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Assessment of 4VsW cod in 1995 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 from other fisheries in the area amounted to 368 t 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. An analysis 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. In the longer term, until it is shown that a number of yearclasses are of near average size and that 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 dirigée de la morue de 4VsW en 1994 à cause du moratoire en vigueur. Les prises accessoires réalisées dans le cadre d'autres pêches dans la région se situaient à 368 t, réparties sur toute l'année, et divisées également entre 4Vs et 4W et entre les secteurs des engins fixes et des engins mobiles. Les prises étrangères se limitaient à 2 t. L'échantillonnage des prises a été difficile à cause des débarquements faibles et éparpillés; par conséquent, seuls 5 échantillons des prises commerciales étaient disponibles.

Le même modèle que par les années passées a été utilisé pour étalonner l'analyse de population séquentielle en fonction de deux indices obtenus par relevés de recherche (juillet et mars). Ces indices récents sont les plus faibles enregistrés et l'analyse de population traduit cette réalité. On a estimé la mortalité par pêche en 1994 à 0,02, les prises accessoires ayant été faibles. La fermeture de la pêche en 1993, tout comme en 1994, a donné lieu à la première importante réduction de la mortalité par pêche depuis la création de la zone de 200 milles en 1977.

Plusieurs indices biologiques et écologiques ont été examinés pour déterminer l'état du stock, notamment les tendances de l'indice de condition et de la longueur selon l'âge, la répartition des reproducteurs, les variables prédictives du recrutement, la prédation par le phoque gris et des corrélations spatiales et écologiques entre la morue et, d'une part, la limande à queue jaune et, d'autre part, le capelan. Une analyse de ces indicateurs portent à croire qu'il y a eu un virage écologique marqué depuis environ 1982, peut-être entraîné ou exacerbé par les plus basses températures de l'eau, la surpêche et la prédation croissante par les phoques.

À court terme, il n'existe aucune perspective raisonnable de pêche de ce stock. À plus long terme, il ne pourra alimenter une pêche dirigée sans danger pour sa survie que lorsque l'on sera en mesure de démontrer qu'un certain nombre de classes d'âge sont d'une taille s'approchant de la moyenne et que le stock se reproduit avec succès. Il faudra au moins 8 ans pour satisfaire ces conditions après le premier recrutement fructueux.

The Fishery

The fishery for cod in divisions 4VsW was closed for the entire year in 1995 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 277 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 however in 1995 the catch was again predominantly from Subdiv 4Vs, presumably reflecting changes in the distribution of the directed effort on other stocks. The catch was taken predominantly by trawls in 4Vs and longline in 4W (Table 2).

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 and unpredicatable based on the historical pattern. As a result samples from the commercial catch were difficult to obtain and only 13 samples were available for the entire year, however this was a significant improvement over the five samples collected in 1994. In total there are 249 ages and 1956 length measurements available from commercial samples. These data were augmented with samples collected by the Observer Program which increased the observations to 313 ages and 10256 lengths. The limited number of age observations in particular made it impossible to follow the usual practice of constructing individual catches at age for gear and quarter strata in 1995 and so a single age length key was used for all landings. These limitations, 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. 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. In the years 1986 to 1992 catches of between 2000 and 8500 t of fish (Table 4) which were apparently migrants from the 4TVn winter component were caught in 4VsW. These are removed from the estimated catch at age prior to conducting the sequential population analyses reported below as in Mohn and MacEachern (1994) and Fanning et al. (1995). This adjustment was not done for 1993-95 as there were nearly no landings from that area in the winter and the usually distinct bimodality in length at age was not apparent.

The mean weights at age from commercial samples up to age 7 seem to have increased slightly from the minima around 1992 (Table 5, Figure 2) however they are still low relative to long term means. Weights at ages greater than 7 also show increases but are poorly estimated due to the smaller number of fish sampled.

The cumulative proportion of the catch in terms of individual mean weights and ages are displayed in Figures 2 and 3 respectively. Each plot has the 10th, 50th (median) and 90th percentiles from 1970 to 1994. The median age shifted by almost 2 years in the late 1970's when the 200 mile limit was proclaimed and since then has had a weak increasing trend. The 10th and 90th percentiles also reflect the exclusion of foreign effort in 1977. In the 1990's the distance between the 10th and 90th 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 90th percentile has fallen since the mid-1980's showing the depletion of the largest fish in the landings.

Indices of Abundance

As in 1994, no commercial catch rate is available for 1995 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 bottom trawl survey series available for this stock, a July series (Table 6) which started in 1970 and a March series (Table 7) 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 the 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 was 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 (Figure 5), yearclasses were estimated as the q-scaled (q's estimated from ADAPT results below) average of mean catch per tow of a cohort at age 2 and a year later at age 3 for yearclasses where both estimates were available. The most recent yearclasses (91-93) are at or near the lowest in their respective series.

In October of 1995 the first 4VsW Sentinel Survey was conducted and landed a total of 6.7t of cod from a total of over 200 standardized longline sets (1500 hooks per set). Sets were distributed throughout Divisions 4Vs and 4W from inshore waters (approximately 18 m contour) to the 370 m contour offshore (Figure 6). Although the results of this single survey do not allow for conclusions about resource abundance they are indicative of distribution of cod in the fall.

As the majority of the sentinel catches came from the area inshore of the 92 m contour, an area not included in the DFO research vessel surveys, the two surveys together provide a more comprehensive picture of the distribution and abundance of adult cod. Due to the selectivity of the longline gear the sentinel survey does not provide an index of prerecruit abundance. Figure 7 illustrates the catch at length of cod in the research vessel and sentinel surveys. The near absence of catch less than 40 cm and greater percentage of fish larger than 45 cm is a direct result of the selectivity of the longlines.

Stock Assessment

Estimation of parameters

The age-based population analysis agreed upon for the last assessment was used as the primary estimate of the current status of the stock. The model is described as:

Parameters:

Terminal F estimates	--	Fi,1995, i=3 to 8
Calibration coefficients	--	K1,i, i=3 to 8 for July RV survey
	--	K2,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 for all ages

Input:

Ci,t, i=1 to 15; t=1970 to 1995 - Full year catch at age
Ji,t, i=3 to 9; t=1970 to 1995 - July RV index
Mi,t, i=3 to 9; t=1979 to 1995 - March RV index (excluding 1985)

Objective function: Minimize:

$$\sum\sum \{\ln J_{i,t} - K_{1,i} N_{i,t}\}^2 - \sum\sum \{\ln M_{i,t} - K_{2,i} N_{i,t}\}^2$$

Summary:

Number of observations: 156 from July RV
112 from March RV

Number of parameters: 19

Summary statistics of the NLLS fit are given in Table 8. As seen in recent years, the terminal F have CV's which range from about 30 to 55%. Also, the summer survey q's are better determined than those of the March surveys. Bias was not a problem with most parameters having less than a 1% bias.

The estimated population numbers (Table 9; Figure 8) 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 near to the average recruitment at age 1. The total numbers and age 1 recruitment from the long term SPA, based on assumed F=0.5 at age 15 prior to 1970, are given for comparison in Figure 9. Estimates of biomass at age (Table 10; Figure 10) 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 11) in a given terminal year are consistently higher, or F's (Figure 12) 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 errors caused by the retrospective effect.

Fishing mortality in 1994 was the lowest on record (Table 11). The fully recruited F (age 7-9, Figure 13), in 1994 was estimated at 0.01 due solely to bycatch removals. The fully recruited F in 1993 is now estimated as 1.5, up from the previous estimate of 0.36. The 1992 estimate remained stable at 2.0. Thus the early closure of the fishery in 1993 does not appear to have had as great an affect as previously thought. The continuing moratorium in 1994 and 1995 has 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 14). Recruitment is numbers at age 1 and the age 6+ population biomass is used as a proxy for spawning stock biomass. It appears that the population since 1987 has been rapidly approaching the origin as both spawning stock biomass and recruitment decline. The figure indicates a significant split in the data points with the recruitment from 1970 to 1982 clustered in a zone substantially higher than from 1983 to the present.

Stock Biology

Trends in Growth and Condition

Size at age declined in this stock from the mid 1980's to about 1992 in both the RV data (Table 12) and the commercial catch data (Table 5). 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 a given 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 analysis on the condition of cod in 4VsW 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 (Figures 15

and 16). 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 (Ocean Production Enhancement Network, 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 (Scotian Shelf Icthyoplankton Program) 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, 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.

Following Frank et al. (1994) the mean length at age 1 in 4VsW was compared to 4X in the July research vessel survey data (Figure 17). Consistent with their observations, the 4VsW fish continue to be small relative to their 4X contemporaries but the gap in size has decreased substantially in 1994 and 1995. Based on their hypothesis this would be taken to indicate that the disparity in spring and fall spawning components contribution to each cohort is decreasing. Unfortunately, this index does not distinguish between recovery of the spring spawning component or depletion of the fall spawners.

Ecosystem Considerations

Grey seal predation

Based on a model incorporating seal dynamics, diet and metabolism (Mohn and Bowen, 1994) estimates of grey seal predation were first presented in 1993 (using information on the

composition of grey seal diets collected between 1989 and early 1993). The proportion of cod (mostly less than 4 years old) in these samples did not indicate a trend over the sampling period. Given the low and declining biomass of cod, it was possible that grey seal would reduce their predation on cod in favour of more abundant prey. However, samples collected from Sable Island between the summer of 1993 and January 1996 show that the proportion of cod in the diet, although variable among samples, has shown no trend over the five years of sampling on the island. The mean percentage of cod in the grey seal diet has remained at about 15%. Given that the grey seal population has continued to increase at the same rate as previously measured, the average estimate of consumption of 4VsW cod by grey seal is 17,700t in 1995; an increase of 12% over 1994. This increase in a significant cod predator is coincidental with an apparent period of low production for cod (see above), thus increasing the ecological pressure on the cod population.

