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Assessment of the 4T and 4Vn (Jan. - Apr.) Cod Stock for 1988

by

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ABSTRACT

Provisional nominal catch for 1987 is 50,596 t, a reduction of almost 13,000 t over 1986 but exceeding the TAC by 5,000 t. The proportion taken by Danish and Scottish seines decreased from 28% of the total catch in 1986 to 19% in 1987 while the proportion taken by otter trawlers increased slightly. Catches by fixed gears increased over the previous year for the first time since 1983. The fishery is becoming concentrated in the second quarter; 54% of the landings were taken in this period. The 1980 and 1981 year-classes are dominant in the catch at age representing respectively 38% and 21% of the numbers. Weights at age are the lowest observed since 1971. The standardized otter trawl catch rate is the highest in the series in 1987. Mean numbers per tow for ages 5+ estimated from the 1987 research survey are 60% and 46% lower than observed in 1985 and 1986 respectively. The large estimate of O-group observed in 1986 did not translate into high numbers of 1 year-olds in 1987. Calibrations of SPA using ordinary least squares techniques resulted in two different estimates of terminal fishing mortality. A framework using non-linear least squares techniques with no constraints on the partial recruitment in 1987 resulted in a fishing mortality of 0.24 for age 7. Results indicate that population numbers were highest in the period 1983-1985. Mean population biomass in the last 6 years is the largest observed since the mid-fifties. Assuming that the 1988 TAC of 49,000 t is caught, the 1989 catch at Fo.1 would be 54,946 t.

RESUME

Les prises nominales provisoires pour 1987 se chiffrent à 50,596 t. Ceci constitue une réduction de 13,000 t sur 1986 mais dépasse le TPA de 5,000 t. Le pourcentage des prises des sennes danoises et écossaises est passé de 28% du total des captures en 1986 à 19% en 1987. Le pourcentage des prises capturées par les chalutiers a augmenté légèrement. Les prises par les engins fixes ont augmentées pour la première fois depuis 1983. Les activités de pêche sont concentrées durant le deuxième trimestre; 54% des prises sont capturées durant cette période. Les classes d'âge de 1980 et 1981 sont dominantes représentant respectivement 38% et 21% des poissons capturés. Les poids moyens sont les plus bas depuis 1971. Le taux de capture standardisé des chalutiers en 1987 est le plus élevé durant la période 1966-1987. Les nombres moyens capturés par trait pour les poissons de cinq ans et plus en 1987 sont inférieurs de 60% et 46% à ceux observés en 1985 et 1986. Le nombre élevé de poissons de classe d'âge O observé en 1986 ne s'est pas traduit en un nombre élevé de poissons de 1 ans en 1987. Les calibrations de l'ASP à l'aide des moindres carrés ordinaires ont donné lieu à deux estimés différents de Ft. Une analyse structurée utilisant les moindres carrés non-linéaires sans aucune contrainte sur le recrutement partiel en 1987 a donné lieu à un F de 0.24 à l'age 7 pour 1987. L'abondance du stock en nombre était la plus élevées de 1983 à 1985. La biomasse moyenne du stock durant les 6 dernières années est la plus élevée depuis le milieu des années cinquante. Si le TPA de 49,000 t pour 1988 est capturé alors la prise au niveau Fo.1 pour 1989 sera de 54,946 t.

INTRODUCTION

Nominal catches of cod in 4T and 4Vn (Jan.- Apr.) have varied from less than 40,000 t prior to the introduction of the otter trawler in the early fifties to a high of 104,000 t in 1956 and a low of 22,000 t in 1977 (Table 1). Between 1977 and 1980, nominal catches increased then fluctuated around an average of 60,000 t. Following the advice to markedly reduce catches in 1987, the TAC was set at 45,200 t. The nominal catch for 1987 was approximately 5,000 t higher than the TAC but represented a 20% decrease over 1986.

The management of this resource has become increasingly complex since TAC were first implemented in 1974. The allocation scheme for 1987 is presented in Table 2.

Since 1977, the fishery in 4T is conducted entirely by Canadian fishermen, mostly between April and December. In order of importance, the fishing gears used are otter trawls, Danish and Scottish seines, gillnets, longlines and handlines. The winter fishery in 4Vn is prosecuted almost entirely by Canadian and French otter trawlers. In 1987, the allocation and subsequent catch to France was reduced, from approximately 40% to 50% of the 4Vn (Jan.- Apr.) allocation in previous years, to about 15%.

As other stocks on the Canadian Atlantic coast, the 4TVn (Jan.- Apr.) cod stock was subjected to high exploitation rates in the early to mid-seventies. This coupled with poor recruitment led to stock decline to 1977. With the reduction in fishing effort and good recruitment in the late seventies, the stock rebounded rapidly and exceeded the high levels of abundance in the 1950's.

A) Nominal Catches and Description of the Fishery

Nominal catch for 1987 was calculated using the provisional data supplied by the Statistics Branches of the Scotia-Fundy, Newfoundland, Québec and Gulf regions of the Department of Fisheries and Oceans. Landings data for the French fleet in 4Vn were obtained from quota monitoring personnel of the Department. The provisional estimate for 1987 is 50,596 t, a reduction of almost 13,000 t over 1986. Breakdowns of nominal catches by month, gear and country are presented in Tables 3 and 4. For 1987, the allocation for France was reduced from 7,000 t in previous years to 1,200 t. As this allocation is usually taken in 4Vn in the winter, the proportion taken in the winter fishery decreased from approximately one quarter of the total landings on this stock to about 18%. Landings in the winter fishery are attributed almost exclusively to trawlers.

In the fishery conducted in 4T, the proportion taken by Quebec increased from 30% of the total catch in 1986 to 35% in 1987, a level comparable to

1985. The proportion taken by Maritimes decreased slightly. Breakdown of catches by gear (Table 5, Figure 1) indicate that the proportion taken by Danish and Scottish seiners decreased from approximately 28% of the total catch in 1986 to 19% in 1987. The proportion taken by trawlers increased marginally. Landings by fixed gears (gillnets, handlines and longlines) increased to 11549 t in 1987, therefore halting the decrease in catches by this fleet observed in the period 1983-1986.

The fishery is becoming concentrated in the second quarter. The proportion of the catch taken in this period has increased from approximately 30% in 1983-1985 to 44% in 1986 and 54% in 1987. While in 1986 this was due to an increase in the seiner catch, in 1987 it was caused by an increase in catches by the trawler component.

Allocations for the mobile fleet were reached quickly in 1987 (Table 2). In addition to the closures imposed when allocations were reached, the fishery for mobile gears was closed for periods of up to one week in three instances in the spring because large quantities of fish less than 43 cm were being caught. In the fall fishery (Mobile gears < 100', Nov. 10 - Dec. 31), the allocation of 1,480 t was exceeded in only two days. The evolution of cumulative catch in the fishery in recent years is illustrated in Figure 2. Several plateaus coinciding with periods of closure are apparent for 1987 as in 1986.

Final statistics from NAFO for 1985 are 909 t lower than previously reported and are presented for reference purposes in Appendices I and II. The changes occured mostly in the division of catches for the trawls and seines for Maritimes. The monthly pattern remained approximately the same.

