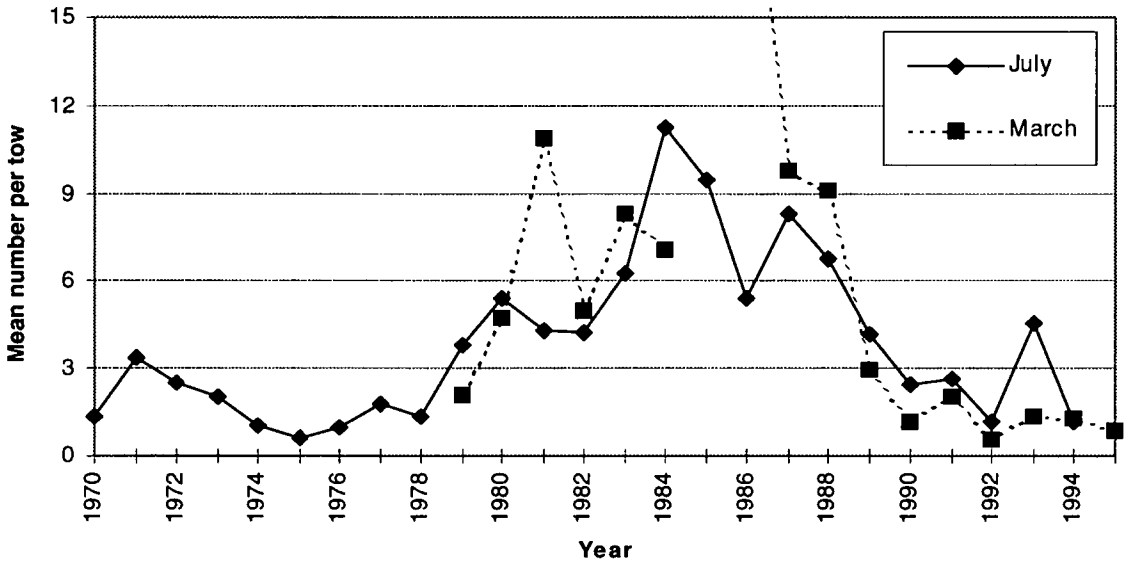

Figure 5. Research vessel survey recruitment index (age 2-3) by yearclass for 4VsW cod.

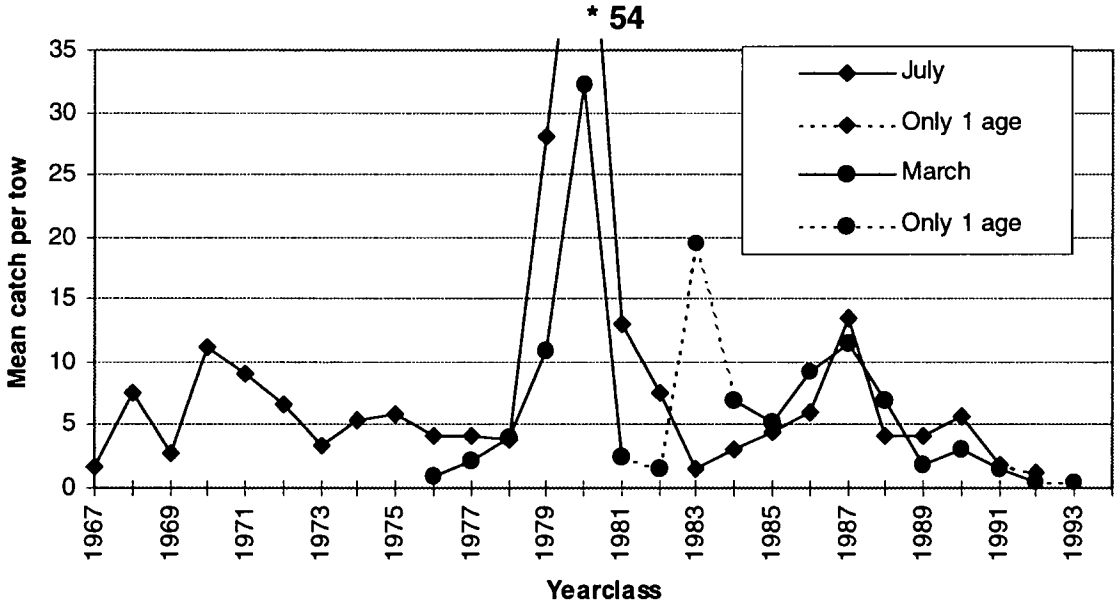

Figure 6. Long term SPA numbers (total and age 1) by year for 4VsW cod.