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 18). 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 (1992-95), although low relative to the predictions for earlier years, are consistently higher than the VPA estimates of recruitment.

Yellowtail-Cod Correlation

An analysis of spatial association (K. Zwanenburg, MFD, BIO; pers. comm.) based on July research vessel 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 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 changed on the eastern Scotian Shelf.

Capelin Abundance

Capelin have been present in both the July and March research vessel surveys in increasing numbers since 1984 and the large numbers occurring since 1990 are unprecedented (Table 13). 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 (i.e. sandlance) 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 after 1986 by 1-2°C and have remained cold since 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 poorer 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 (growth and recruitment), thus increasing the ecological pressure on the cod population. Regardless of the environmental changes experienced by 4VsW cod it is clear that this population was under continuous and severe stress from the fishery throughout the 1980's.

Outlook

Projections

Population and catch projections for the years 1996 to 1998 were calculated using the same mean weights and selectivity pattern as in the last assessment (Fanning et al., 1995). The GM recruitment for the years 1984-93 (??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 300 t each year and secondly, $F_{0.1}$ (0.22) fishing mortality in each year.

Option 1: Closed fishery at 300t bycatch

Year	F	Yield (t)	Population Biomass (t)	Adult (6+) Biomass (t)
1996	0.01	300	44119	28928
1997	0.009	300	50808	33586
1998	0.007	300	57504	37809

Option 2: $F_{0.1}$ fishing mortality

Year	F	Yield (t)	Population Biomass (t)	Adult (6+) Biomass (t)
1996	0.22	5878	44119	28924
1997	0.22	6023	45265	28210
1998	0.22	6060	46303	26877

The short-term fishery prospects for this stock remain poor. 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 several of yearclasses are seen to be of near average or larger size, 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	4Vs	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]	368	180	188	
1995	276 [1]	-	-	-	-	1 [2]	277 [1]	184 [1]	92 [1]	

[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
1995	110	63	2	10	185	12	70	.	10	92	122	133	2	20	277

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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	1995
Age													
1	0	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	0
3	3507	430	156	124	38	185	671	291	277	571	32	0	6
4	8679	5778	2253	4210	877	1512	2544	2329	3365	2541	427	4	14
5	7484	9101	8151	7640	5694	2399	4111	3983	6790	9251	605	68	45
6	6278	5678	7523	9221	5885	4531	3334	3659	4486	6080	758	29	51
7	1905	3829	4284	3589	6049	4075	3669	2208	3348	2125	513	72	21
8	1012	1250	2430	1571	2733	3295	1796	3212	1332	1401	129	15	18
9	625	544	1063	1123	1105	1731	2018	1600	1356	521	44	5	8
10	224	290	452	447	604	626	590	1879	861	471	8	1	2
11	149	153	284	285	233	260	251	328	457	231	7	0	0
12	52	63	173	105	131	153	156	135	154	178	4	0	0
13	24	34	68	66	61	64	29	55	65	33	2	0	0
14	15	17	20	11	11	9	15	15	10	7	1	0	0
15	6	8	17	19	14	10	58	14	6	6	0	0	0
16	11	5	15	18	12	11	35	13	5	7	0	0	0
1+	29977	27181	26893	28432	23447	18869	19284	19721	22513	23425	2530	194	165
3+	29971	27180	26889	28429	23447	18861	19277	19721	22512	23423	2530	194	165
6+	10301	11871	16329	16455	16838	14765	11951	13118	12080	11060	1466	122	100

Table 4. Estimated contribution of 4TVn fish in the 4VsW cod catch at age (000's).

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Age										
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	8	0	0	0	3	3	0	0	0
4	121	62	5	0	65	128	137	0	0	0
5	542	294	391	45	94	495	1019	0	0	0
6	1637	518	611	201	1082	897	183	0	0	0
7	221	584	579	353	602	2740	435	0	0	0
8	213	97	513	552	276	703	749	0	0	0
9	201	177	277	664	709	1029	336	0	0	0
10	108	112	155	106	828	800	186	0	0	0
11	96	13	0	49	5	25	147	0	0	0
12	24	9	1	118	0	85	70	0	0	0
13	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0
3+	3163	1874	2532	2088	3661	6905	3265	0	0	0
4+	3163	1866	2532	2088	3661	6902	3262	0	0	0
5+	3042	1804	2527	2088	3596	6774	3125	0	0	0
6+	2500	1510	2136	2043	3502	6279	2106	0	0	0
Landings (mt.)	3469	2029	2496	2574	4606	8761	4358	0	0	0

Table 5. 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	1995
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	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	0.87
5	1.50	1.45	1.26	1.28	1.26	1.28	1.23	1.14	1.01	1.05	1.53	1.25
6	2.06	1.97	1.65	1.54	1.73	1.56	1.40	1.46	1.31	1.39	1.83	1.69
7	2.69	2.38	2.38	1.87	1.92	2.19	1.68	1.57	1.76	1.79	1.80	2.06
8	3.64	3.10	2.74	2.61	2.37	2.21	2.27	1.96	1.84	2.21	2.12	2.34
9	4.03	3.84	3.67	3.58	2.79	2.50	2.18	2.37	1.96	4.05	2.70	3.08
10	5.19	5.03	4.99	4.31	3.67	3.93	2.17	2.29	2.72	3.71	2.85	4.28
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	.	8.09
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 6. 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	1995
Age													
0	0.02	0.07	.	0.03	0.04	0.07	0.03	.	.	.	0.01	0.06	0.21
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	0.18
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	0.66
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	2.39
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	2.41
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	1.91
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	0.77
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	0.42
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	0.49
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	0.07
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	9.52
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	8.46
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	1.75

Table 7. 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 8. Summary Statistics from ADAPT.

Mean Square of the Residuals = 0.71731

	Est. Param.	SE	CV	Bias	
1	0.00107071	0.000575906	0.537873	-2.28734	f3
2	0.00291386	0.00116029	0.398198	-0.631013	f4
3	0.00509849	0.00167848	0.32921	0.177304	f5
4	0.0137286	0.00397416	0.28948	0.883175	f6
5	0.00649188	0.00189871	0.292474	0.178985	f7
6	0.00814114	0.00262939	0.322976	-0.335209	f8
7	0.255001	0.0413329	0.162089	0.807216	q3
8	0.282646	0.0460884	0.163061	0.343517	q4
9	0.261635	0.0427388	0.163353	0.125034	q5
10	0.217635	0.0356067	0.163607	-0.0376668	q6
11	0.206077	0.0337098	0.163578	-0.208231	q7
12	0.181384	0.0296667	0.163557	-0.374065	q8
13	0.159925	0.0326684	0.204274	1.34651	q23
14	0.189344	0.0390525	0.206252	0.577267	q24
15	0.200941	0.0415707	0.20688	0.220885	q25
16	0.205622	0.0426479	0.207409	0.00763729	q26
17	0.170799	0.0354787	0.207721	-0.23203	q27
18	0.172735	0.0358311	0.207434	-0.493681	q28
19	0.120988	0.0251536	0.207902	-0.699375	q29

Table 9. 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	84967	84749	66999	61754	74327	84658	70853	66548	101948	90245	106032	112028	63253
2	80064	68395	67592	53003	49458	59702	67921	57545	54484	83437	73875	86784	91718
3	40548	57741	44394	40984	34147	33869	41125	53015	47093	44523	68228	60401	70819
4	47459	25157	38549	25668	26315	15901	21032	31082	42924	37500	34858	54264	46556
5	39971	25463	15960	20713	15765	10963	10157	12960	24336	31453	24767	24130	36161
6	17292	20353	14864	6386	8241	6705	4644	4787	9171	15566	17133	14001	13168
7	6583	10050	12024	6264	2220	4714	2507	1915	3154	5173	8169	8438	7255
8	3843	3632	5135	6851	2079	1213	1197	888	1125	1889	3140	3929	4233
9	902	2460	1198	2503	1328	790	429	575	547	697	1205	1557	1931
10	375	525	1377	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	0	9	0	8	3	0	2	12	48
Total	323,061	299,431	268,349	225,604	214,698	219,943	220,292	229,789	285,406	311,188	338,450	366,932	336,911

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Age													
1	62629	26069	26231	33537	44746	39509	18810	13094	21790	9880	9536	.	.
2	51784	51276	21344	21476	27458	36635	32347	15400	10720	17840	8089	7807	.
3	74967	42392	41981	17471	17581	22481	29987	26477	12609	8776	14605	6623	6392
4	55744	58205	34319	34230	14192	14367	18238	23944	21415	10075	6671	11928	5422
5	31180	37786	42426	26059	24325	10882	10399	12630	17555	14604	6074	5076	9762
6	20446	18756	22702	27360	14913	15030	7093	4835	6822	8677	4508	4425	4094
7	7450	11059	10218	11780	15538	7353	8758	2972	1627	2338	1768	3005	3597
8	3616	4376	5590	4490	6597	7777	2857	4170	980	782	385	984	2395
9	2276	2045	2452	2378	2447	3016	3850	1214	758	233	50	198	792
10	966	1298	1182	1045	1113	1164	1154	1927	187	324	24	1	158
11	462	589	800	559	549	466	527	507	627	98	8	12	0
12	233	243	343	398	286	251	146	248	122	122	4	0	10
13	110	144	142	125	253	124	68	85	81	38	2	0	0
14	43	68	87	55	42	152	44	29	20	8	1	0	0
15	17	22	40	53	35	25	116	22	10	7	0	0	0
Total	311,923	254,328	209,857	181,016	170,075	159,232	134,394	107,554	95,323	73,802	51,725	40,059	32,622