INPUT DATA

A) Commercial Fishery Data

i) Catch and Weight at Age

In 1987, sampling of the commercial fishery generally exceeded NAFO standards. Most gear and quarter components were sampled with a total of nearly 55,000 fish measured and 6,235 aged (Table 6). The results of age determination comparisons (Table 7) indicated that the level of agreement in age assignment between readers, and between readers and a reference collection exceeded 70%. There was no evidence of bias with respect to the differences between readers.

Quarterly age-length keys containing a minimum of 400 otoliths were constructed. The length frequencies by gear and quarter adjusted to the corresponding landings were used with the apppropriate age-length key to obtain the catch at age by gear and quarter. The combinations used in the calculations of catch at age are presented in Table 8. Unsampled landings were estimated by multiplying the catch at age for sampled gears by the

ratio of unsampled to sampled landings.

The catch of the 1980 year-class in the second quarter by mobile gears (otter trawls and seines) accounted for more than half of the numbers of this year-class caught in 1987 (Table 9). The fishery in 1987 was unusual in the large proportion of the catch taken in the second quarter. As anticipated from their selection patterns, fixed gears caught a larger proportion of fish 10 years and older compared to the mobile gears.

A comparison of the observed catch at age and the one predicted in the previous assessment (Chouinard and Sinclair, 1987) indicates that the 1980 year-class was much more abundant in the landings than had been predicted (Figure 3).

Length at age by gear and quarter are presented in Table 10. As expected, the mobile gears tend to catch smaller fish at age than the fixed gears.

Weights at age (kg) were calculated using a length-weight relationship derived from the 1987 research survey data (Table 11). The parameters of the power curve were a = 0.000004123 and b = 3.1920 with a correlation coefficient of 0.99.

Catch at age for the years 1971-1987 is presented in Table 12 with the corresponding weights at age in Table 13. The 1980 year-class which had appeared in high numbers in 1985 and 1986 accounts for 38% of the numbers caught in 1987. The catch of the 1981 year-class represented 21% of the numbers.

Weights at age for 1987 are generally 15 to 30% lower than in 1986 for age-classes 4 to 9. Approximately 10% of this decrease is due to change in the length-weight relationship used in the calculations. Weights at age for the 1979 and 1980 cohorts are lower than in 1986.

ii) Commercial Catch Rates

Catch rate index (t/hr) was calculated for otter trawls only, given that handling time may be included in the fishing time recorded for seiners. The years 1966-1987 were used. Data from Quebec for 1984, which had been previously excluded due to problems with the data, have been corrected and were included in the analysis. The 1985 data were revised according to the NAFO statistics. Provisional data for 1987 were obtained from DFO Statistics Branches. Observations with less than 10 units of catch or effort were removed. A multiplicative model was used to calculate a standardized catch rate index (Gavaris, 1980).

Observations were aggregated to categories of gear/tonnage class/region, Division, month and year. Gears with less than 10 observations for the time series were eliminated from the analysis. Data for Canada (Maritimes-Quebec),

Canada (Maritimes) and Canada (Quebec) were grouped for each Division, month and year because the same vessels are involved. Examination of the residuals distribution from an initial analysis indicated that weighting was not necessary (Figure 4).

The analysis of variance and regression coefficients from the final run are given in Table 14. The model explained 71% of the variation and each category was significant.

The overall trend is for decreasing catch rates from 1968-74 followed by increases to 1983 and a decrease in 1984. Catch rates have been increasing since 1984. The 1987 catch rate is the highest in the series (Table 15, Figure 5).

B) Research Survey Data

Mean numbers per tow at age 5+ estimated from the 1987 survey are respectively 46% and 60% lower than observed in 1985 and 1986 (Table 16). The 1985 and 1986 estimates were high due to a few unusually large sets. This is reflected in the high coefficients of variation for these surveys (25% to 50%) compared to those obtained in 1984 and 1987 (10 to 20%)(Table 17a). The standard errors are presented in Table 17b.

The 1987 survey indicates that the 1980 year-class is dominant in the population; the 1979 year-class also appears in large numbers. The 1982 and 1984 year-classes appear to be above average. The estimate of 0-group in 1986 which was the highest observed in the time series did not translate into high numbers of 1 year-olds in 1987.

Strata 22 and 23 (Figure 6) accounted for 22% and 13% respectively of the 1987 estimate; these two strata combined have historically accounted for 20% to 50% of the estimates.

ESTIMATION OF STOCK PARAMETERS

A) Partial Recruitment (PR)

Analysis of fishing mortalities (F) for the 1983-1986 period for ages 3 to 15 using analysis of variance (APL function MULTPR) indicated full recruitment at age 9. The resulting vector was standardized to the mean of ages 9 to 13 and resulted in the following partial recruitment vector:

Age	3	4	5	6	7	8	9	10	...
PR	0.001	0.024	0.163	0.497	0.718	0.835	1.000	1.000	...

B) Sequential Population Analysis

Calibration was first conducted using otter trawl catch rates and otter trawl fishable biomass. The otter trawl fishable biomass was calculated as otter trawl PR multiplied by mean biomass. Otter trawl PR was determined from tables of partial fishing mortalities, assuming that the otter trawl catch was evenly distributed throughout the year. Examination of the partial fishing mortality tables had indicated full recruitment at ages 6-7 from 1971 to 1979 and following that at ages 8 to 10 (Chouinard and Sinclair, 1987). To estimate yearly PR, catch weighted mean fishing mortality for the fully recruited ages was calculated and divided into age by age values in the respective years. Values greater than 1 were set to 1 and for the ages assumed to be fully recruited, a PR of 1 was assigned.

Cohort analyses were performed over a range of F from 0.1 to 0.5. The highest correlation coefficient and minimum intercept were attained at Ft=0.20 however the 1987 residual was high (Table 18, Figure 7). The 1987 residual was minimized at a terminal fishing mortality (Ft) of 0.40 however at this level the intercept was significantly different from 0 and the residuals for the period 1983-1987 were all negative. The sum of the last 5 standardized (MSE) residuals declined with increasing F. Given these divergent indications, the simpler model with a zero intercept was chosen and this calibration indicated an Ft of 0.20.

In recent assessments, it was suggested that there was a change in catchability to the research vessel series around 1979. For this reason, calibrations using this index were conducted using only the post-1978 survey estimates. Calibration of 5+ research vessel numbers per tow and 5+ SPA estimates for this period indicated an Ft of 0.55 (Table 19, Figure 8). It was apparent however that the 1985 and 1986 points were very influential. In addition, as fishing mortality was increased, the relationship became unstable; the slope of the line was large with large residuals of opposite signs in the last 2 years.

It was noted that high standard errors were generally associated with high research vessel estimates. This heterogeneity of variance would require either that the dependent variable be transformed or that a weighted regression be used in calibrations.