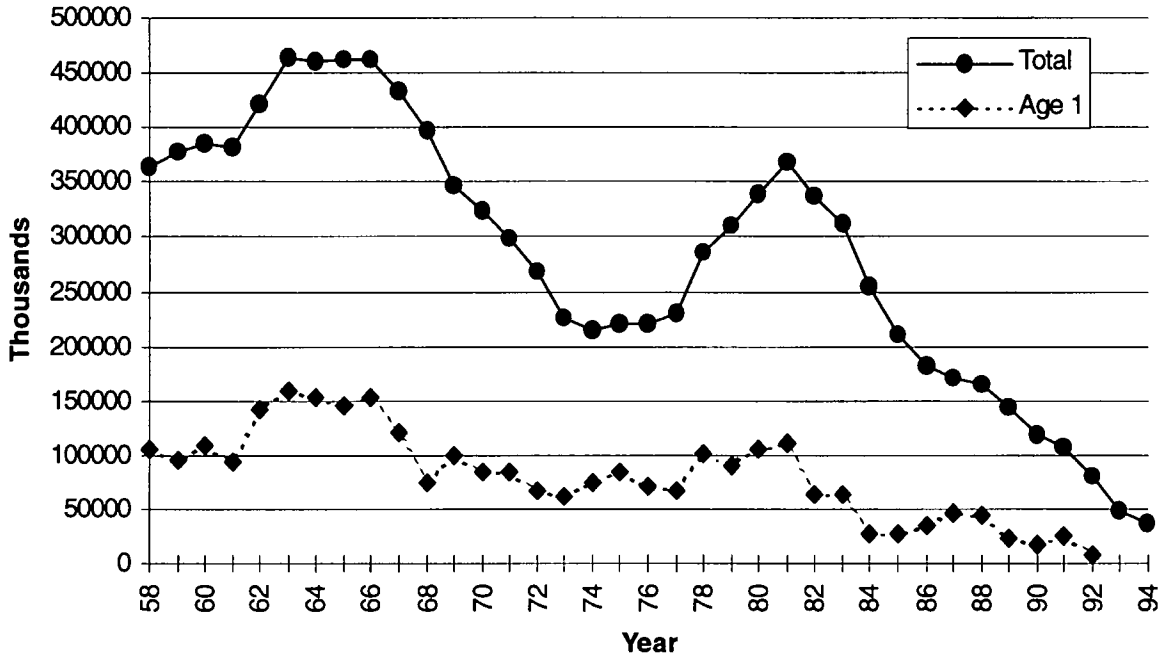

Figure 7. SPA population biomass (total and adult (age 6+)) by year for 4VsW cod.

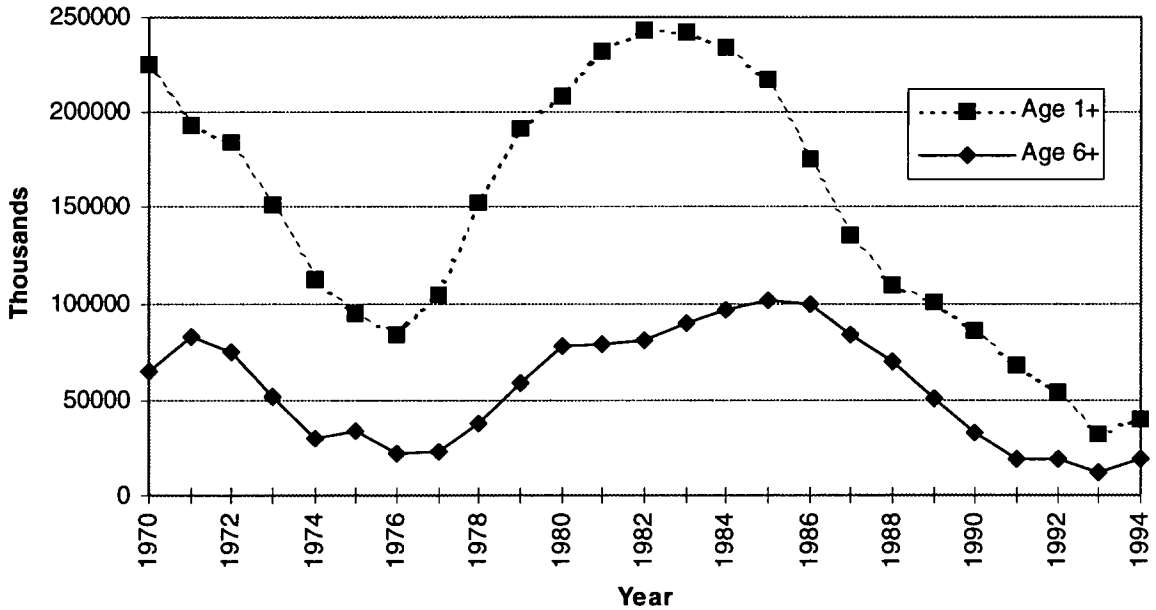

Figure 8a. Retrospective population biomass from 4VsW cod SPA.