Table 10. 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	4,574	2,697
2	35436	15746	18998	11733	10256	8855	10074	8535	13457	19920	17944	21,258	21,510
3	25851	36646	32480	35692	21245	18714	17145	22241	21642	28885	46360	41,755	48,136
4	44235	22792	36039	25011	28127	13030	18159	29106	42232	36000	31186	51,684	42,730
5	52019	31864	19555	24026	20162	13947	11468	17417	32734	43352	30695	33,684	47,335
6	27656	32882	24279	9641	13132	12128	8141	9082	18360	30139	31986	25,785	26,050
7	12114	20360	24412	12858	4576	10623	6272	5110	8997	13857	21814	21,628	17,452
8	11403	10261	13158	15655	4945	3346	3827	3425	4355	6707	11374	13,661	14,544
9	4062	10155	4919	6902	3608	2386	1620	2417	2671	3368	5391	7,663	8,812
10	2138	2768	6488	3024	1625	3158	895	1156	1822	2049	2932	4,323	5,709
11	2240	1379	644	2957	884	1215	650	583	1015	1543	1834	2,397	3,512
12	3184	1937	440	159	481	757	335	547	350	898	1530	1,448	1,701
13	913	1629	506	335	68	560	79	121	237	225	740	1,356	1,143
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
6+	64318	82585	75127	51946	29417	34344	21960	22614	37926	58814	77800	78902	80343

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Age													
1	2889	1122	1006	2041	3017	2112	1105	883	1016	717	643	0	0
2	11227	11916	5566	3529	4073	6854	5509	2284	2299	2459	1200	1158	0
3	49102	25001	25994	11880	6329	8369	15567	12430	5190	4724	4806	2580	2490
4	49884	52925	29962	28112	11286	9803	14548	21011	17513	7858	4910	10189	4201
5	39331	47195	52598	29687	26824	11780	11587	14078	18744	13768	5532	5822	12348
6	36910	33298	39025	42320	20773	22365	9944	6472	9142	10604	5341	6134	6583
7	19991	26473	22626	25507	27294	12644	17047	4811	2412	3748	2708	4753	6985
8	11257	14676	16143	11465	16442	16372	5885	9298	1778	1328	759	1916	4915
9	9514	7734	9166	8021	7664	8138	9371	2664	1757	457	136	485	2023
10	5374	6188	5321	4576	4425	4219	3820	4488	419	824	64	4	538
11	3157	3771	4583	2884	3126	2145	2279	2102	1569	235	36	47	0
12	2060	1847	2264	2623	1657	1696	736	1396	481	335	15	0	56
13	1068	1326	1297	985	1781	863	526	564	411	169	12	0	0
14	490	724	883	532	462	1363	423	299	210	58	10	0	0
15	202	266	439	611	384	295	1088	250	109	95	0	0	0
6+	90023	96303	101747	99524	84008	70100	51119	32344	18288	17853	9081	13339	21100

Table 11. 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
F(7-9)	0.33	0.59	0.42	1.23	0.45	1.07	0.60	0.29	0.28	0.23	0.46	0.44	0.47

Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Age													
1	.	.	.	.	.	.	.	.	.	.	.	.	.
2	.	.	.	.	.	.	.	.	.	.	.	.	.
3	0.05	0.01	.	0.01	.	0.01	0.03	0.01	0.02	0.07	.	.	.
4	0.19	0.12	0.08	0.14	0.07	0.12	0.17	0.11	0.18	0.31	0.07	.	.
5	0.31	0.31	0.24	0.36	0.28	0.23	0.57	0.42	0.50	0.98	0.12	0.02	0.01
6	0.41	0.41	0.46	0.37	0.51	0.34	0.67	0.89	0.87	1.39	0.21	0.01	0.01
7	0.33	0.48	0.62	0.38	0.49	0.75	0.54	0.91	0.53	1.60	0.39	0.03	0.01
8	0.37	0.38	0.65	0.41	0.58	0.50	0.66	1.51	1.24	2.55	0.46	0.02	0.01
9	0.36	0.35	0.65	0.56	0.54	0.76	0.49	1.67	0.65	2.09	3.61	0.03	0.01
10	0.30	0.28	0.55	0.44	0.67	0.59	0.62	0.92	0.45	3.54	0.47	2.20	0.01
11	0.44	0.34	0.50	0.47	0.58	0.96	0.55	1.22	1.44	2.90	4.15	.	0.01
12	0.28	0.34	0.81	0.25	0.64	1.11	0.34	0.92	0.97	3.81	3.59	.	0.01
13	0.28	0.30	0.75	0.88	0.31	0.84	0.64	1.25	2.15	3.33	2.90	.	0.01
14	0.48	0.32	0.29	0.25	0.34	0.07	0.48	0.84	0.80	4.15	2.20	.	0.01
15	0.50	0.51	0.61	0.50	0.58	0.58	0.79	1.15	1.00	2.07	0.37	0.02	0.01
F(7-9)	0.35	0.40	0.64	0.45	0.54	0.67	0.56	1.36	0.81	2.08	1.49	0.03	0.01

Table 12. Mean length at age in 4Vs and 4W cod from July RV surveys.

SubDivision 4Vs

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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	.	.	.	.	.	.	.
94	.	17.78	27.78	34.10	41.06	47.82	52.89	60.05	67.88	64.56	82.00	97.00	.	.	.	.
95	8.08	17.50	28.89	35.01	43.58	47.09	51.24	54.60	57.99	52.06	.	.	.	.	.	.

Division 4W

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
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	.	.	.	.	.
95	8.53	19.33	27.90	34.00	37.78	40.30	42.29	45.65	45.66	49.00	.	.	.	.	.	.

Table 13. July RV survey population numbers at length for capelin by NAFO Division.

NAFO Division	Length (cm)	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
4Vn	8																							19732			
	9																									2884760	
	10																								53736	5851110	
	11																								53736	4311344	
	12				82388																			36763		307953	
	13				109850																					61691	39465
	14				184775																			98659	104401	15610	19842
	15				27463										25375									151799	52201	79620	
	16																							16478			
	17																							16478			
	23				27463																						
	24				27463																						
	25				27463																						
4Vs	7			34903		64874																			15048		
	8					758535																			1402579		124729
	9					1746204																			8669464	28897	8774048
	10					721259														15048	168026	48913			40503012	2567560	37144578
	11					297284															342393	23704	213719	40421	58515500	7051793	38189477
	12					64874											342393				1420296	72541	407299		15414752	3672590	5228349
	13				23704	585826											1198375				4194313	450384	192379	222409	8422243	3054548	25730723
	14			17848	107294	414629											684786	78783	63212		4270400	1365147	189933	321531	21377114	2775067	42659886
	15	23340			147217	57065											268208		88001		1931305	864300	281492	436180	19205588	2285913	14997004
	16	46680				14448												14873	178480		3453287	402975	178383	274391	17984148	529207	7642931
	17	20228																	23704		1668995	23704	249549	38916	7990507	249326	1210838
	18																				53895	94818	42799		1266047		21673
	19																					71113			104628		
	20																					47408					
	30																					23704					
4W	6																								60696		
	7																								111278		13951
	8																							210047	1021164	78880	376714
	9																			48629			223620	771209	1685070	363530	2017718
	10																						5255079	1494126	1603387	196700	1926363
	11																			48629		33408	12410930	1259137	641870	9835	1541240
	12																			48629		384194	6655156	698159		7808140	480342
	13																48629			126450		930024	170165	3021440	6891	78175269	2551708
	14										55576									2088428		1662991	116710	13979850	266766	499919732	4140704
	15																			5374131		1584150	388272	42826591	2474363	515621844	4010470
	16																		109845	1201276		315046	1508018	82908850	4816343	258015839	2537007
	17																			63225		47208	623478	37443621	6869228	312780010	477847
	18																							1931718	2474363	101577310	53655
	19																								66692		
	20																					51871					
4X	14																										96438
	15																					18467					
Total		90248	0	52751	745080	4724598	0	0	0	0	55576	0	0	0	25375	0	2542391	93656	463242	9012445	17502910	6494070	29112981	########	224231811	1816274978	201986498
4VW	6																								60696		
	7			34903		64874																			126324		13951
	8					758535																		229779	2423743	78880	500443
	9					1746204														48629			223620	771209	10354534	3287286	10791764
	10					721259														15048	168026	48913	5255079	1494126	42160135	8605371	39070941
	11					297284														48629	342393	57113	12624649	1299558	60211106	11372973	39730717
	12				82388	64874											342393			48629	1420296	456735	7062455	736922	15414752	11786683	5588691
	13				133554	585826											1247004			126450	4194313	1380409	382544	3243849	8429134	61292408	28321895
	14			17848	272069	414629					55576						684786	78783	63212	2088428	4270400	3028138	308643	14399939	21748282	502710409	48820432
	15	23340			174680	57065									25375		268208		88001	5374131	1931305	2428451	680764	43414670	21732152	517987377	19007474
	16	46680				14448												14873	288325	1201276	3453287	718020	1884401	83197519	22799491	266545146	10179938
	17	20228																	23704	63225	1668995	70912	870027	37499015	14859735	313028335	1888485
	18																				53895	94818	42799	1931718	3740410	101577310	78327
	19																					71113			171318		
	20																					98280					
	23				27463																						
	24				27463																						
	25				27463																						
	30																					23704					

Figure 1. Nominal landings and TAC from 4VsW cod.