Calibration of SPA described above was conducted using ordinary least squares techniques and two indices of abundance (OTB CPUE and RV numbers). As in some of the previous assessments, this led to different estimates of terminal fishing mortality and subjective decisions would be needed to arrive at a conclusion. In addition, information regarding the variability of the indices were not included in the process. To improve the calibration process, a framework using non-linear least squares techniques was used (APL software ADAPT developed by S. Gavaris, Biological Station, St. Andrews, N.B.).

C) Non-linear Least Squares Technique - Adaptive Framework

Preliminary examination of the abundance indices (CPUE and RV) and catch

at age coefficients of variation indicated generally higher values for the abundance indices than for the catch at age. Therefore, the 'no catch error' option was used for ADAPT which then estimates parameters by minimizing the residuals with respect to the abundance indices. Residuals were minimized using the inverse of the standard errors of the indices as weights.

Initially, the formulation used the same calibrations described in the previous section and used in the previous assessment (Chouinard and Sinclair, 1987). The parameters estimated were 1) the size of age-classes 4 and 5 in 1988, 2) the slopes of the lines relating RV mean numbers per tow at age 3, 4 and 5+ with SPA mean numbers for the corresponding age-classes and 3) the catchability coefficient (i.e. the slope of the line relating CPUE and fishable biomass). Details of the analysis are presented in Table 20.

Results of the analysis indicated that autocorrelation of the parameters was low. The coefficients of variation of the estimates were in the range of 10 to 30%. However, examination of the residuals revealed that more residuals were positive (Table 21) indicating that the assumed PR (described above) for 1987 may not have been appropriate.

Examination of relationships between RV estimates for successive ages of a cohort indicated that this index was consistent for ages 3 to 11. With the second formulation, the parameters estimated were the individual size of the age-classes 3 to 11 in 1988, the slopes of the lines of age by age relationships between RV index at age and SPA mean population numbers for ages 3 to 9 and 10+, and the catchability coefficient (Table 22). No constraints were placed on the partial recruitment pattern in 1987.

Results of this analysis were comparable to the first , except that the pattern of residuals was more balanced (Table 23, Figure 9). Since the assumption of average PR in 1987 was not used, this analysis was considered to be more objective and favored as the current view of the resource.

The coefficient of variation on the estimate for the 1984 year-class was 45% while those on older ages ranged from 18% to 32%. The 1984 year-class was estimated to be 191 million fish at age 3, the second largest observed. Due to the relatively high coefficient of variation on the estimate, the size of this year-class was set to the geometric mean of the 1968-1982 year-classes of 107 million.

ASSESSMENT RESULTS

A) Recruitment

The geometric mean recruitment (age 3 numbers) from the 1968-1982 year-classes is 107 million fish. The 1979-1982 year-classes are all estimated to be well above the mean (Figure 10) and the 1979 and 1980 year-classes are the largest since 1950. The large size of the early 1980 year-classes is considered responsible for the increased landings of small cod in the southern Gulf of St. Lawrence.

B) Fishing Mortality and Stock Size

The highest F in 1987 was 0.24 at age 7. The partial recruitment implied would be dome-shaped with full recruitment at age 7 compared to the historical flat-topped pattern calculated above, which is similar to the one used in the previous assessment (Chouinard and Sinclair, 1987). This shift in the PR pattern may be the effect of the very large 1980 year-class being targetted by the fishery. Population numbers, mean population biomass and fishing mortality are presented in Tables 24, 25 and 26 respectively.

The 3+ biomass of the stock was the highest in the mid-1950's (Figure 11). It declined to the mid-1960's then increased slightly in the early 1970's. The biomass then declined to attain its lowest level in the period in 1975. This corresponds to a period of relatively poor recruitment and high fishing mortality (Figure 12). With the reduction of fishing mortality in 1977-78, and the recruitment of the large 1974 and 1975 year-classes, biomass increased rapidly to 1979. After a period of relative stability in 1979-1981, the stock biomass attained a higher level in 1982 and remained stable in the period 1984-1986. The combination of lower average weights at age in 1987 and recruitment closer to the average in recent years has caused a reduction in the estimated biomass in 1987. Population numbers in 1987 are near their highest level in the period 1950-1987 (Figure 13).

PROGNOSIS

Catch projections to 1989 used the 1988 begining of the year population numbers from the non-linear least squares analysis, average weights at age from 1985-87, and a PR derived from fishing mortalities in the period 1983-1986 assuming full recruitment at age 8. Input data are given below.

Age	1988 Population	Weight at Age (kg)	PR
3	107000	.378	.002
4	87544	.553	.032
5	72875	.760	.179
6	80463	.954	.533
7	55924	1.232	.705
8	59254	1.555	1.000
9	30626	1.848	1.000
10	13666	2.049	1.000
11	6923	2.396	1.000
12	3010	2.715	1.000
13	1718	5.043	1.000
14	617	4.759	1.000
15	592	12.967	1.000

Age 3 recruitment in 1987-88 was set at the geometric mean of the 1968-82 year classes of 107 million.

The results (Table 27) indicate that if the 1988 TAC of 49,000 t is caught this will result in a terminal fishing mortality of .181, and a Fo.1=.2 catch in 1989 of 54,946 t. Fishing at Fo.1 in 1988 would give a catch of 53,729 t.

Average weights at age can have a substantial impact on catch projections for this cod stock (Rivard and Foy, 1987). The current practice is to use an average of the recent years' weights at age for projections, as factors controlling growth are not well known. Since the late 1970's, average weights at age for this stock have declined to attain their lowest level in 1987. To illustrate the impact of weights at age on catch biomass estimates, a projection assuming that weights at age in 1988-1989 would be similar to the 1987 weights was performed. This resulted in an Fo.1 catch of 48,773 t assuming that the 1988 TAC is caught.

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Table 1: Nominal 4T-Vn (Jan-Apr) cod catch and total allowable catch (TAC) for 1950 to 1987. Sources: a. 1950-1964 from Lett,1978; b. 1965-1985 from NAFO statistics; c. 1986 and 1987 provisional from Department of Fisheries and Oceans, Statistics Branches.

YEAR	NOMINAL CATCH (t)	TAC (t)	YEAR	NOMINAL CATCH (t)	TAC (t)
1950	44023[a]	-	69	47819	-
51	34827	-	1970	64465	-
52	41956	-	71	56375	-
53	58911	-	72	65291	-
54	63901	-	73	50635	-
1955	65227	-	74	48747	63000
56	104469	-	1975	42471	50000
57	89131	-	76	33415	30000
58	86582	-	77	22219	15000
59	70720	-	78	37892	38000
1960	66013	-	79	55996	46000
61	65583	-	1980	54634	54000
62	66664	-	81	65177	53000
63	70202	-	82	58193	60000
64	60547	-	83	61295	62000
1965	63027[b]	-	84	55364	67000
66	54851	-	1985	62138	67000
67	41316	-	86	63441[c]	60000
1968	46551	-	87	50596	45200

Table 2 : Resource allocation scheme for cod in Division 4T and Subdivision 4Vn (Jan. - Apr.) for 1987.

