4VsW Cod: Another Look at the Sizes of the 1980 and 1981 Year-Classes

by

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Abstract

The sizes of the 1980 and 1981 year-classes were reevaluated based on evidence available from the first half of 1985 commercial fishery and the 1985 summer research survey. Comparison of the projected first half year catch at age to that observed did not indicate that the 1980 year-class had been underestimated. The observed catches of both the 1981 and 1982 year-classes were less than expected but this may have been due to size segregation on the fishing grounds and selective fishing. Results from the 1985 research survey also confirmed that the size of the 1980 year-class was well estimated but that the 1981 and 1982 year-classes may have been overestimated. The first half of 1985 commercial catch rates were higher than expected. However, the estimates were complicated by a change in the fishing pattern and an abnormal trend in monthly catch rates.

Résumé

Les tailles des classes d'âge de 1980 et de 1981 ont été réévaluées à partir de données recueillies au cours de la première moitié de la saison de pêche commerciale de 1985 et lors du recensement de l'été 1985. La comparaison entre les prises par âge projetées pour la première moitié de l'année et celles observées n'indiquaient pas que la classe d'âge de 1980 avait été sous-estimée. Les prises observées dans les classes d'âge de 1981 et de 1982 ont été moins nombreuses que prévu, peut-être à cause d'une ségrégation par taille sur les lieux de pêche et de la pêche sélective. Les résultats du recensement de 1985 ont aussi confirmé que la taille de la classe d'âge de 1980 avait été bien estimée mais que celles des classes d'âge de 1981 et de 1982 auraient été surestimées. Les taux de prises commerciales pour la première moitié de 1985 ont été plus élevées que prévu. Toutefois, les estimations ont été compliquées par un changement dans les conditions de pêche et une tendance anormale dans les taux de prises mensuelles.

Introduction

A greatly reduced $F_{0.1}$ catch level was recommended for the 4VsW cod stock complex for 1986. The 1984 and 1985 TACs were set at

	1982	1983	1984	1985	1986
TAC ('000 t)	55.6	64	55	55	(35)

55,000 t based on CAFSAC advice but following the May, 1985 assessment the recommended $F_{0.1}$ catch for 1986 was reduced to 35,000 t providing the 1985 catch was equal to the TAC (CAFSAC Advisory Doc. 85/14). This change in advice should not be interpreted as indicative of a reduction in the size of the cod population, but rather as a change in our perception of the size of the population.

A comparison of the estimated 5+ numbers from the most recent sequential population analysis (SPA) of this stock (Sinclair and Gavaris 1985) and the corresponding estimates from previous assessments shows that the population was consistently overestimated between 1977 and 1982 (Table 1). This was due to an underestimation of fully recruited terminal fishing mortalities (F_t). However Gagne et al. (1984) concluded that the 1983 F_t was substantially higher than those estimated for earlier years in earlier assessments (see below). This resulted in a reduction in

		Year		
	1980	1981	1982	1983
F_t	.225	.225	.25	.35

the estimated 5+ population. At the same time the recruiting year-classes, namely the 1979-1980, were estimated to be the highest ever and the 1981 was estimated to be average in size. Consequently the projected 1984 and 1985 $F_{0.1}$ catches were 42,000 t and 52,000 t respectively.

The most recent assessment of the stock (Sinclair and Gavaris 1985) indicated that the sizes of the 1979-1981 year-classes were much lower than previously estimated.

Assessment	Year-Class at age 3 (millions)		
Year	1979	1980	1981
1984	111	111	71
1985	81	69	43

The resulting catch projections indicated that a catch of 55,000 t in 1985 would result in a fully recruited fishing mortality of .35, far in excess of $F_{0.1}$ = .2, and that the 1986 $F_{0.1}$ catch would be 35,000 t.

CAFSAC noted that the 1980 and 1981 year-classes may not have been precisely estimated due to uncertainty about the estimated age 3 and 4 partial recruitment in the 1984 fishery. The objective of this study is to re-evaluate the sizes of these year-classes based on information available from the 1985 fishery.

Despite this drastic reduction in the recommended $F_{0.1}$ catch level the current population size is quite large compared to that in the mid 1970s and is projected to increase in size through 1986 (Figure 1). This is based on the presence of strong 1977-1980 year-classes and lower exploitation rates since the extension of jurisdiction in 1977 (Figure 1). However, the recent exploitation rates have been in excess of F_{max} and if these are to be reduced to $F_{0.1}$ there will have to be a reduction in catch.

Nominal Catch

Nominal catch estimates for the first half of 1985 were taken from Scotia Fundy Region Statistics files and quota reports. Catch by gear sector from the first quota report in July for 1982 to 1985 indicates that in 1985 the mobile gear <65' gear sector caught substantially more fish than in previous years (Table 2). This was because of an influx of vessels from Southwest Nova Scotia which have traditionally not fished the stock. This fishery was closed on 6 June but was allowed to continue at a rate of 16,000 kg per week per vessel with no quota transfer. Catches by other gear sectors have remained stable over the past 4 years. Thus, there is likely to have been an increase in effective fishing effort on the stock in the first half of 1985 over previous years.

First Half 1985 Catch at Age

Four age length keys were used to calculate the first half of 1985 catch at age. Sampling for otter trawler and the longline gears was adequate but a greater number of aged samples for seines may have been desirable (Table 3). The same length-weight relationship used last year was used again. The four keys accounted for 32,807 t of the 33,628 t total catch. Total catch for Scotia Fundy landings came from the regional statistics files while landings in other regions were taken from quota reports.

The first half catch at age was dominated by the 1979 (age 6), 1980 (age 5), 1978 (age 7), and 1977 (age 8) year-classes which made up 85% of the catch numbers (Table 4). The 1981 year-class (age 4) was the fifth largest in the catch. Catch at age and age compositions for the first and second halves of 1981-1984 are also given in Table 4. The 1981 year-class had the smallest age 3 catch numbers since 1978 (Sinclair and Gavaris 1985) and the smallest age 4 catch in the first of the year since 1981, the time period for which catch data for the first half of the year were available. The catch of the 1982 year-class (age 3) in the first half of 1985 was smaller than that of the 1981 year-class in the first half of 1984.