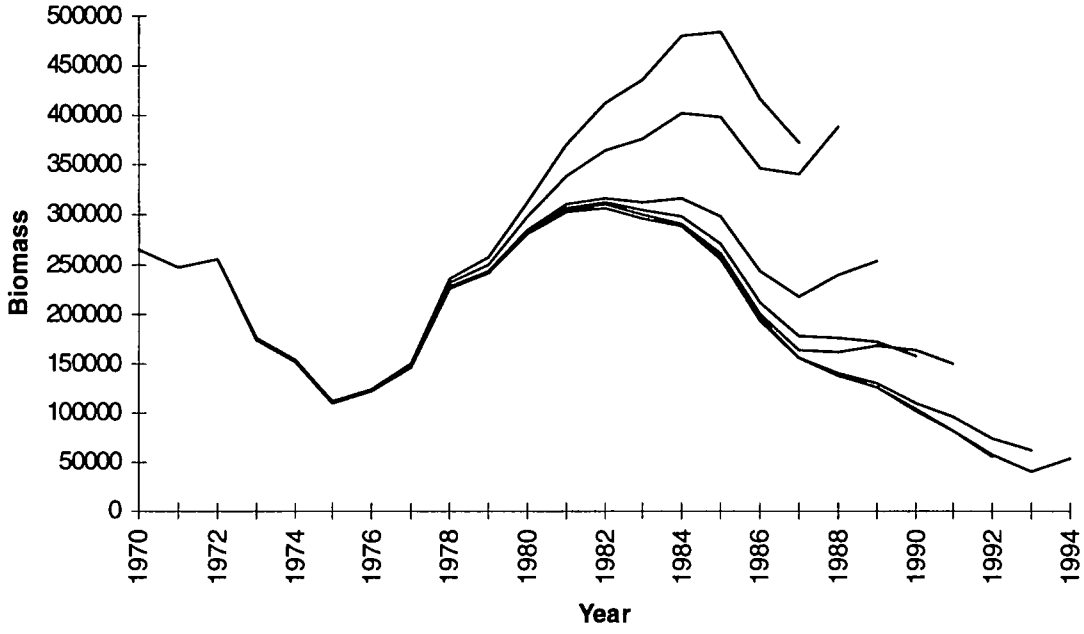

Figure 8b. Retrospective fishing mortality from 4VsW cod SPA.

Figure 9. Long term SPA estimates of fully recruited (age 7-9) fishing mortality in 4VsW cod.