	Area	Gear/Period	Final Allocation (t)	Catch[1] (t)	Closure Date
1987	4T	M.G. < 100′ (Jan 1–Apr 14)	1200	1584	Jan 24
		Enterprise Allocation W. Nfld	800	1722	Apr 16
		M.G. < 100′ (Apr 15–Jun 11)	13750	17236	May 22[2]
		M.G. < 100′ (Jun 12–Jun 27)	3000	3325	Jun 23
		M.G. < 100′ (Jun 28–Jul 4)	600	938	Jun 30
		M.G. < 100′ (Jul 5–Aug 5) (by - catch)	670	559	
		M.G. < 100′ (Aug 6–Nov 9)	5150	5433	Aug 21
		M.G. < 100′ (Nov 10–Dec 31)	1480	1733	Nov 11
		F.G. < 65′ (Apr 1–Jun 10)	3200	1843	
		F.G. < 65′ (Jun 11–Nov 4)	7300	8210	
		F.G. < 65′ (Nov 5–Dec 31)	300	459	Dec 13
	4Vn	All > 100′	5100	5275	
		F.G. 65′ - 100′	80	—	
		M.G. 65′ - 100′	85	103	Jan 24
		F.G. < 65′	245	133	Apr 17
		M.G. < 65′ (Jan 1–Apr 15)	940	812	
		M.G. < 65′ (Apr 16–Apr 30)	100	225	
		France Allocation	1200	1203	

Notes:

1 Preliminary from Canadian Atlantic Quota Report

2 This fishery was also closed on three occasions because of occurence of small cod.

M.G. - Mobile Gear
F.G. - Fixed Gear

Table 3 : Provisional 4T cod catches (t round weight) during 1987 by gear type and month in Maritime Provinces, Newfoundland and Quebec.

MARITIMES

GEAR	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL	% OF 4TVn (Jan-Apr) CATCH
						MONTH								
Otter trawl (side)	120	9		684	1223	77	16	370	32	74	325		2930	5.79
Otter trawl (stern)	1638			839	2616	435	146	800	59	66	255	13	6867	13.57
Bottom pair trawl					50								50	0.10
Shrimp trawl										12			12	0.02
Danish seine	9		5	720	3779	1134	139	735	61	63	419	7	7071	13.98
Scottish seine				219	1040	241	15	58	1	1	49		1624	3.21
Pair seine				22	55	47	29	20	2	5			180	0.36
Gillnets (set)					215	320	648	504	348	200	8		2243	4.43
Set lines					139	234	181	137	90	401	569	128	1879	3.71
Handlines					20	108	86	26	17	11			268	0.53
Baited handlines					9	92	60	69	18	39	3	1	291	0.58
Uncov. pound nets						5	2						7	0.01
TOTAL	1767	9	5	2484	9146	2693	1322	2719	628	872	1628	149	23422	46.29

NEWFOUNDLAND

Otter trawl (stern)	38	17		1651	49	2	6	132	9	1	66		1971	3.90
TOTAL	38	17	0	1651	49	2	6	132	9	1	66		1971	3.90

QUEBEC

Otter trawl (side)				254	1970	856	150	1184	6	55	117		4592	9.08
Otter trawl (stern)				429	2446	863	257	1156	15	15	317		5498	10.87
Bottom pair trawl				9	33	19	19	31	27	9	19		166	0.33
Shrimp trawl				2	53	1	5	52		1	20		134	0.26
Danish seine				14	76	128	90	76	18	20	28		450	0.89
Set gillnet				17	986	411	401	336	247	118			2516	4.97
Set lines				4	413	559	529	510	318	438	17		2788	5.51
Handlines					2	5	3	3	2	3			18	0.04
Baited handlines					88	291	357	335	205	143	3		1422	2.81
Uncov. pound nets					1								1	0.00
Covered pots					6	25	7						38	0.08
TOTAL	0	0	0	729	6074	3158	1818	3683	838	802	521	0	17623	34.83
TOTAL 4T	1805	26	5	4864	15269	5853	3146	6534	1475	1675	2215	149	43016	85.02

Table 4 : Provisional 4Vn (Jan.-Apr.) cod catches (t round weight) during 1987 by gear type and month in Maritime Provinces, Newfoundland and France.

GEAR TYPE	MONTH J	F	M	A	TOTAL	% OF 4TVn (Jan-Apr) CATCH
Maritimes						
Otter trawl (side)	782	783			1565	3.09
Otter trawl (stern)	794	751	319	217	2081	4.11
Midwater trawl (st)	9	12	1	6	28	0.06
Bottom pair trawl			10	32	42	0.08
Danish seine	13			16	29	0.06
Scottish seine			5	24	29	0.06
Set gillnet				1	1	0.00
Set lines	5	2		116	123	0.24
TOTAL	1603	1548	335	412	3898	7.70
NEWFOUNDLAND						
Otter trawl (side)				79	79	0.16
Otter trawl (stern)	1528	749	69	54	2400	4.74
TOTAL	1528	749	69	133	2479	4.90
FRANCE						
Otter trawl (stern)		851	352		1203	2.38
Total	0	851	352	0	1203	2.38
TOTAL 4VN	3131	3148	756	545	7580	14.98

Table 5 : Cod catch (t) by gear in 4T-Vn (Jan-Apr) 1965-1987.

	GEAR						
YEAR	Otter trawl	Seine	Gillnet	Longline	Handline	Misc.	TOTAL
1965	48371	2673	3571	3189	-	5223	63027
1966	36684	2391	9414	1302	-	5060	54851
1967	23971	2225	9942	1579	2371	1228	41316
1968	28205	994	12933	395	2883	1141	46551
1969	27048	1228	9578	3710	5020	1235	47819
1970	43059	1793	9786	5490	3191	1146	64465
1971	35463	2255	9676	3008	3985	1988	56375
1972	46462	2115	7854	995	2100	5765	65291
1973	35798	2106	8129	420	2127	2055	50635
1974	34565	1741	6070	906	1266	4199	48747
1975	28408	1972	6327	139	3527	2098	42471
1976	25170	1354	4449	55	1169	1218	33415
1977	10964	3058	5931	207	1114	945	22219
1978	22539	4474	8929	155	1342	453	37892
1979	31576	8767	12022	615	1781	1235	55996
1980	32473	9977	4260	1443	723	5758	54634
1981	33963	12327	4053	5839	1055	7940	65177
1982	30627	11273	4175	3781	872	7465	58193
1983	31979	13763	3010	3070	1270	8203	61295
1984	31593	10616	6891	3738	1862	664	55364
1985	39524	11822	5287	3208	2062	235	62138
1986	35570	17594	4360	4024	1862	31	63441
1987	29618	9383	4760	4790	1999	46	50596

Table 6: Number of fish sampled from the 1987 fishery for cod in 4TVn (Number measured/Number aged).