Comparison of Projected to Observed Catch at Age

One method which may be used to judge the accuracy of the predicted strengths of the 1980 and 1981 year-class is to compare the projected to the observed catch at age for the first half of 1985. It was necessary to develop partial recruitment and weight-at-age parameters which would be representative of conditions in the first half of the year. It would be expected that the recruiting year-classes would be less recruited in the first half of the year than the average for the entire year. A new partial recruitment vector was calculated to represent the first half year catch using a partial F matrix derived from a modified cohort analysis equation.

$$N_{t+.5} = N_t{}^{-M/2} - C_{t+.5}{}^{-M/4}$$

where $N_{t+.5}$ = estimated numbers at the end of June

N_t = beginning of the year numbers (from Gavaris and Sinclair 1985).

$C_{t+.5}$ = catch in the first half of the year

M = natural mortality rate

Total mortality was taken as

$$Z_{t+.5} = 2 \ln (N_t \div N_{t+.5})$$

and the corresponding fishing mortalities were

$$F_{t+.5} = Z_{t+.5}{}^{-M}$$

The partial recruitment pattern for the first half of the year was determined using analysis of variances of the model (O'Boyle pers. comm.)

$$\ln F = a + b_1 A + b_2 Y$$

where A = age
Y = year

The antilog of the resulting F vector was then standardized to the mean age 7-9 F value (fully recruited) to find the partial recruitment pattern. The first half and whole year PR's determined by this method are given in Table 5. For ages 3-6 the first half PR was smaller than the whole year PR as expected.

Differences between projected and observed catches at age may be partially attributed to differences in weights at age. To avoid this problem the observed first half 1985 weights at age were used to project the catch at age. The observed nominal catch was also used. The parameters used in the projection are given in Table 6.

The projected and observed catches at age were in close agreement for ages 5-8 (Table 7 and Figure 2). This indicates that the relative sizes of the corresponding year-classes (1980-1977) were well estimated in the previous assessment. Furthermore, if one accepts the previous estimates

of the 1977-1979 year-classes (Sinclair and Gavaris 1985), this suggests that the absolute size of the 1980 year-class was also well established.

The first half of 1985 catch of the 1977-1980 year-classes was approximately 80% of the projected total year catch. Given the projected beginning of the year 1985 population, the first half catch would have produced an instantaneous mortality rate (F) of .58 on the fully recruited year-classes. This is well above the projected full year F of .35. Thus, if this level of F is to be realized there will have to be a substantial reduction in effective fishing effort in the second half of 1985.

The observed catch of the 1981 year-class (age 4) was less than half the projected catch, while the observed catch of the 1982 year-class was less than one tenth the projected catch. These shortfalls may be due either to an overestimation of the 1985 partial recruitments or an overestimation of the year-class sizes.

The partial recruitments may be overestimated if the fish were spatially segregated by size and fishing effort was concentrated in areas where the fish were larger. Sampling and effort data from the Scotia Fundy Observer Program were used to investigate size segregation on the fishing grounds. Unculled length frequency samples were selected for analysis. Mean fish weights by sample were calculated and symbols corresponding to quartiles of the mean weight distribution were plotted by quarter (Figure 3). In both quarters the mean weights from the area west of 58°20' were larger than those to the east. The individual samples were weighted by the catch in the set and combined by quarters and area. In both quarters the combined length frequencies from the eastern area were slightly smaller than those from the western area (Figure 4). Thus there appears to have been size segregation across the bank. However, this is not likely to be sufficient to cause a significant change in partial recruitment.

The length composition of the catch changed in July (Figure 5). While the first and second quarter combined length frequencies were very similar, a very strong mode at 49 cm appeared in July. While ageing material was not available for this month it is likely that the smaller fish were predominatly age 4, the 1981 year-class. Thus the observed shortfall in catch at age 4 may be made up in the third quarter.

Research Survey Results

The stratified mean numbers per tow and population length frequency estimates from the July 1985 groundfish survey were available for the September 1985 Groundfish Subcommittee meeting. However, ageing material was not. The trend in total population numbers has been declining since 1982 (Figure 6). However, this estimate was over five times greater than that for 1981. This was largely due to very high estimates of ages 2 and 3 fish, the 1979 and 1980 year-classes.

Where the survey ageing material were not processed in time for the Subcommittee meeting, the second quarter commercial otter trawler age-length key was used to "age" the survey length frequency. Following the meeting, the otoliths from the survey were read and the age composition was recalculated. These results agreed well with those obtained using the commercial age-length key.

The 1982 to 1985 survey population-at-age estimates are given in Table 8. The 1985 age 5+ estimate was lower than that of 1984, but higher than the 1983 estimate. This supports the conclusion of Sinclair and Gavaris (1985) that the 1984 estimate was anomalous. Comparisons of the survey estimates of the 1979 and 1980 year-classes at ages 3, 4 and 5 indicate that the 1979 is 1.3 times the size of the 1980 (Table 9). The ages 3 and 4 estimates of the 1980 and 1981 year-classes indicate that the former is 2.6 times the size of the latter. The 1982 year-class estimate at age 3 in 1985 was smaller than the 1981 year-class in 1984. The most recent assessment of the management unit indicated that the 1979 year-class was 1.2 times the 1980, the 1980 year-class was 1.6 times the size of the 1981, and the 1982 year-class was assumed to be 1.7 times larger than the 1981. Thus, while the assessed relative sizes of the 1979 and 1980 year-classes are in approximate agreement with the survey results, these results indicate that the 1981 and 1982 year-class sizes may have been overestimated in the assessment.