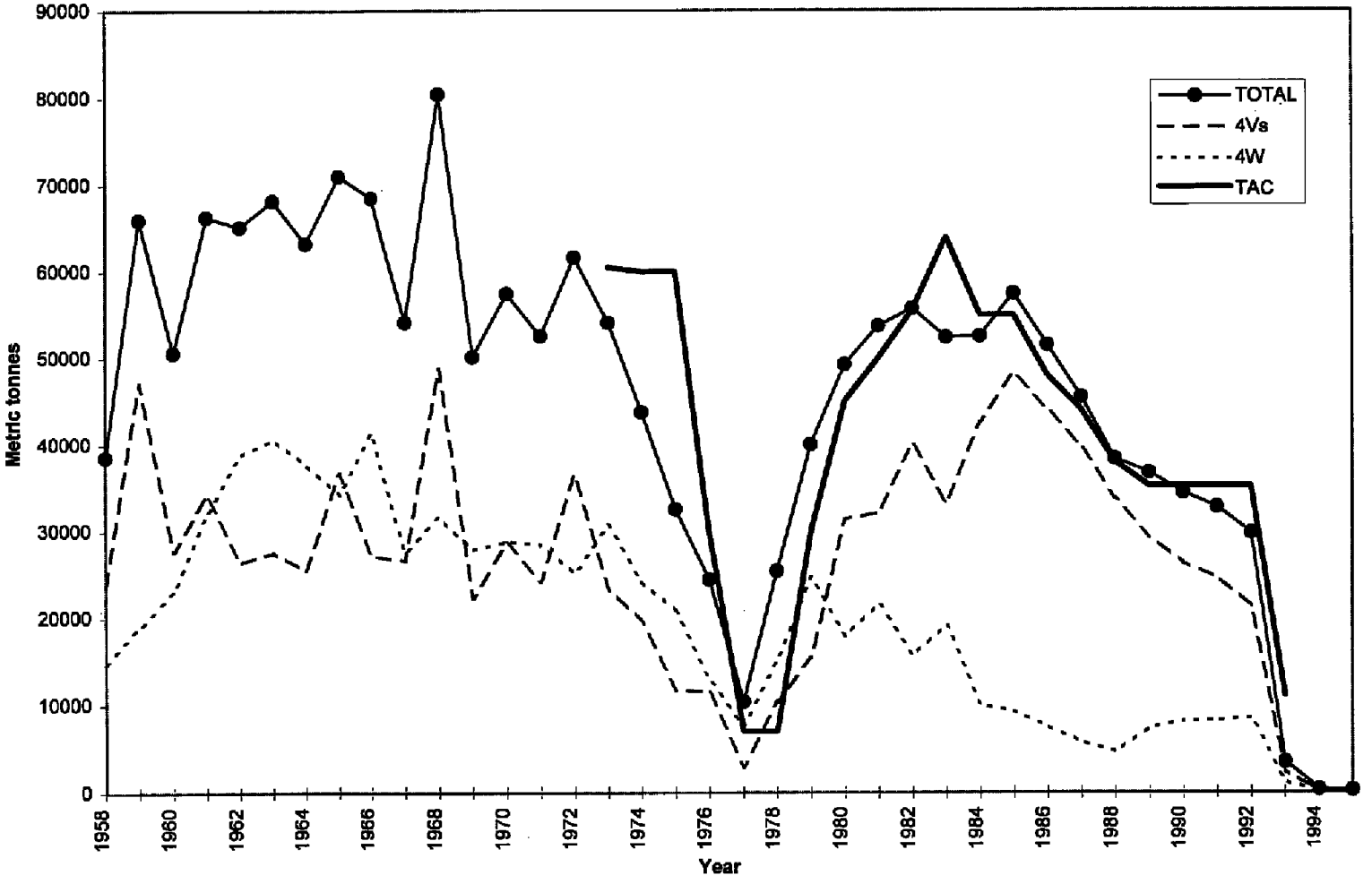

Figure 2. Cumulative percentiles of weight in the 4VsW commercial catch

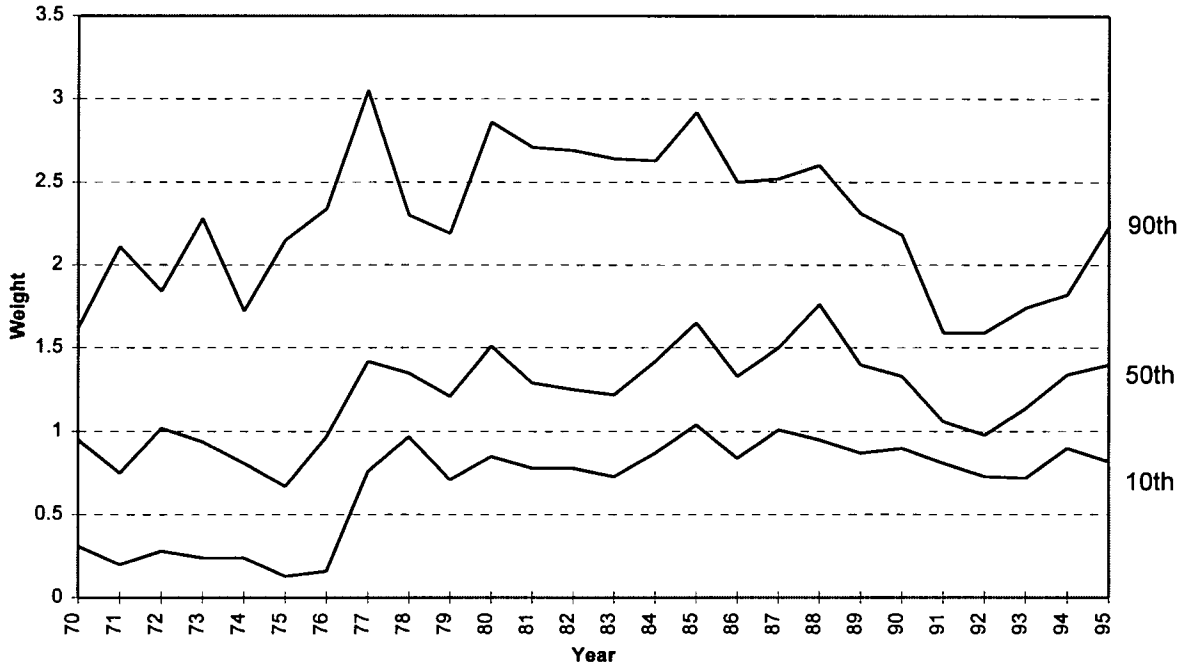

Figure 3. Cumulative percentiles of age in the 4VsW commercial catch

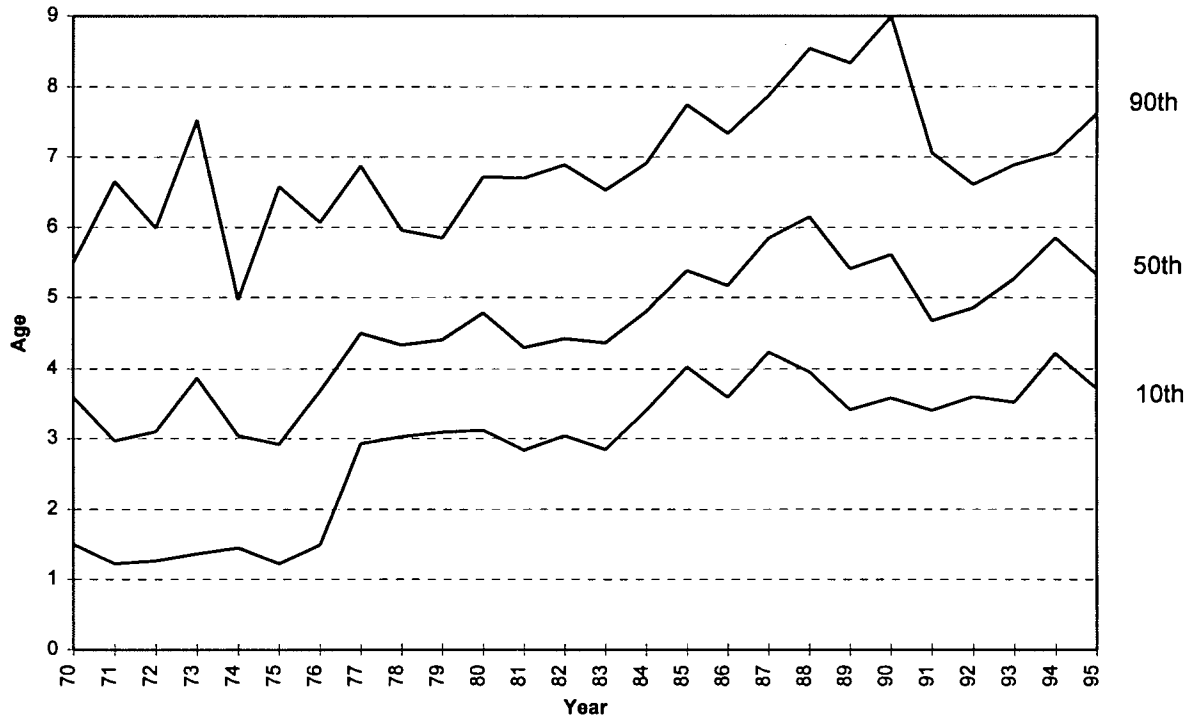

Figure 4. RV mean catch per tow (ages 3+) for 4VsW Cod

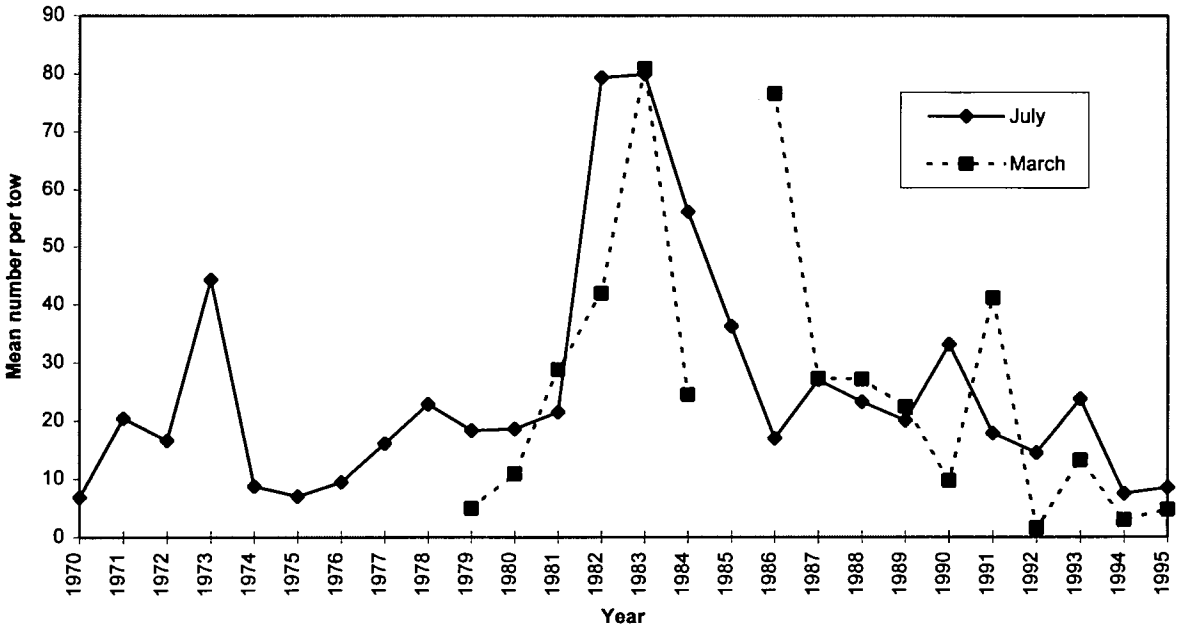