Gear	MONTH J	F	M	A	M	J	J	A	S	O	N	D	Total
Otter Trawl	2837	1231	0	2061	9074	527	0	5153	0	786	2368	0	24037
	258	153	0	194	784	44	0	382	0	86	203	0	2104
Seines	0	0	0	913	3547	3217	2041	2582	1000	2198	2777	0	18275
	0	0	0	95	405	498	258	267	121	258	275	0	2177
Gillnets	0	0	0	0	618	581	1012	766	251	622	0	0	3850
	0	0	0	0	103	125	190	146	37	112	0	0	713
Longlines	0	0	0	0	455	1263	293	535	294	2516	731	0	6087
	0	0	0	0	96	192	54	119	27	291	115	0	894
Handlines	0	0	0	0	0	203	1905	311	0	0	0	0	2419
	0	0	0	0	0	23	267	57	0	0	0	0	347
Total	2837	1231	0	2974	13694	5791	5251	9347	1545	6122	5876	0	54668
	258	153	0	289	1388	882	769	971	185	747	593	0	6235

Table 7 : Summary of age determination comparisons conducted during the age reading of the 1987 otoliths.

(+ or - indicates bias)

Date (1988)	Comparison (%) Reader 1 vs Reference	Reader 2 vs Reference	Reader 1 vs Reader 2
Jan 5		75	
Jan 13	79		
Jan 15-22	82	74	70
Jan 28-Feb 1	85	83	89
Feb 8-10	74	73	72- (n=87, t=7.709)
Feb 15-16	88	90	91
Feb 18-19	86	85	84

Table 8 : Age-length keys used in the calculation of the 1987 catch at age for 4T-Vn (Jan.-Apr.) cod.

AGE-KEY NUMBER	FISHERY	SAMPLES	SAMPLE SIZE		CATCH (t)
1	OTB JAN.-MAR.	L.F.: JAN.-MAR. OTB A.L.K.: JAN.-MAR. OTB	LENGTHS AGES	4068 411	8832
2	OTB APR.-JUNE	L.F.: APR.-JUNE OTB A.L.K.:APR.-JUNE OTB	LENGTHS AGES	11324 998	14949
3	OTB JULY-SEPT.	L.F.: JULY-SEPT. OTB A.L.K.: JULY-SEPT. OTB JULY-SEPT. SNU	LENGTHS AGES	5153 404	4472
4	OTB OCT.-DEC.	L.F.: OCT.-DEC. OTB A.L.K.: OCT.-DEC. OTB OCT.-DEC. SNU	LENGTHS AGES	3154 289	1365
5	SNU APR.-JUNE	L.F.: APR.-JUNE SNU A.L.K.: APR.-JUNE SNU	LENGTHS AGES	7727 998	7515
6	SNU JULY-SEPT.	L.F.: JULY-SEPT. SNU A.L.K.: JULY-SEPT. SNU	LENGTHS AGES	5623 646	1244
7	SNU OCT.-DEC.	L.F.: OCT.-DEC. SNU A.L.K.: OCT.-DEC. SNU	LENGTHS AGES	4719 502	592
8	GN APR.-JUNE	L.F.: APR.-JUNE A.L.K.: APR.-JUNE GN APR.-JUNE LL APR.-JUNE LHP	LENGTHS AGES	1199 590	1950
9	GN JULY-SEPT.	L.F.: JULY-SEPT. GN A.L.K.: JULY-SEPT. GN JULY-SEPT. LL JULY-SEPT. LHP	LENGTHS AGES	2029 846	2484
10	GN OCT.-DEC.	L.F.: OCT.-DEC. GN A.L.K.: OCT.-DEC. GN OCT.-DEC. LL OCT.-DEC. LHP	LENGTHS AGES	622 518	326
11	LL APR.-JUNE	L.F.: APR.-JUNE LL A.L.K.: APR.-JUNE GN APR.-JUNE LL APR.-JUNE LHP	LENGTHS AGES	1718 590	1465
12	LL JULY-SEPT.	L.F.: JULY-SEPT. LL A.L.K.: JULY-SEPT. GN JULY-SEPT. LL JULY-SEPT. LHP	LENGTHS AGES	1122 846	1765
13	LL OCT.-DEC.	L.F.: OCT.-DEC. LL A.L.K.: OCT.-DEC. GN OCT.-DEC. LL OCT.-DEC. LHP	LENGTHS AGES	3247 518	1553
14	LHP APR.-JUNE	L.F.: APR.-JUNE LHP A.L.K.: APR.-JUNE GN APR.-JUNE LL APR.-JUNE LHP	LENGTHS AGES	748 590	615
15	LHP JULY-SEPT.	L.F.: JULY-SEPT. LHP A.L.K.: JULY-SEPT. GN JULY-SEPT. LL JULY-SEPT. LHP	LENGTHS AGES	1671 846	1181
UNSAMPLED CATCH					288

Table 9 : Cod (4T-Vn Jan.-Apr.) catch at age by gear and quarter in 1987. Age-Key numbers correspond to Table 8.

AGE-KEY #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
GEAR	OTB	OTB	OTB	OTB	SNU	SNU	SNU	GNS	GNS	GNS	LL	LL	LL	LHP	LHP	UNSAMPLED	
QUARTER	1	2	3	4	2	3	4	2	3	4	2	3	4	2	3	CATCH	TOTAL
AGE																	
3	15	43	0	6	1	0	0	0	0	0	0	0	2	0	0	0	67
4	239	221	89	71	37	116	4	1	0	4	1	3	27	8	54	5	880
5	1682	1931	934	324	834	398	81	3	9	11	7	70	185	131	176	39	6815
6	1764	3266	1094	374	2029	371	130	39	29	25	28	148	382	137	270	57	10065
7	3933	6949	1655	485	2704	370	189	160	93	41	87	261	390	214	258	102	17891
8	1327	1995	618	163	1035	117	95	157	161	35	84	272	186	77	161	37	6540
9	422	420	150	49	339	40	35	109	121	17	65	100	48	28	43	11	1997
10	365	377	53	14	152	15	10	121	136	14	72	91	37	16	38	9	1520
11	116	151	22	11	76	8	8	64	59	7	39	52	15	10	22	4	664
12	30	73	9	6	30	5	5	49	60	4	42	35	9	3	17	2	379
13	8	25	5	3	14	2	3	17	22	1	12	15	2	1	5	1	136
14	1	21	0	1	20	0	1	18	14	1	16	6	5	1	2	1	108
15	0	0	0	0	0	0	0	2	3	0	7	2	0	0	0	0	14
16	0	0	0	0	2	0	0	3	2	0	2	3	0	0	0	0	12
TOTAL	9904	15472	4629	1507	7293	1442	561	743	709	160	462	1058	1298	626	1046	268	47988

Table 10: Cod (4T-Vn Jan.-Apr.) length at age (cm) by gear and quarter in 1987. Age-Key numbers correspond to Table 8.