Commercial Catch Rates

Data from the Observer Program and comments from the fishing industry indicated that the spring 1985 fishery was very successful. Catch rates from the statistical system for stern otter trawlers TC3 and side otter trawlers TC4 confirmed this. However, catch rates from stern otter trawlers TC4 and 5 did not. Two factors contributed to this. Firstly, National Sea Products, the primary owners of these vessels, imposed restrictive cod trip limits on the vessels in 1985. These ranged from 75,000 to 200,000 lbs and averaged 100,000 lbs in the first quarter, in the second quarter the range was 30,000 to 100,000 lbs averaging 75,000 lbs, while in July the range was again reduced. (In the first half of 1984, the cod trip limits were generally in excess of 200,000 lbs.) At the same time vessels were given no limits on haddock or flounders and 50,000 to 75,000 lbs limit on pollock. Usually the captains would fill their cod trip limit at the beginning of the trip then direct for other species. The second factor was that in 1985, unlike previous years, haddock and pollock were available in commercial quantities in the same statistical unit area as cod. Data from the Observer Program indicated that proportionally more effort was directed at haddock and pollock on a set-by-set basis in unit area 4Vsc in 1985 than in previous years (Table 10).

These two factors together would tend to deflate cod catch rates as computed by the statistical system. The catches and effort are first aggregated by trip fraction (unit area within trip), then the directed species is determined as the main species caught in the unit area. In 1985 the fishing captains could seek several species separately in the same unit area but in the statistical system all the effort would be allocated to one directed species, the main species caught. Since cod was very abundant it was often the main species in unit area 4Vsc. However effort actually directed towards other species would be misallocated to cod fishing, thus deflating the cod catch rate.

The effect of this was investigated using data from the Scotia Fundy Observer Program. Monthly catch rates for otter trawlers TC5 from 1980-1985 were calculated using trip-by-trip (as in the statistical system) and set-by-set criteria for determining the directed species. The ratio of set-by-set to trip-by-trip cod directed catch rates for unit area 4Vsc are plotted against time in Figure 7. In the fall of 1984 and the first half of 1985 (months 57 onward) the ratio increased indicating the effect described above. The average ratios for the periods January 1980 to August 1984 and September 1984 to June 1985 were calculated, and the ratio of the averages was used to compensate for this condition. Specifically the resulting factor of 1.4 was divided into the reported efforts for stern otter-trawlers TC4 and 5 in 1985 when calculating catch rate indices.

The standardized series of catch rate indices with and without the adjusted 1985 data were virtually identical to the series presented by Gavaris and Sinclair (1985) for the period 1965 to 1984. The 1985 catch rates were 1.29 and 1.49 times the 1984 value in the unadjusted and adjusted analyses respectively. The projected 1985 catch rate from the May 1985 assessment was 1.22 times the 1984 value. It was noted that in 1985, catch rates peaked in March and April and declined sharply thereafter. The normal seasonal pattern gives peak catch rates in January. Thus, the 1985 signal is contrary to the normal pattern. If the March-April catch rates were abnormally high, then additional data from the second half of 1985 would reduce the catch-rate index.

Summary

The evidence from the first half of 1985 fishery did not indicate that the sizes of the 1981 and 1980 year-classes were underestimated. The comparison of projected and observed catch at age indicated that the relative sizes of the 1977-1980 year-classes had been well predicted. If it is accepted that the previous estimates of the 1977-1979 year-classes are accurate, which depends almost entirely on the choice of F_t in 1984, then it may be concluded that the absolute size of the 1980 year-class was well predicted. The shortfall in the actual catch of the 1981 year-class may be due in part to selective fishing on a size segregated population. However, the length composition of the July catch indicated that the 1981 year-class may recruit to the fishery in the third quarter. The survey results confirmed the relative size estimates of the 1979-81 year-classes. However both the survey results and the commercial catch indicate that the 1982 year-class is below average.

References

Gagne, J., A. Sinclair, and C. Dale. 1984. The 1984 assessment of 4VsW
Cod: A completely revised procedure. CAFSAC Res. Doc. 84/78.

Gavaris, S. and A.F. Sinclair. 1985. Abundance indices of 4VsW cod.
CAFSAC Res. Doc. 85/39.

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4VsW cod following the 1984 fishery. CAFSAC Res. Doc. 85/48.

Table 1. Comparison of 4VsW cod 5+ numbers (x 10-3) estimated in the most recent sequential population analysis and those from the corresponding final years of previous assessments.

YEAR	CAFSAC Res. Doc.	Final Year Estimates	Most Recent SPA	% overestimated
1984	-	89917	89917	-
1983	84/78	73290	74054	-4
1982	83/56	96683	66196	41
1981	82/40	88837	51776	72
1980	81/19	103184	53875	92
1979	80/38	71016	53070	34
1978	79/30	56186	37440	50
1977	78/13	24861	20908	19

Table 2. Catch (t) by gear sector from the first quota report in July for 1982-1985

	Catch to end of June			
	1982	1983	1984	1985
Vessels > 100'	24,941	20,924	21,039	21,388
Mg 65-100'	485	584	841	1,034
Mg <65'	2,691	1,448	1,446	7,928
Fg 65-100'	463	131	243	22
Fg <65'	2,194	3,272	2,058	2,567
TOTAL	30,774	26,359	25,627	32,939

Fixed gear (Fg)
Mobile gear (Mg)

Table 3. Data used to generate 1985 age-length keys for 4VsW Cod.

Key	Gear	Period Covered	Length-Weight Coeff.		Number Measured	Number Aged	Catch (t)
			a	b			
1	Otter trawl	Jan-Mar	.0042	3.150	7420	536	11,755
2	Otter trawl	Apr-June	.0042	3.150	9590	350	15,946
3	Longline	Jan-June	.0042	3.150	3318	248	3,549
4	Seine	Jan-June	.0042	3.150	1581	86	1,557

Table 4. First and second half year catch at age (x 10^{-3}) and proportion at age for 4VsW cod, 1981-1985.