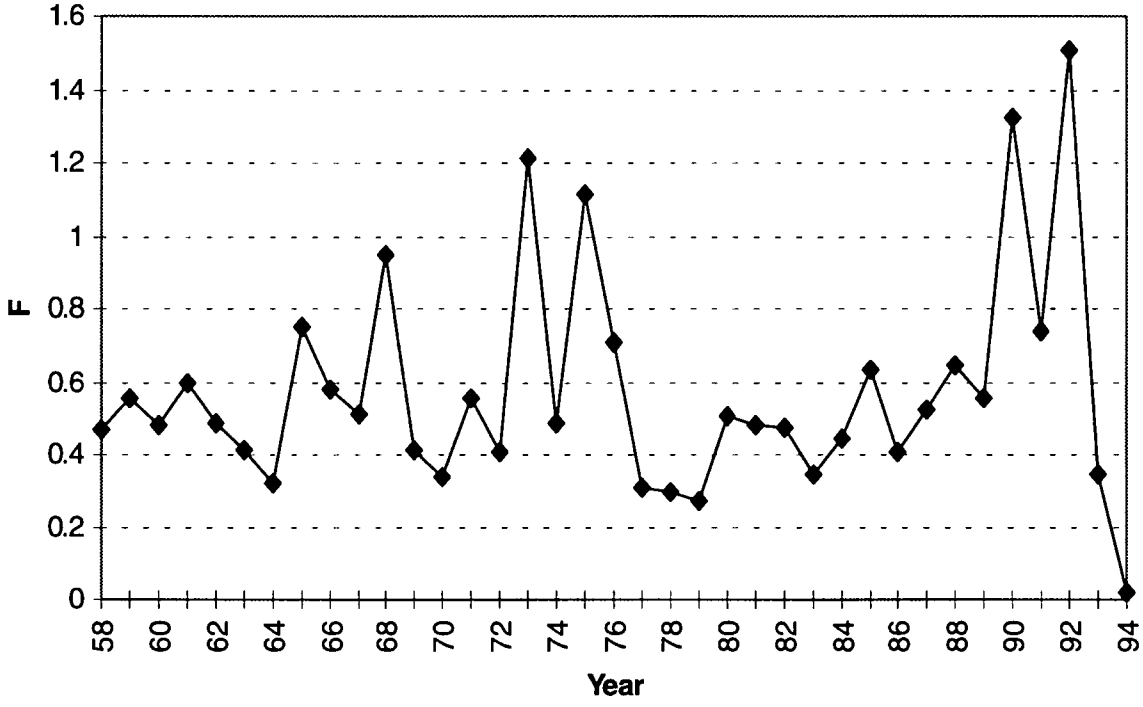

Figure 10a. Spawning stock (age 6+) biomass and recruitment (age 1) from 4VsW cod SPA.

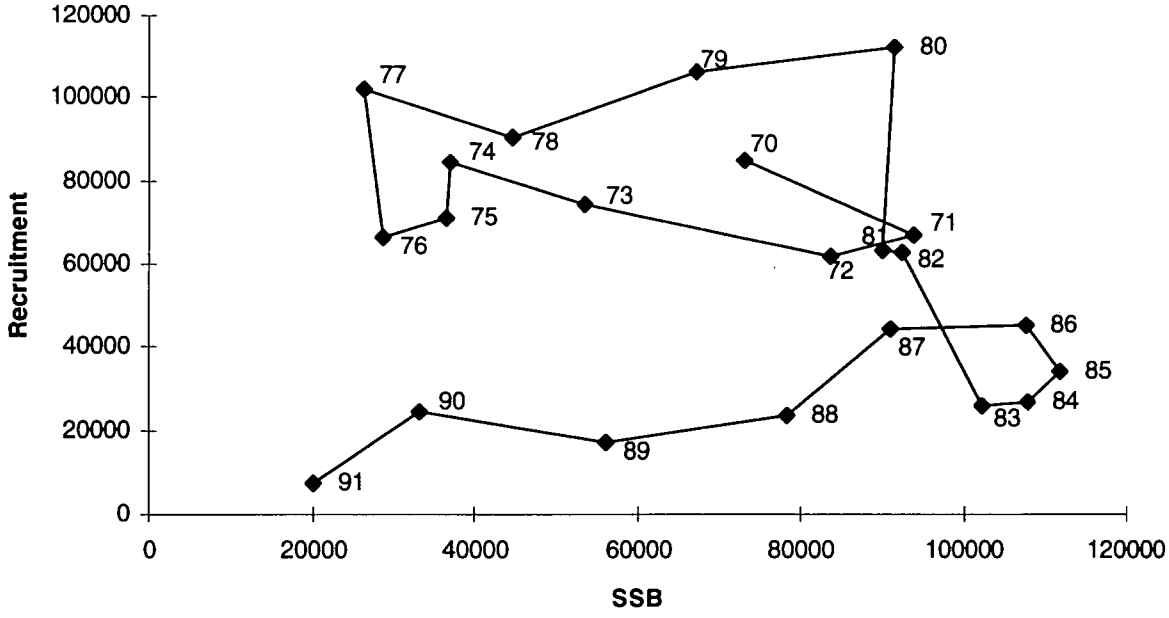

Figure 10b. Spawning stock (age 6+) biomass and recruitment (mean of ages 2+3) from RV surveys for 4VsW cod.