AGE-KEY #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
GEAR	OTB	OTB	OTB	OTB	SNU	SNU	SNU	GNS	GNS	GNS	LL	LL	LL	LHP	LHP	AVERAGE
QUARTER	1	2	3	4	2	3	4	2	3	4	2	3	4	2	3	LENGTH
AGE																
3	33.37	28.77	0.00	38.50	29.00	0.00	0.00	0.00	0.00	38.50	0.00	0.00	41.89	0.00	0.00	31.07
4	37.09	36.36	40.61	41.60	37.08	39.16	42.71	42.46	41.34	39.90	39.65	43.05	41.82	42.62	40.87	38.40
5	42.45	42.63	44.52	44.24	43.71	42.05	44.37	43.10	48.96	46.39	44.14	47.46	46.38	42.39	44.43	43.26
6	44.85	45.80	46.59	45.90	45.94	43.83	46.29	53.55	53.41	52.28	50.99	50.04	49.51	46.65	45.59	45.95
7	46.32	47.91	48.47	47.55	48.43	47.09	47.98	56.51	58.62	55.80	55.66	52.71	51.48	48.60	48.75	48.02
8	49.48	50.80	50.25	49.66	49.57	53.08	50.86	60.34	63.52	61.36	60.29	55.56	54.63	51.54	53.07	51.39
9	51.34	53.50	53.29	52.13	56.13	57.59	54.52	65.78	72.15	66.28	67.51	58.86	59.34	51.99	58.68	56.42
10	53.17	55.30	54.84	56.27	59.09	60.59	60.69	68.08	75.32	67.64	72.14	60.33	59.76	56.89	60.55	59.55
11	56.23	55.45	56.42	55.38	57.96	61.32	59.55	68.39	72.68	67.24	70.66	59.64	64.54	55.11	59.32	60.51
12	61.49	59.85	63.37	58.18	65.11	66.39	58.77	73.43	74.34	68.32	78.28	62.73	62.53	59.53	63.22	67.07
13	62.51	62.90	59.11	55.99	73.36	66.99	59.88	74.30	77.66	74.63	76.31	66.93	71.52	66.51	67.41	69.35
14	70.00	57.62	65.50	58.33	59.42	72.00	65.46	72.69	87.41	62.27	80.25	81.01	64.73	64.84	80.31	70.19
15	0.00	0.00	0.00	0.00	105.05	120.00	113.36	102.85	106.95	94.01	103.13	115.31	107.11	0.00	100.66	105.65
16	0.00	0.00	0.00	0.00	93.00	106.00	103.07	110.56	100.29	0.00	111.71	110.70	130.25	0.00	105.34	106.16

Table 11: Cod (4T-Vn Jan.-Apr) weight at age (kg) by gear and quarter in 1987. Age-Key numbers correspond to Table 8.

AGE-KEY #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
GEAR	OTB	OTB	OTB	OTB	SNU	SNU	SNU	GNS	GNS	GNS	LL	LL	LL	LHP	LHP	AVERAGE
QUARTER	1	2	3	4	2	3	4	2	3	4	2	3	4	2	3	WEIGHT
AGE																
3	0.302	0.189	0.000	0.485	0.192	0.000	0.000	0.000	0.000	0.484	0.000	0.000	0.622	0.000	0.000	0.254
4	0.428	0.403	0.367	0.418	0.426	0.504	0.462	0.451	0.604	0.537	0.537	0.679	0.621	0.659	0.580	0.481
5	0.664	0.668	0.766	0.752	0.725	0.637	0.758	0.688	1.040	0.886	0.745	0.936	0.891	0.654	0.765	0.703
6	0.791	0.844	0.888	0.845	0.853	0.738	0.870	1.390	1.392	1.331	1.204	1.130	1.089	0.895	0.833	0.856
7	0.879	0.978	1.008	0.947	1.017	0.932	0.987	1.672	1.901	1.629	1.616	1.337	1.233	1.026	1.053	0.991
8	1.090	1.183	1.138	1.096	1.121	1.392	1.203	2.076	2.528	2.211	2.091	1.582	1.514	1.238	1.401	1.256
9	1.227	1.415	1.381	1.285	1.674	1.869	1.540	2.769	3.856	2.850	3.079	1.943	2.034	1.288	1.972	1.766
10	1.365	1.582	1.610	1.685	2.081	2.141	2.261	3.209	4.481	3.071	3.908	2.142	2.059	1.698	2.219	2.159
11	1.609	1.567	1.670	1.539	1.936	2.327	2.017	3.215	4.104	2.963	3.604	2.019	2.611	1.549	2.030	2.226
12	2.169	1.980	2.326	1.911	2.012	2.927	1.963	4.113	4.365	3.173	4.945	2.625	2.394	1.958	2.568	3.112
13	2.233	2.484	1.991	1.581	4.106	2.916	2.072	4.254	5.300	4.247	4.552	3.316	3.995	2.731	3.165	3.613
14	3.197	1.733	2.622	1.794	2.074	3.498	2.984	4.070	7.537	2.224	5.874	6.483	3.271	2.519	5.951	4.023
15	0.000	0.000	0.000	0.000	11.984	17.863	15.056	11.025	12.665	8.221	11.125	15.957	12.966	0.000	10.029	12.131
16	0.000	0.000	0.000	0.000	8.678	12.822	11.333	14.042	10.218	0.000	14.716	14.063	23.716	0.000	11.790	12.628

Notes: Gears: OTB = trawlers, SNU = seiners, GNS = gillnets, LLS = longlines, LHP = handlines
Quarters: 1 = Jan.-Mar., 2 = Apr.-June, 3 = July-Sept., 4 = Oct. - Dec.

Table 12: 4T-Vn cod catch at age ('000) for the period 1971-1987.

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	6	3177	1337	2731	1556	466	546	538	142	314	96	372	33
4	2040	22152	6888	4980	8781	3460	3357	9854	4959	2019	3762	1244	1073
5	7082	11824	14327	4774	6761	8930	4115	10627	15531	15000	7277	10101	6031
6	9018	6541	5242	9404	2487	6563	2865	4463	10956	14152	18841	9530	11662
7	5746	7422	3648	2986	3237	1592	1686	2589	3391	9541	12863	12737	11328
8	2276	3467	2736	1795	1293	1138	406	1065	1670	1274	6026	6690	7223
9	1225	919	1803	1702	1104	446	291	237	835	699	867	2157	5067
10	510	529	540	1035	791	265	180	241	291	320	432	326	2478
11	129	354	328	266	671	135	124	104	247	124	190	110	105
12	346	114	97	194	150	140	55	72	64	24	64	58	40
13	73	49	67	85	53	45	59	44	33	16	81	6	15
14	117	14	46	26	74	14	11	5	15	8	2	3	7
15	151	46	11	6	7	10	4	13	15	11	14	2	4
16	61	36	23	15	66	9	5	6	8	26	3	2	2
3+	28780	56644	37093	29999	27031	23213	13704	29858	38157	43528	50518	43338	45068

	1984	1985	1986	1987
3	25	165	129	67
4	1198	1476	3400	880
5	3899	9915	7639	6815
6	7040	16666	21623	10065
7	8828	8148	9280	17891
8	6736	5975	3697	6540
9	5062	3928	2718	1997
10	2871	2226	2191	1520
11	931	942	1067	664
12	154	347	753	379
13	52	22	159	136
14	7	7	17	108
15	5	8	3	14
16	8	4	2	12
3+	36816	49829	52678	47088

Table 13: 4T-Vn cod average weight at age (kg) for the period 1971-1987.