Catch at age (x 10^{-3})

AGE	1981* H1	H2	1982** H1	H2	1983 H1	H2	1984 H1	H2	1985 H1
2	37	242	–	114	–	–	–	–	–
3	842	2435	691	1390	1726	1201	89	286	65
4	3690	4617	3470	3238	4596	3418	2901	2758	1195
5	3693	3435	6469	2504	3993	3136	4362	4821	4989
6	2826	2035	2409	883	3947	1902	3716	2412	5638
7	1838	1244	1737	553	1036	871	2740	1409	3084
8	892	677	830	390	641	370	773	559	1802
9	363	829	407	230	345	228	349	218	817
10	95	54	148	151	79	148	120	168	299
11	43	23	96	57	51	89	44	102	209
12	17	17	29	26	21	28	18	42	170

Catch Composition

AGE	1981* H1	H2	1982** H1	H2	1983 H1	H2	1984 H1	H2	1985 H1
2	.003	.016	–	.013	–	–	–	–	–
3	.059	.156	.042	.159	.105	.105	.006	.022	.004
4	.257	.296	.213	.371	.280	.300	.192	.216	.065
5	.258	.220	.397	.287	.243	.275	.289	.377	.272
6	.197	.130	.148	.101	.240	.167	.246	.189	.307
7	.128	.080	.107	.063	.063	.076	.181	.110	.168
8	.062	.043	.051	.045	.039	.032	.051	.044	.098
9	.025	.053	.025	.026	.021	.020	.023	.017	.045
10	.007	.003	.009	.017	.005	.013	.008	.013	.016
11	.003	.001	.006	.007	.003	.008	.003	.008	.011
12	.001	.001	.002	.003	.001	.002	.001	.003	.009

* 1981 First half included July and August for Danish seine.
** 1982 did not include Danish seine.

Table 5. Comparison of partial recruitment estimates for the first half of the year and the total year for 4VsW cod.

	Partial Recruitment	
Year	First Half Year	Whole Year
3	.047	.095
4	.278	.373
5	.591	.699
6	.853	.854
7	1.000	1.000
8	1.000	1.000
9	1.000	1.000
10	.591	.816
11	.591	.816
12	.591	.816

Table 6. Data used to project the first half of 1985 catch at age for 4VsW cod.

Age	1984 [1] Population (X 10^{-3})	1984 [1] Catch (t)	Weight [2] at age (kg)	P.R. [3]
3	43000	421	.519	.047
4	53762	6210	.840	.278
5	44965	9371	1.163	.591
6	23269	6113	1.599	.853
7	13637	4102	2.029	1.000
8	4302	1294	2.564	1.000
9	1892	569	3.384	1.000
10	974	293	4.707	.591
11	495	149	5.406	.591
12	203	61	4.616	.591
13	116	35	9.724	.591
14	57	17	10.484	.591
15	7	2	12.300	.591

[1] From Sinclair and Gavaris 1985.

[2] 1985 first half of year weights at age

[3] Partial recruitment adjusted to first half of year.

Table 7. Comparison of actual and projected catch-at-age for 4VsW cod in the first half of 1985.

Age	Observed Catch (X 10^{-3})	Projected Catch (X 10^{-3})
3	65	918
4	1195	2574
5	4989	5771
6	5638	5929
7	3084	3253
8	1802	1795
9	817	570
10	299	163
11	209	84
12	170	43
13	30	17
14	14	10
15	7	5

Table 8. 4VsW cod survey population-at-age estimates (X 10^{-3}).

Age	1982	1983	1984	1985[1]
1	2633	39572	1165	3689
2	226028	37813	20894	4944
3	188892	120818	36823	22365
4	65976	48451	54858	27346
5	14824	24808	37171	26206
6	8020	11398	17253	14318
7	4325	2611	11861	7062
8	1850	1444	1170	2797
9	413	395	955	1313
10	419	222	284	379
11	226	64	674	258
12	0	29	17	185
1+	513606	287625	183125	110862
2+	510973	248053	181960	107173
3+	284945	210240	161066	102229
4+	96053	89422	124243	79864
5+	30077	40971	69385	52518
6+	15253	16163	32214	26312

[1] Preliminary

Table 9. Comparison of estimates of the 1979, 1980, and 1981 year-classes from survey data.

	Year-class size $(X\ 10^{-6})$				Year-class size $(X\ 10^{-6})$		
AGE	1979	1980	ln 79/80		1980	1981	ln 80/81
3	189	121	.4460		121	37	1.1849
4	48	55	-.1362		55	27	.7115
5	37	26	.3528				
Mean			.2209				.9482
Antilog Mean			1.3				2.6

Table 10. Observed effort (hours) by OTB-2 TC4+ vessels in unit area 4Vsc by directed species determined by set.

Directed Species	Effort					
	1980	1981	1982	1983	1984	1985
Cod	270	952	1117	705	1377	1531
Haddock	18	53	9	12	27	659
Pollock	27	167	45	101	76	434
Redfish	28	107	23	18	298	321
Plaice	12	102	57	51	121	105
Witch	3	11	17	5	15	27
Yellowtail	0	44	13	25	25	37
Other	56	291	162	109	226	362
Total	415	1727	1442	1025	2167	3478