Figure 5. RV recruitement estimates for 4VsW cod (q-scaled mean of ages 2+3)

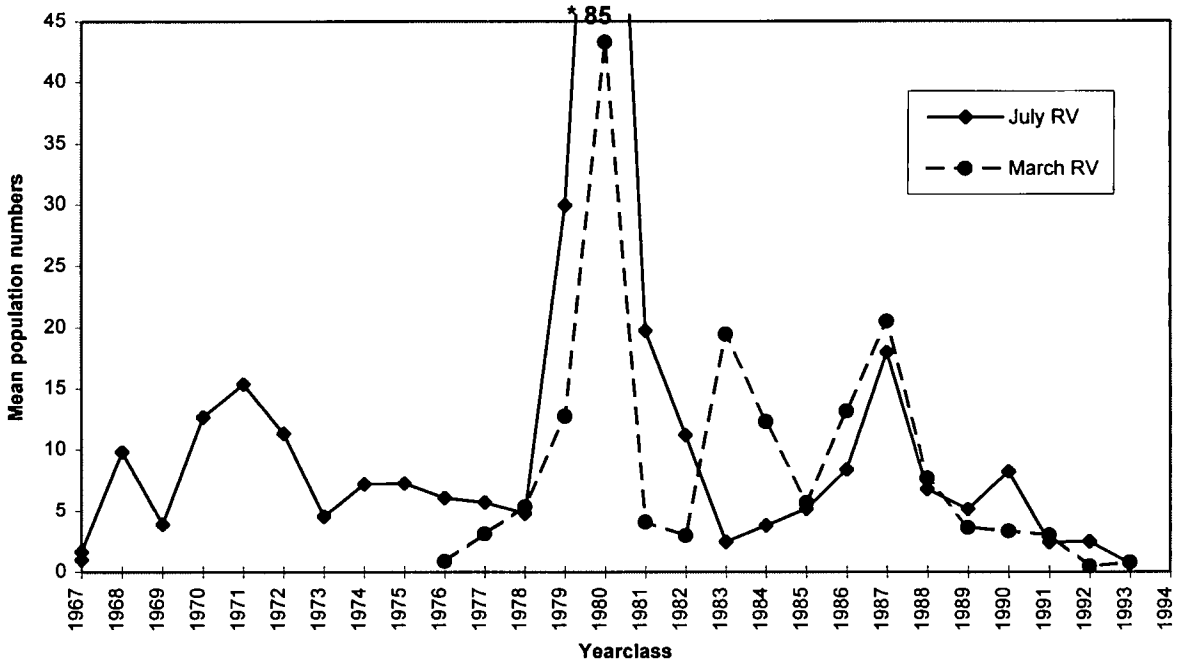

Figure 6. 4VsW cod sentinel survey catch numbers in 1995.

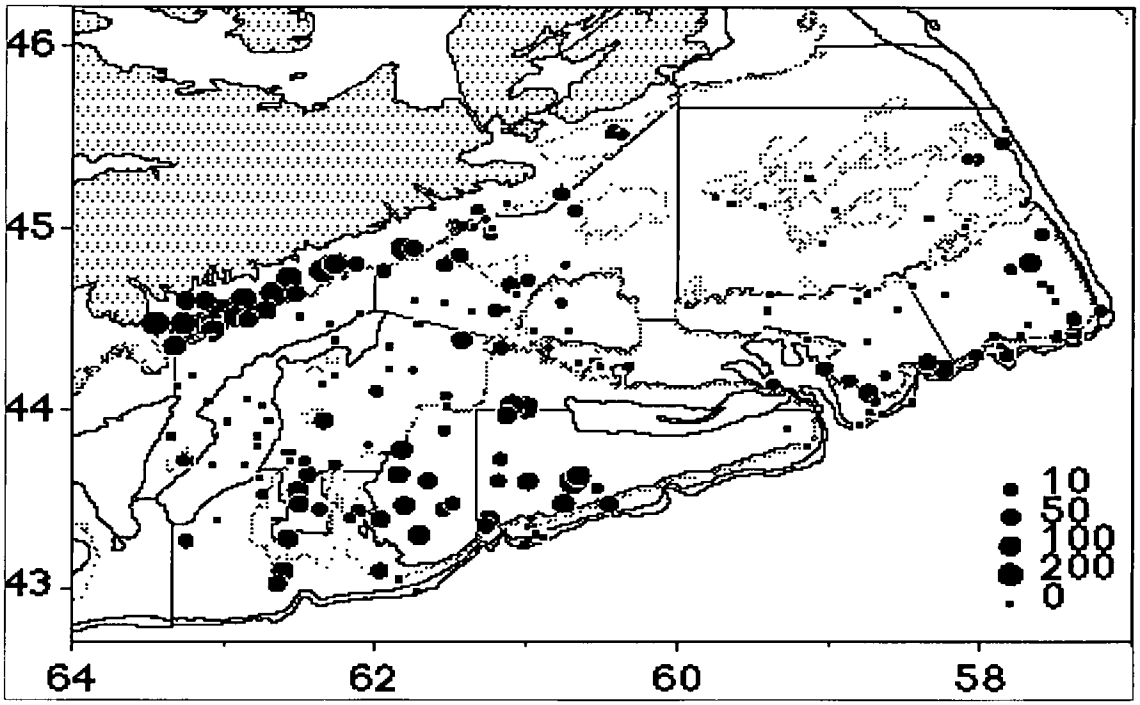

Figure 7. Percent catch at length in 1995 RV and sentinel surveys.

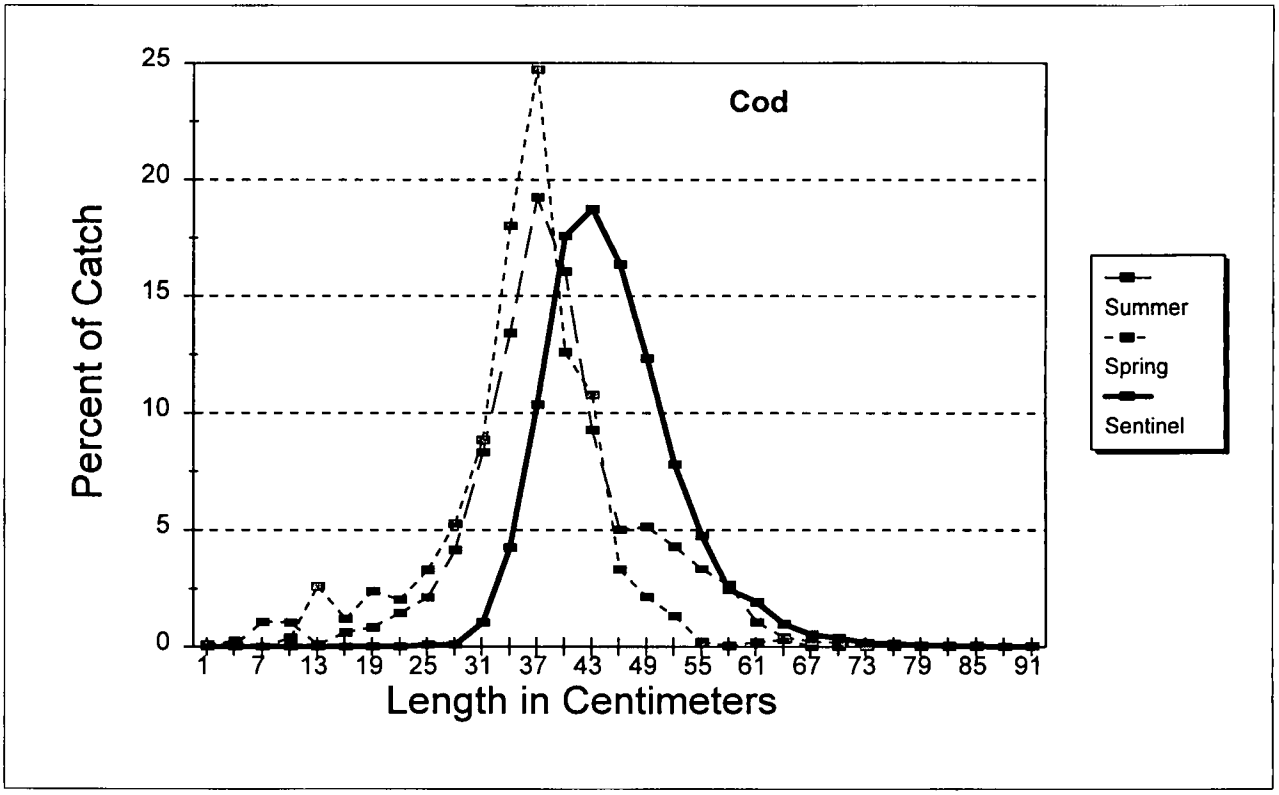

Figure 8. 4VsW cod SPA population numbers for selected ages.