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
3	.760	.352	.456	.601	.481	.649	.533	.400	.505	.564	.503
4	.815	.560	.667	.778	.737	.745	.758	.681	.706	.688	.674
5	1.115	.916	.920	1.078	1.142	1.071	1.249	1.030	1.004	.919	.848
6	1.402	1.331	1.274	1.485	1.763	1.505	1.809	1.661	1.414	1.206	1.132
7	2.146	1.516	1.683	1.959	2.363	2.170	2.437	2.261	2.213	1.472	1.382
8	3.681	2.542	2.301	2.677	2.752	2.835	3.513	2.815	3.299	2.643	1.832
9	3.836	4.922	3.574	2.893	3.221	3.220	4.242	4.354	4.064	2.895	3.150
10	5.253	5.929	5.507	4.176	3.699	3.867	4.290	4.657	7.134	3.566	4.122
11	6.010	7.117	6.004	6.065	4.457	4.750	5.074	6.495	7.021	7.958	4.456
12	4.775	8.051	7.904	7.260	6.961	5.058	5.492	6.551	6.701	5.805	5.603
13	6.821	8.830	6.150	8.290	9.202	6.238	6.743	6.250	4.698	10.316	6.032
14	7.457	10.124	6.707	6.600	6.319	10.343	8.977	5.090	8.713	5.813	7.080
15	7.914	5.599	8.918	9.122	8.390	11.472	10.795	11.566	15.415	9.770	3.490
16	17.897	11.185	6.047	11.748	6.175	14.301	9.258	10.195	17.396	9.355	6.760

	1982	1983	1984	1985	1986	1987
3	.713	.324	.448	.442	.437	.254
4	.756	.612	.655	.575	.602	.481
5	.971	.884	.786	.762	.816	.703
6	1.179	1.138	1.082	.991	1.014	.856
7	1.448	1.296	1.369	1.422	1.283	.991
8	1.670	1.557	1.613	1.666	1.743	1.256
9	2.111	1.717	2.058	1.822	1.956	1.766
10	3.077	1.946	2.266	2.122	1.866	2.159
11	3.847	4.947	3.043	2.378	2.585	2.226
12	3.712	7.462	4.880	2.810	2.223	3.112
13	6.880	8.465	5.653	8.435	3.081	3.613
14	9.287	11.358	8.619	5.844	4.409	4.023
15	4.180	12.820	11.736	11.406	15.363	12.131
16	11.100	14.760	12.808	13.547	13.531	12.628

Table 14: ANOVA and coefficient estimates from the otter trawl catch rate standardization for the 4T-Vn (Jan.-Apr.) cod stock.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R..... .845
MULTIPLE R SQUARED..... .714

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	6.677E0002	6.677E0002	
REGRESSION	41	7.252E0002	1.769E0001	71.176
TYPE 1	8	1.346E0002	1.683E0001	67.711
TYPE 2	1	4.625E0000	4.625E0000	18.610
TYPE 3	11	9.892E0001	8.993E0000	36.186
TYPE 4	21	1.607E0002	7.653E0000	30.797
RESIDUALS	1168	2.903E0002	2.485E-001	
TOTAL	1210	1.683E0003		

REGRESSION COEFFICIENTS

CATEGORY	CODE	VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
1	2114	INTERCEPT	-0.081	0.112	1210
2	44				
3	1				
4	66				
1	2112	1	-1.200	0.062	160
	2113	2	-0.775	0.056	258
	2122	3	-0.473	0.091	63
	2123	4	-0.491	0.060	184
	2124	5	-0.156	0.060	121
	2125	6	0.169	0.064	99
	3114	7	-0.132	0.065	98
	3125	8	0.162	0.069	80
2	43	9	0.209	0.048	869
3	2	10	0.105	0.062	118
	3	11	-0.219	0.071	77
	4	12	-0.583	0.056	174
	5	13	-0.845	0.067	134
	6	14	-1.007	0.075	92
	7	15	-0.988	0.085	66
	8	16	-1.210	0.083	68
	9	17	-1.175	0.085	65
	10	18	-1.096	0.081	75
	11	19	-0.908	0.073	104
	12	20	-0.653	0.076	78
4	67	21	-0.089	0.130	37
	68	22	0.260	0.130	37
	69	23	0.147	0.119	55
	70	24	0.035	0.117	60
	71	25	-0.167	0.115	68
	72	26	0.016	0.116	65
	73	27	-0.207	0.118	57
	74	28	-0.322	0.116	63
	75	29	-0.351	0.119	55
	76	30	-0.239	0.119	54
	77	31	-0.173	0.127	40
	78	32	0.172	0.128	40
	79	33	0.431	0.117	67
	80	34	0.399	0.119	61
	81	35	0.449	0.121	54
	82	36	0.536	0.119	62
	83	37	0.765	0.118	67
	84	38	0.552	0.119	61
	85	39	0.792	0.121	58
	86	40	0.820	0.119	61
	87	41	0.930	0.120	61

Category	Description
1	Region/Gear/Tonnage Class
	Region 2 - Maritimes and Quebec 3 - Newfoundland
	Gear 11 - Side trawler 12 - Stern trawler
	Tonnage class 2 - 25 - 49.9 t 3 - 50 - 149.9 t 4 - 150 - 499.9 t 5 - 500 - 999.9 t
2	Division 43 - 4T 44 - 4Vn
3	Month 1 - 12 - (Jan. - Dec.)
4	Year 67 - 87 - (1967 - 1987)

Table 15: Standardized catch rate for otter trawls for the 4T-Vn (Jan.-Apr.) cod stock.

PREDICTED CATCH RATE

STANDARDS USED VARIABLE NUMBERS: 2114 43 9

YEAR	TOTAL CATCH	PROP.	CATCH RATE MEAN	S.E.	EFFORT
1966	54851	0.194	0.394	0.049	139272
1967	41316	0.322	0.361	0.040	114462
1968	46551	0.389	0.501	0.057	92831
1969	47819	0.462	0.457	0.047	104599
1970	64465	0.355	0.409	0.042	157678
1971	56375	0.427	0.334	0.033	168638
1972	65291	0.458	0.401	0.040	162684
1973	50635	0.339	0.321	0.033	157668
1974	48747	0.310	0.286	0.029	170380
1975	42471	0.355	0.278	0.028	152832
1976	33415	0.504	0.293	0.030	114075
1977	22219	0.428	0.332	0.037	66922
1978	37892	0.439	0.468	0.052	80891
1979	55996	0.470	0.608	0.061	92104
1980	54634	0.399	0.588	0.060	92865
1981	65177	0.351	0.619	0.064	105320
1982	58193	0.372	0.675	0.068	86205
1983	61295	0.396	0.849	0.086	72187
1984	55364	0.325	0.685	0.071	80766
1985	62138	0.369	0.872	0.090	71252
1986	63441	0.316	0.896	0.092	70779
1987	50596	0.359	1.000	0.107	50584

AVERAGE C.V. FOR THE MEAN: .105

Table 16: Research vessel survey mean numbers per tow at age (1971-1987) for the 4T-Vn (Jan.-Apr.) cod stock.