4VSW COD EXPLOITATION RATE 1970-84
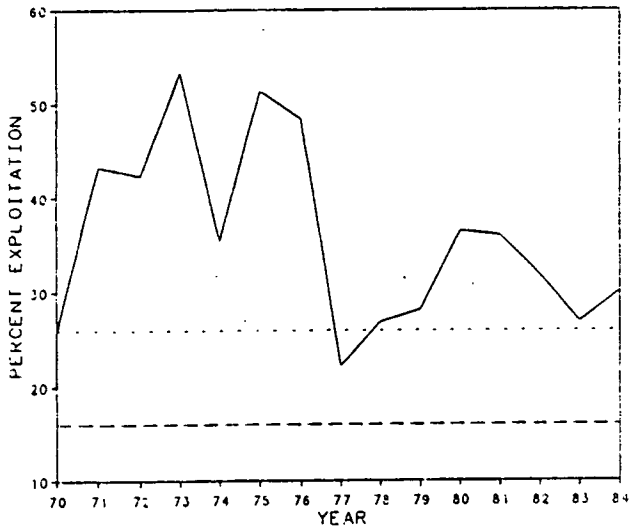
4VSW COD RECRUITMENT TRENDS
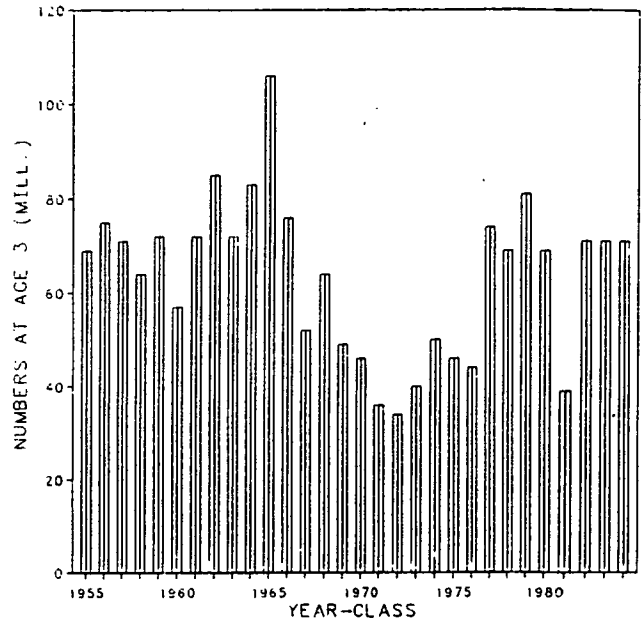
4VSW COD FISHABLE BIOMASS TREND
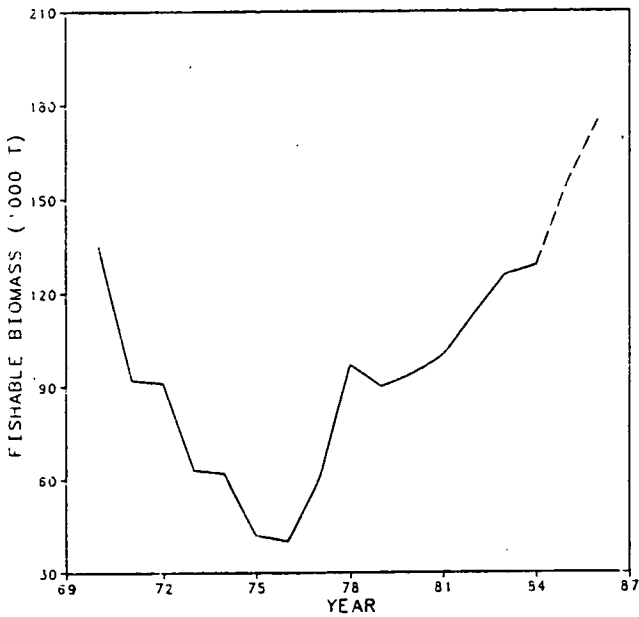
Figure 1: Trends in exploitation rate,