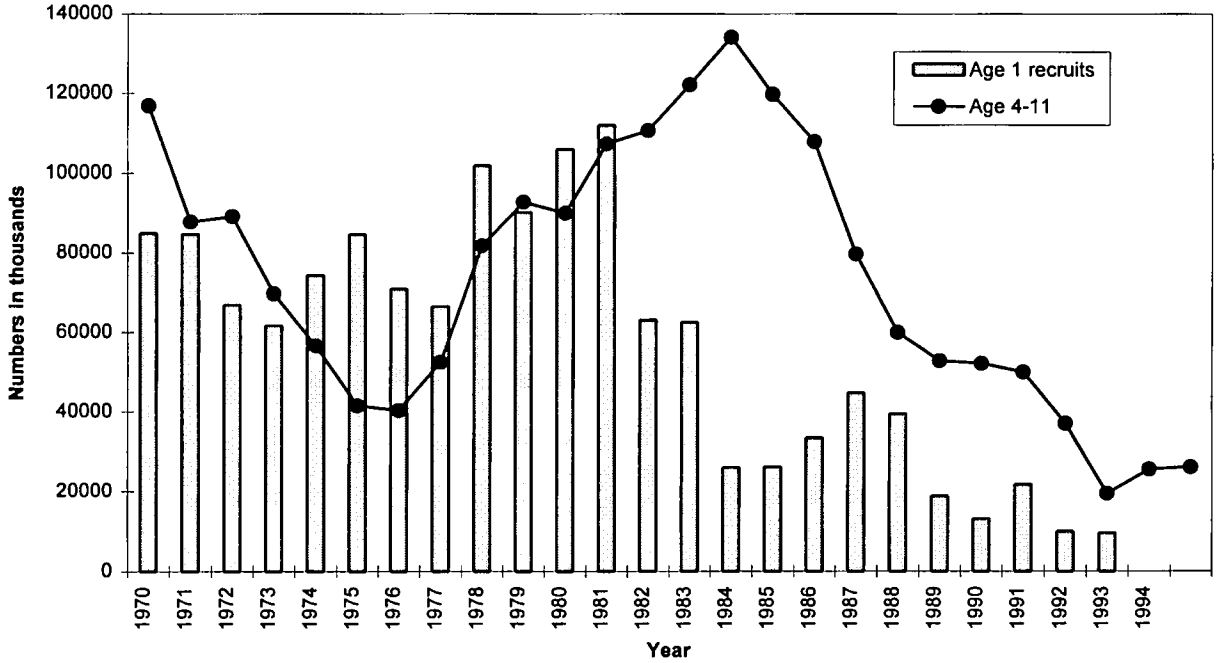

Figure 9. Longterm SPA numbers and recruitment for 4VsW cod.

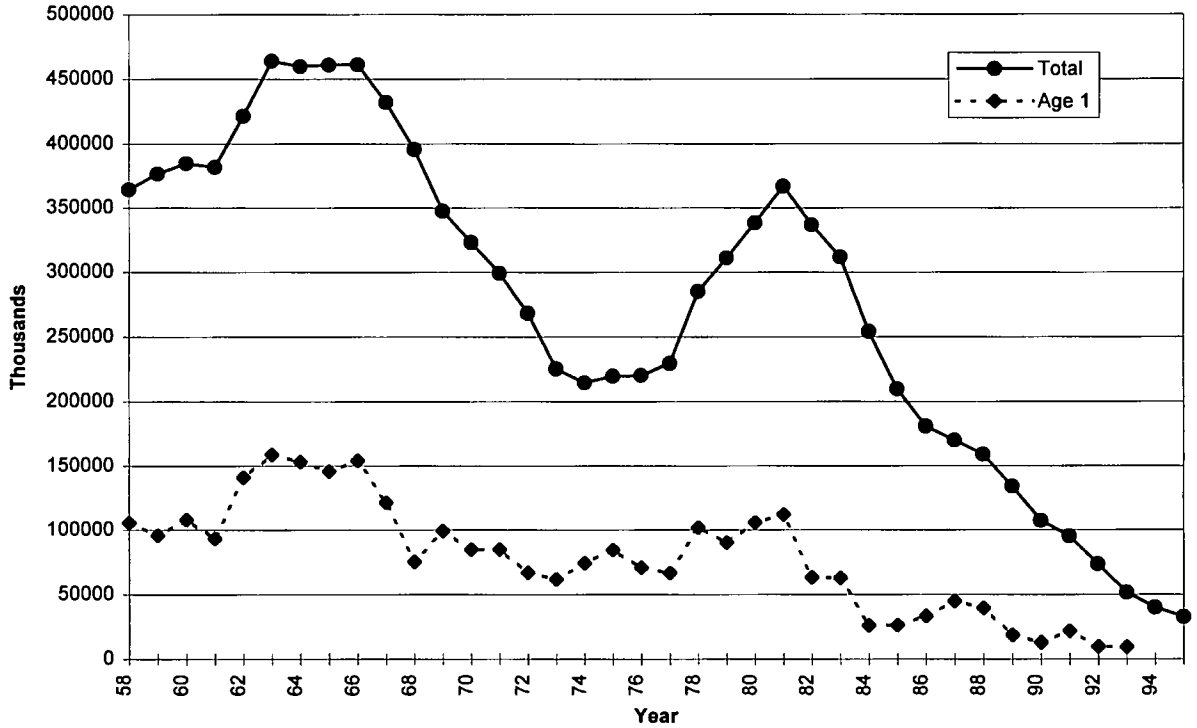

Figure 10. 4VsW cod SPA population biomass total and adult (age 6+)