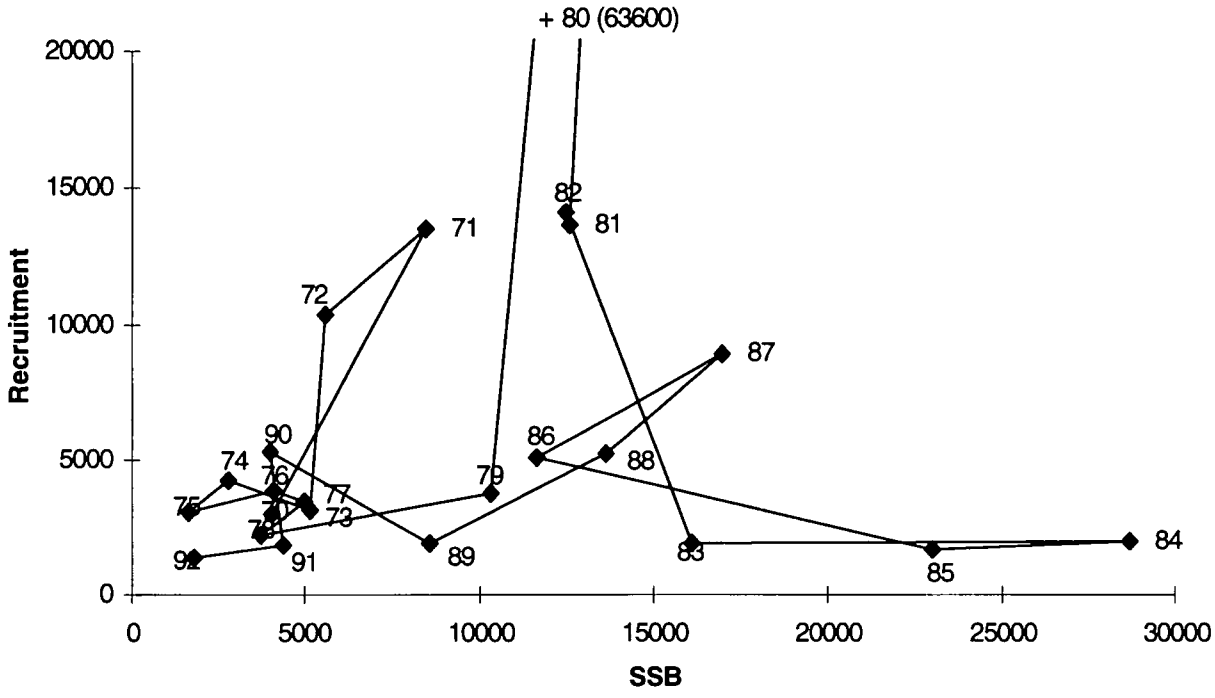

Figure 11. Condition (predicted mean weight at length) of 4VsW cod from July RV surveys.

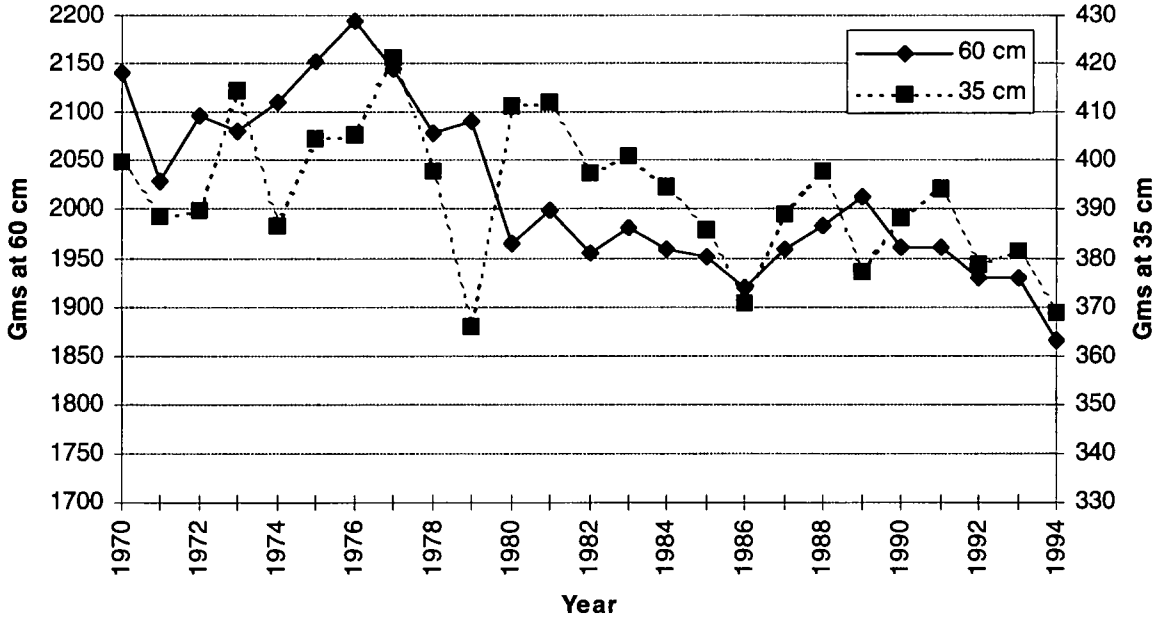

Figure 12. Recruitment of 4VsW cod from SPA and environmental correlation predictions based on Emerald Basin 200m temperature.