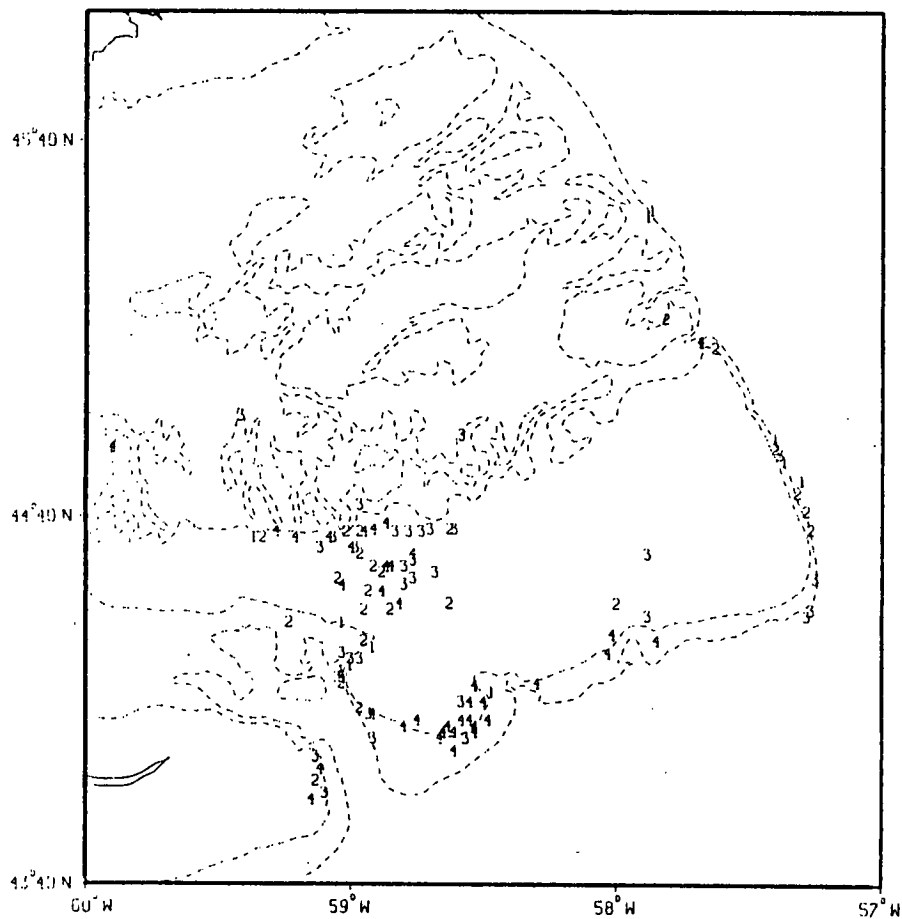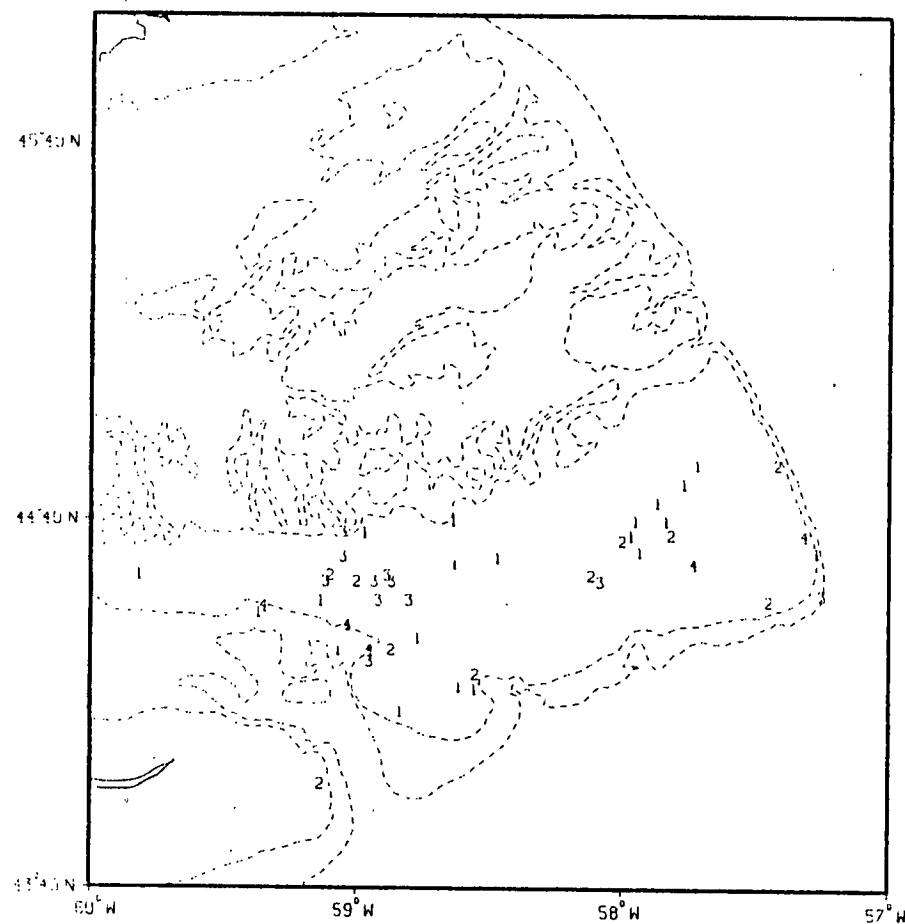recruitment, and fishable
biomass for 4VsW cod.
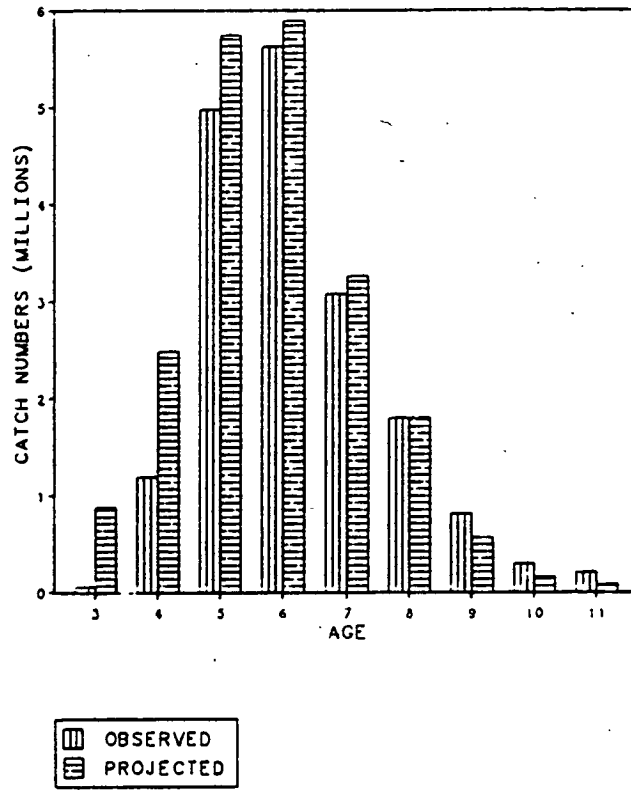
Figure 2: Comparison of observed and projected catch at age
for 4VsW cod in the first half of 1985.