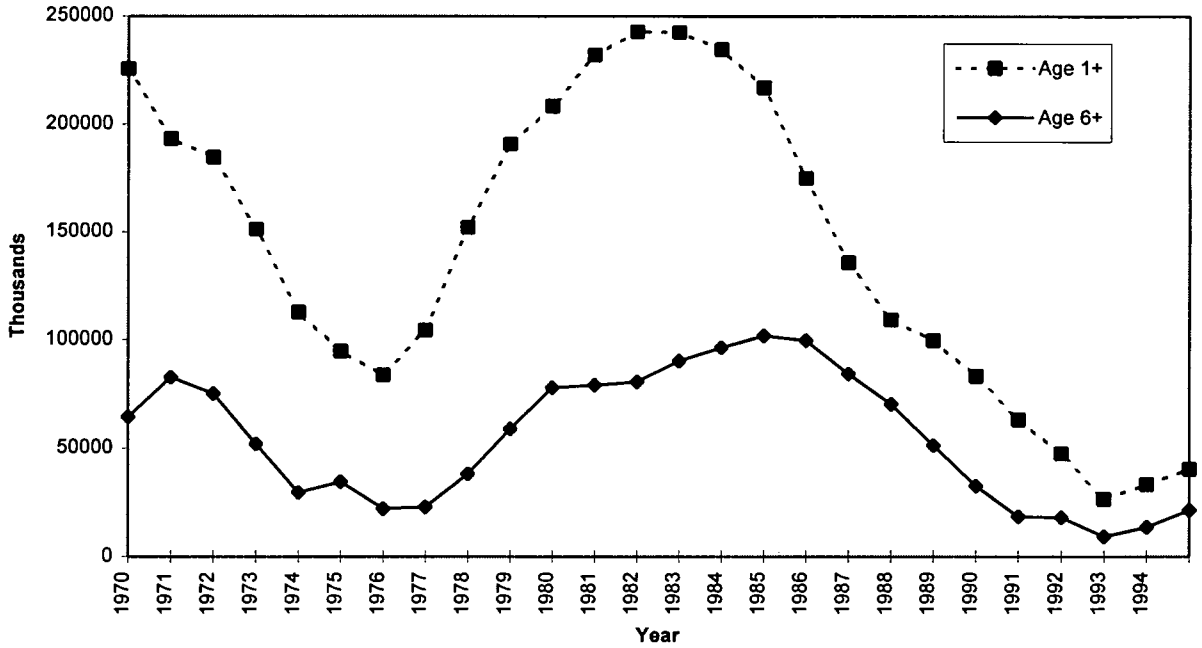

Figure 11. Retrospective patterns in 4VsW cod biomass estimates

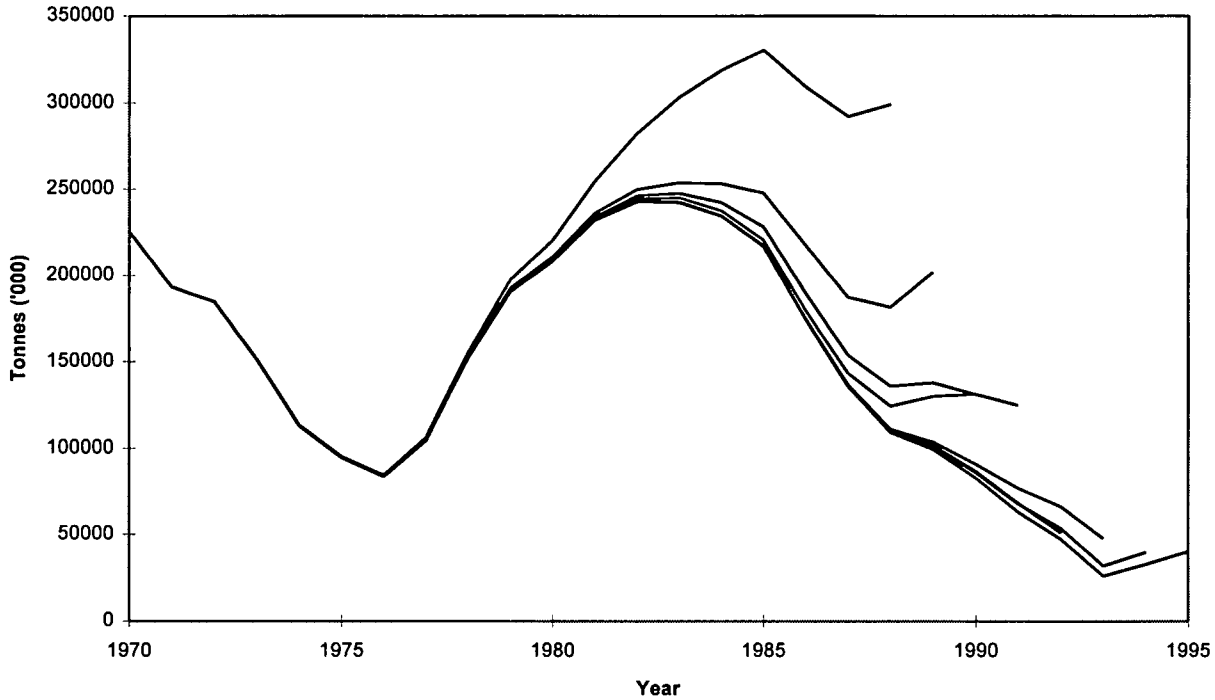

Figure 12. Retrospective patterns in 4VsW cod fishing mortality estimates.

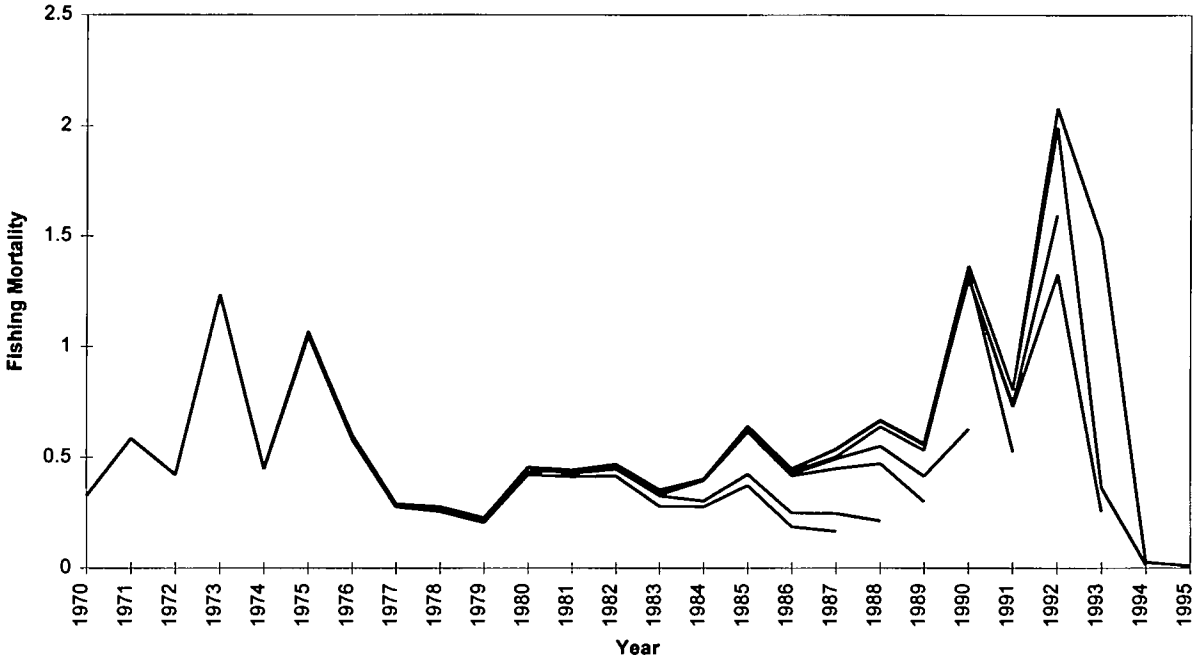

Figure 13. Fully recruited F (ages 7-9) in 4VsW cod.

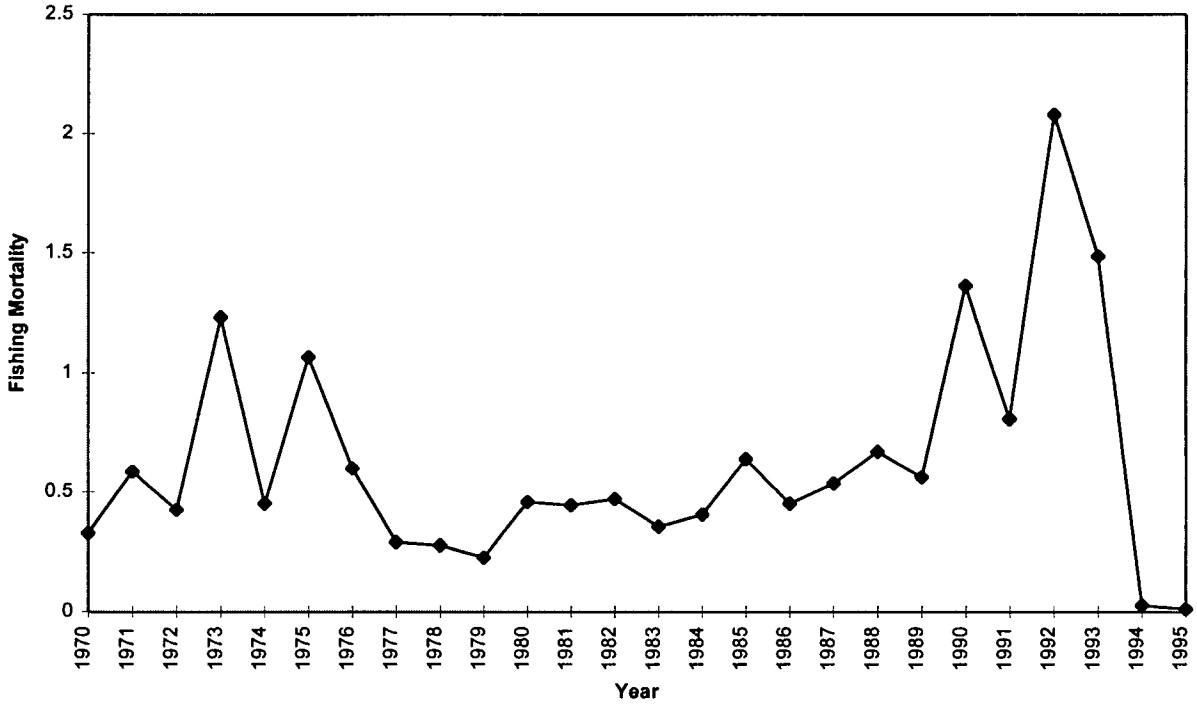

Figure 14. Age 1 recruitment as related to spawning stock biomass for 4VsW cod yearclasses from VPA

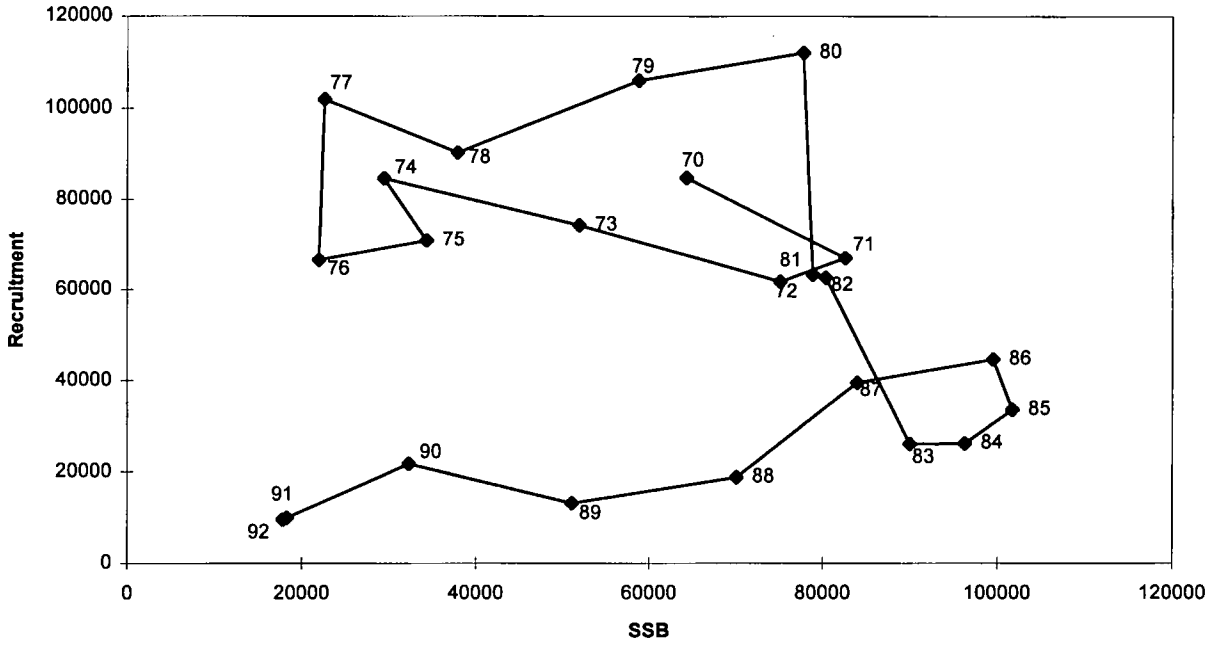

Figure 15. 4VsW cod trends in condition and population biomass (ages 3+).

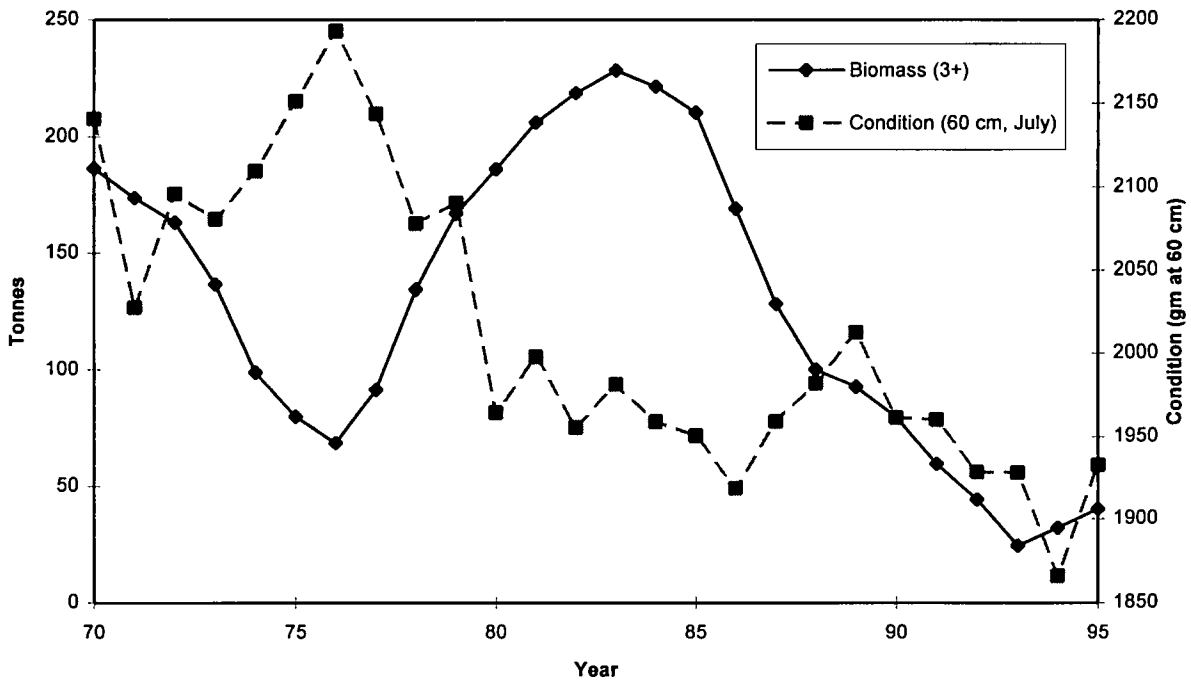

Figure 16. Condition of 4VsW cod with respect to population biomass (ages 3+).

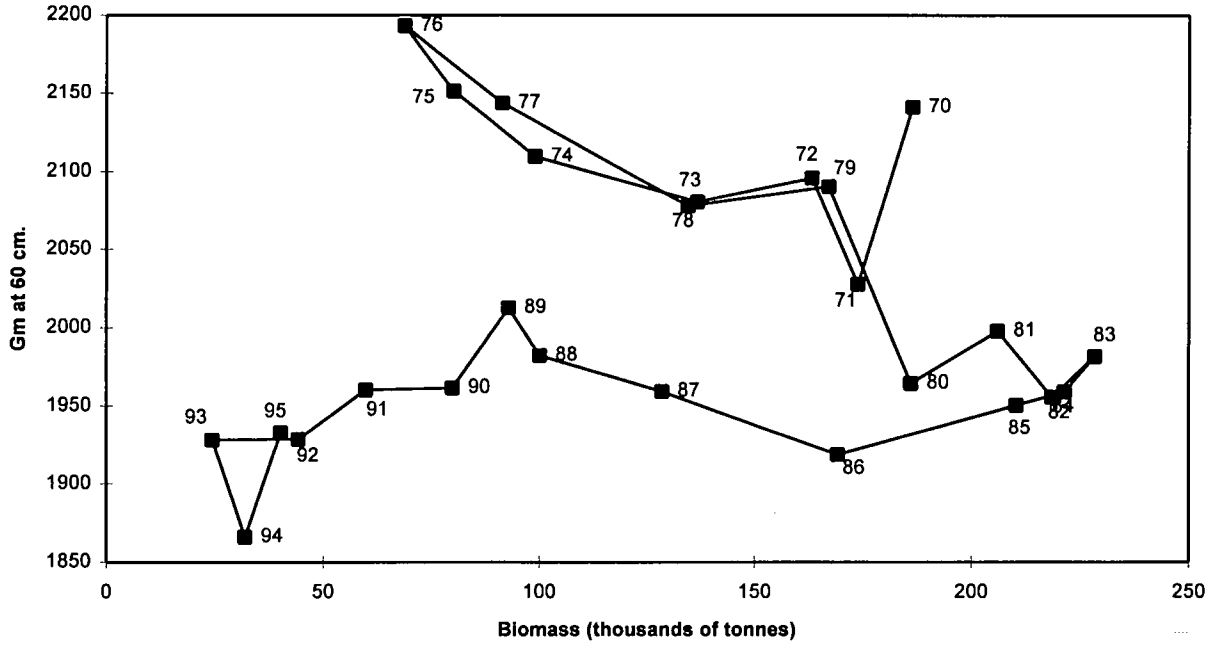

Figure 17. Mean length at age 1 for 4VsW and 4X cod from July RV surveys.

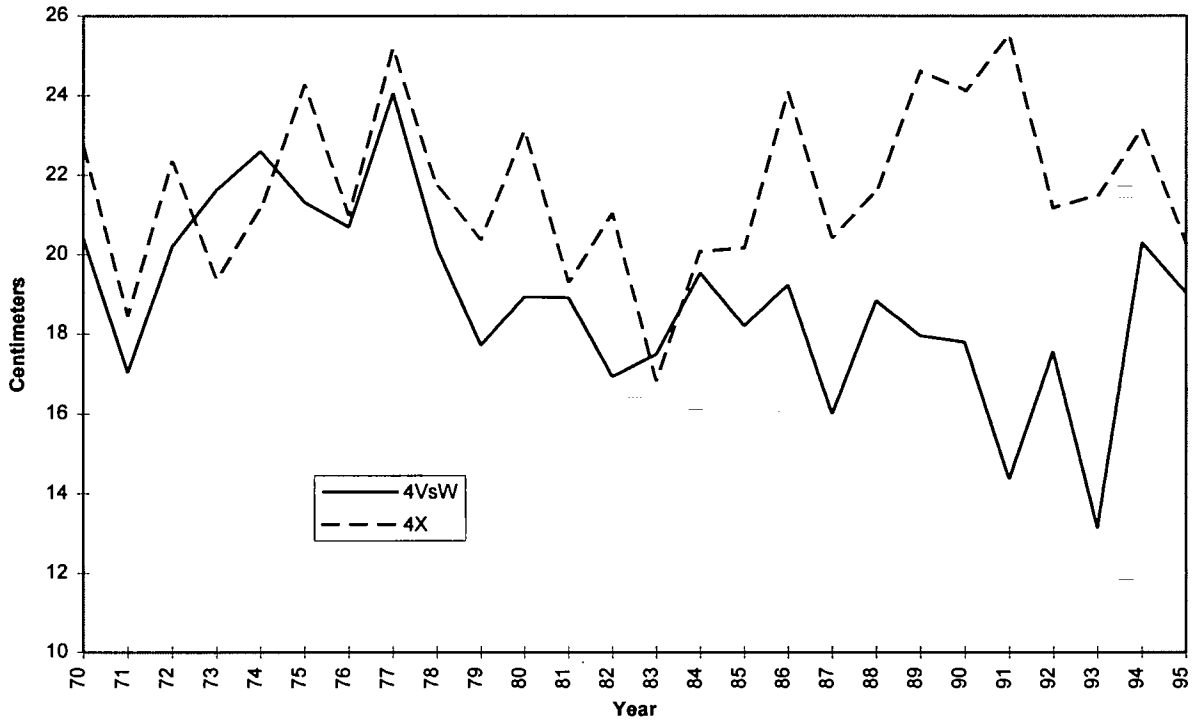

Figure 18. Estimates of age 1 recruitment from VPA and Emerald Basin temperature for 4VsW cod.