JAN-MAR 1985

APR-JUN 1985

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1=.7-1.69KG   2=1.7-1.99KG   3=2.0-2.39KG   4=2.4KG+

Figure 3: Sampling locations and mean fish weights for cod length frequency samples in 4VsW collected by the Scotia Fundy Observer Program in the first two quarters of 1985.
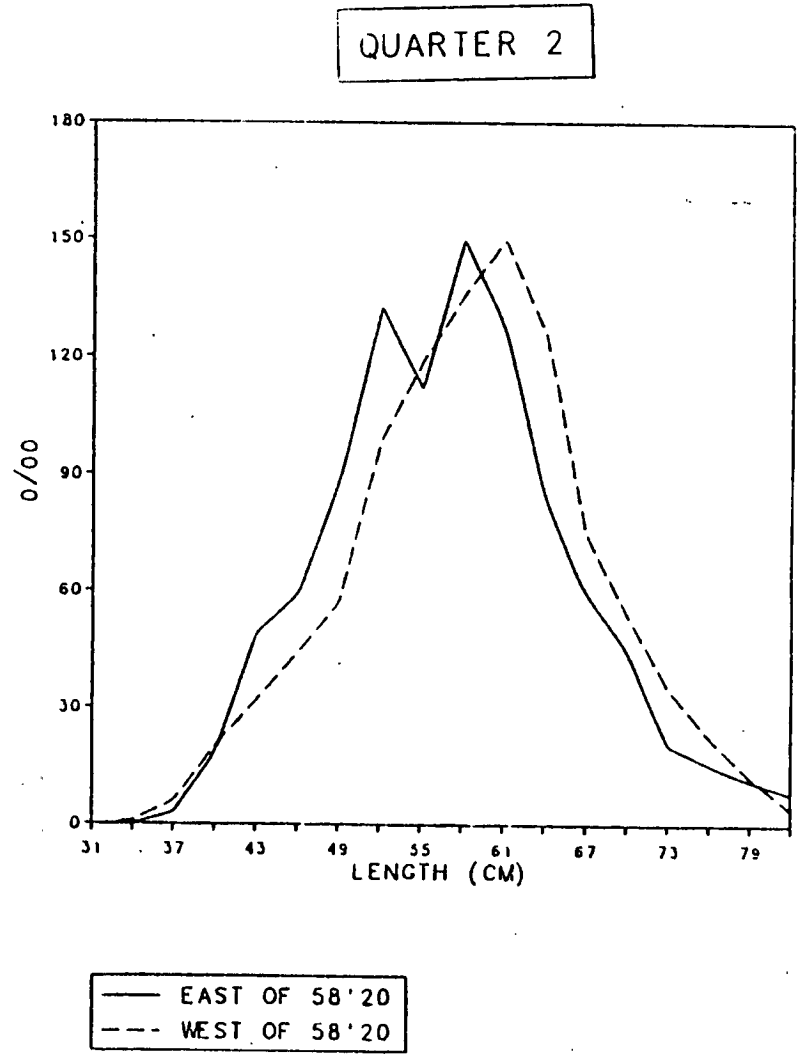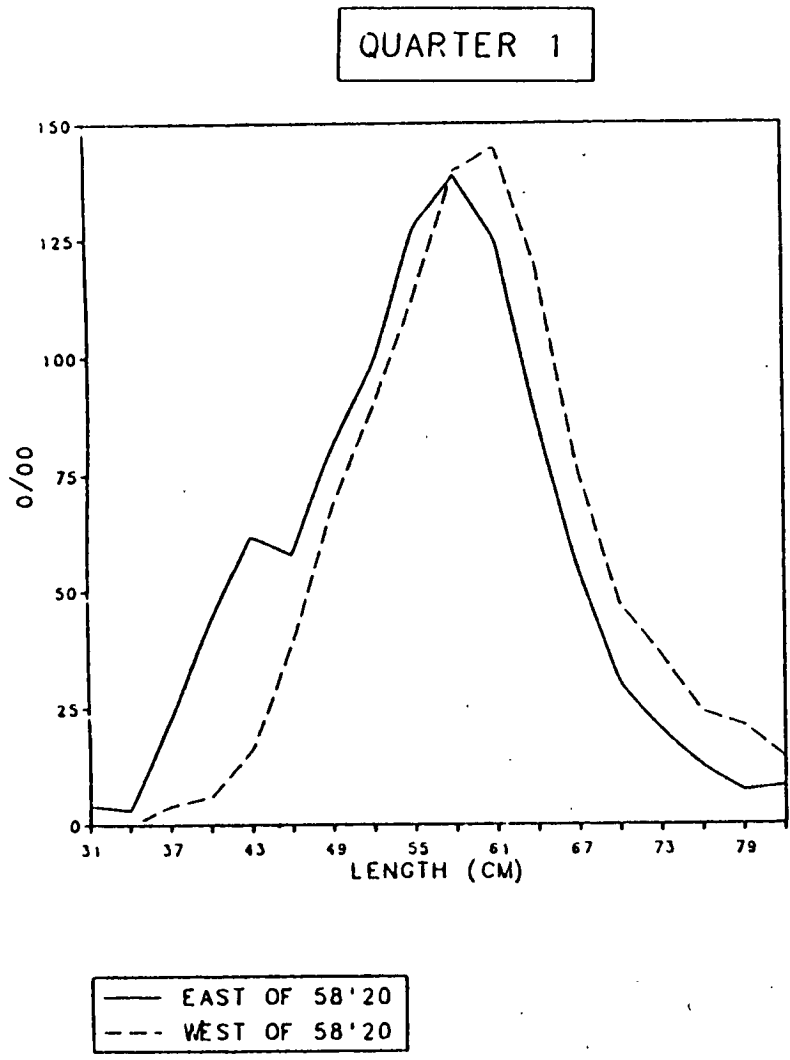
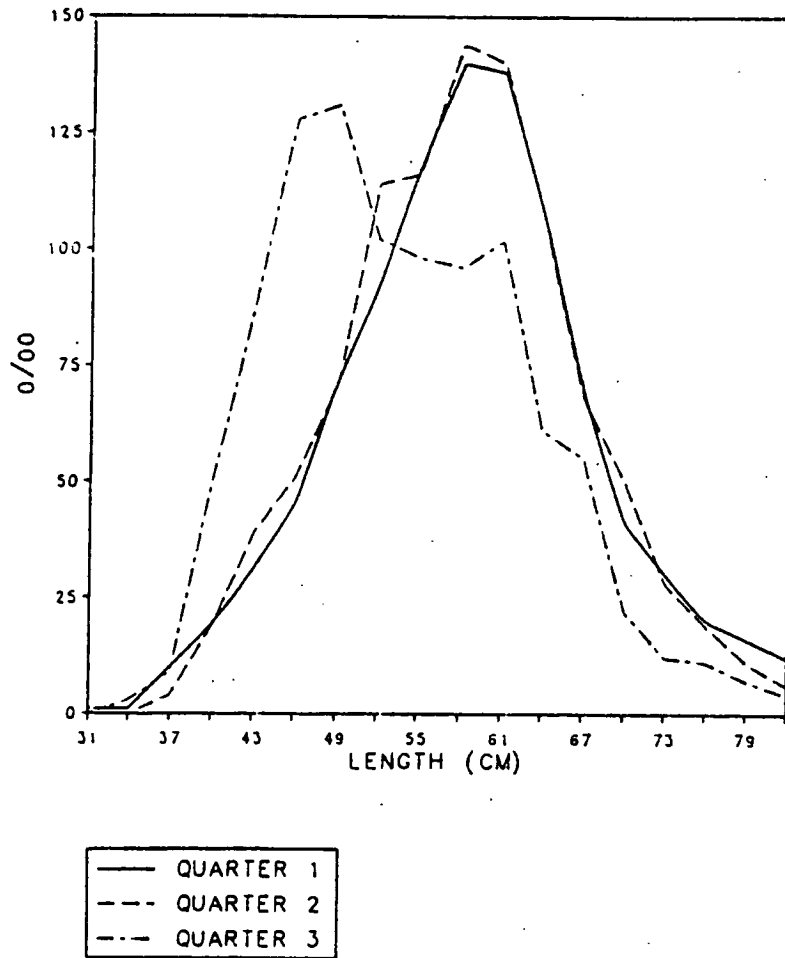Figure 4. 1985 Observer Program unculled length frequencies by quarter and area.

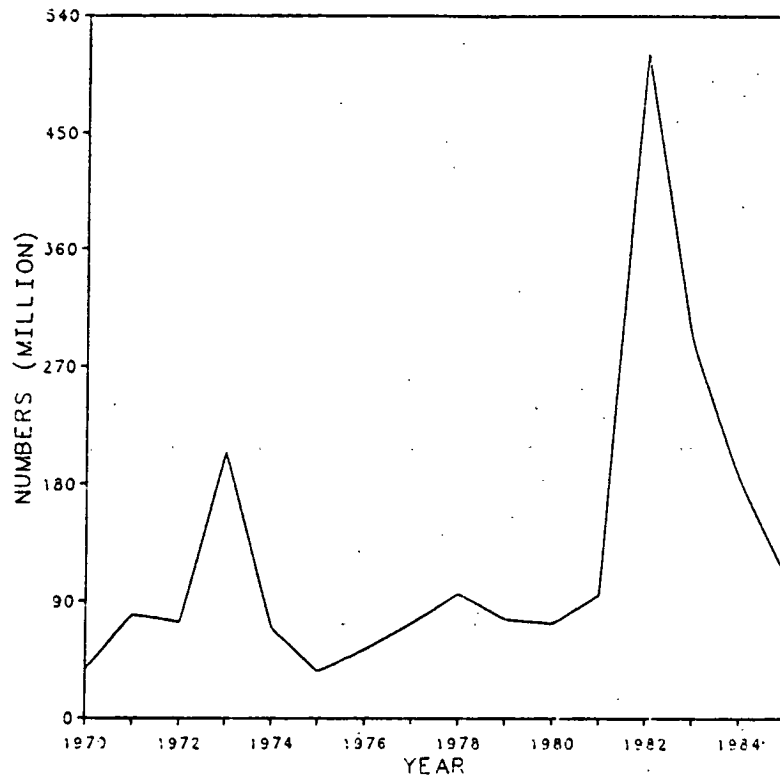Figure 5. 1985 Observer Program unculled length frequencies by quarter.

Firgure 6: Trend in 1+ population estimates of 4VsW cod from
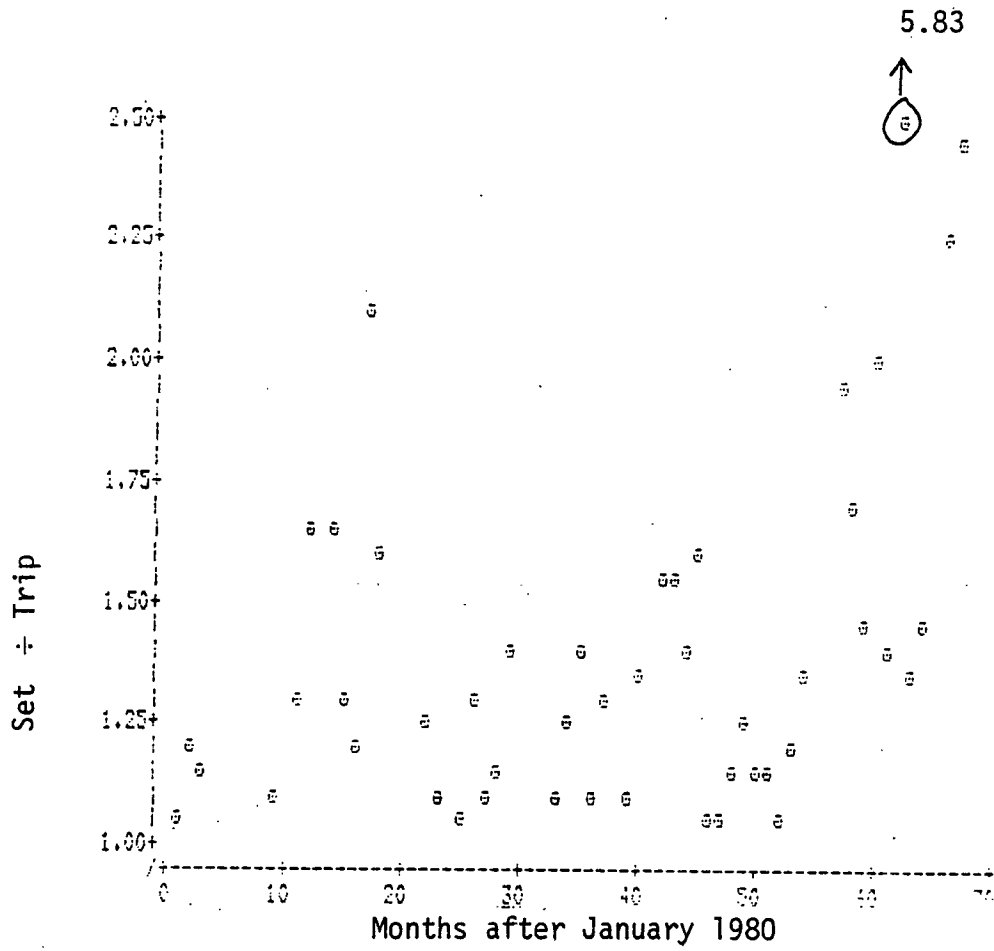research surveys.

Figure 7: Ratios of OTB-2 TC5 catch rates where cod was
the main species in the set and main species in
the trip. For Subdiv. 4Vs.