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
0	.00	.00	.02	.00	.00	.00	.01	.00	.14	.24	.19	.21	.01
1	.06	.73	.07	.08	.40	2.99	.55	1.24	.17	.98	4.72	3.04	5.94
2	.57	2.07	4.69	2.31	5.42	7.33	10.19	5.11	21.67	4.61	20.50	25.17	19.66
3	6.18	4.54	9.30	10.10	4.08	31.73	15.12	23.12	22.00	31.99	19.03	16.10	42.39
4	7.48	12.13	4.31	7.08	6.18	7.98	12.75	24.91	46.65	24.03	56.76	20.63	36.50
5	7.10	5.02	6.86	2.74	5.18	5.34	4.99	14.08	28.46	41.83	47.03	23.94	19.46
6	5.52	4.18	3.23	3.31	1.82	2.25	2.65	4.28	11.60	20.53	45.89	38.14	14.04
7	3.49	2.85	2.29	1.43	1.30	.60	1.51	2.42	3.03	7.41	19.31	19.67	12.16
8	.85	1.65	1.73	1.01	.87	.44	.65	.83	1.24	1.23	10.40	9.35	8.36
9	.16	.31	1.09	1.01	.40	.25	.48	.33	.62	.60	1.38	2.89	3.98
10	.19	.23	.31	.44	.30	.23	.31	.41	.17	.25	.57	.32	2.62
11	.11	.20	.07	.18	.35	.21	.25	.48	.18	.06	.25	.12	.56
12	.09	.06	.21	.09	.08	.06	.20	.06	.15	.01	.10	.10	.11
13	.00	.03	.03	.19	.04	.06	.24	.00	.05	.01	.06	.05	.32
14	.08	.02	.05	.00	.00	.02	.00	.13	.04	.05	.05	.02	.04
15	.07	.03	.01	.04	.00	.00	.04	.03	.04	.01	.06	.00	.06
16	.16	.04	.16	.11	.00	.02	.07	.00	.02	.01	.08	.05	.00
0+	32.10	34.09	34.44	30.11	26.44	59.51	50.01	77.42	136.23	133.84	226.39	159.80	166.20
1+	32.10	34.09	34.42	30.11	26.44	59.51	50.00	77.42	136.10	133.60	226.20	159.59	166.19
2+	32.04	33.36	34.34	30.03	26.04	56.52	49.45	76.17	135.93	132.62	221.48	156.54	160.25
3+	31.47	31.29	29.65	27.72	20.62	49.19	39.26	71.06	114.26	128.02	200.97	131.37	140.59
4+	25.29	26.75	20.36	17.62	16.54	17.45	24.14	47.95	92.26	96.02	181.94	115.27	98.20
5+	17.82	14.62	16.04	10.54	10.36	9.48	11.39	23.04	45.61	72.00	125.19	94.64	61.70
6+	10.71	9.59	9.18	7.80	5.18	4.14	6.40	8.96	17.15	30.17	78.16	70.70	42.24

	1984	1985	1986	1987
0	.00	1.30	2.08	.29
1	2.18	3.93	6.42	.33
2	11.06	12.65	21.43	8.34
3	15.06	33.09	38.16	20.06
4	33.86	43.45	51.50	17.74
5	42.10	78.66	51.00	24.44
6	15.67	88.85	54.89	19.19
7	8.09	21.13	35.33	26.20
8	8.54	8.32	9.28	9.95
9	3.41	5.93	1.85	2.18
10	1.56	3.06	2.64	1.61
11	.54	2.00	.91	.60
12	.13	.68	.58	.49
13	.04	.03	.20	.20
14	.13	.00	.11	.09
15	.02	.00	.00	.01
16	.02	.07	.12	.01
0+	142.42	303.16	276.52	131.73
1+	142.42	301.85	274.43	131.44
2+	140.24	297.93	268.01	131.11
3+	129.17	285.27	246.58	122.77
4+	114.11	252.18	208.41	102.71
5+	80.25	208.73	156.92	84.97
6+	38.15	130.07	105.92	60.53

Table 17a): 4T-Vn cod (Jan-Apr) research vessel survey coefficients of variation for ages 1 to 10 (1971-1987).

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	68.26	33.51	63.84	56.20	72.30	36.64	30.35	43.47	41.10	36.01	33.57	25.47	21.95
2	26.71	48.37	22.40	25.70	50.60	27.44	16.54	19.73	25.14	19.10	42.88	29.83	13.26
3	11.02	18.58	18.64	13.09	59.45	18.31	17.84	21.10	15.17	26.49	18.40	31.55	15.52
4	15.01	15.66	18.66	9.60	46.10	13.52	17.23	35.65	13.40	19.50	20.04	23.09	16.16
5	16.43	19.76	17.49	9.96	36.24	21.48	22.22	37.37	12.22	21.24	20.52	22.76	11.94
6	16.80	20.30	16.47	6.94	38.40	27.55	28.49	27.77	11.26	22.17	19.33	23.07	9.28
7	16.00	19.12	16.24	7.29	35.63	38.32	33.96	23.59	8.55	20.47	17.64	19.62	9.73
8	15.96	16.25	15.34	7.07	34.37	30.44	31.68	25.47	10.06	21.92	16.08	17.25	10.01
9	19.73	15.64	16.36	8.14	32.31	29.91	30.79	44.29	13.32	25.02	13.06	15.49	13.76
10	55.95	36.00	41.82	28.41	56.40	40.63	68.27	94.01	60.93	30.12	24.61	.00	12.07

	1984	1985	1986	1987
1	20.49	73.82	66.06	.00
2	20.81	27.60	34.29	27.07
3	18.06	22.68	34.07	18.45
4	18.11	36.06	46.90	10.70
5	20.15	44.91	43.48	10.98
6	13.23	46.62	36.56	14.65
7	9.58	45.68	26.43	20.59
8	9.07	36.26	21.00	26.20
9	9.27	36.95	.00	29.07
10	.00	41.37	20.71	33.99

Table 17b): 4T-Vn cod (Jan-Apr) research vessel survey standard errors for ages 1 to 10 (1971-1987).

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
1	.04	.24	.05	.04	.29	1.09	.17	.54	.07	.35	1.58	.77	1.30	.45	2.90
2	.15	1.00	1.05	.59	2.75	2.01	1.69	1.01	5.45	.88	8.79	7.51	2.61	2.30	3.49
3	.68	.84	1.73	1.32	2.43	5.81	2.70	4.88	3.34	8.47	3.50	5.08	6.58	2.72	7.50
4	1.12	1.90	.80	.68	2.85	1.08	2.20	8.88	6.25	4.69	11.37	4.76	5.90	6.13	15.67
5	1.17	.99	1.20	.27	1.88	1.15	1.11	5.26	3.48	8.89	9.65	5.45	2.32	8.49	35.32
6	.93	.85	.53	.23	.70	.62	.75	1.19	1.31	4.55	8.87	8.80	1.30	2.07	41.42
7	.56	.54	.37	.10	.46	.23	.51	.57	.26	1.52	3.41	3.86	1.18	.77	9.65
8	.14	.27	.26	.07	.30	.13	.21	.21	.13	.27	1.67	1.61	.84	.77	3.02
9	.03	.05	.18	.08	.13	.07	.15	.15	.08	.15	.18	.45	.55	.32	2.19
10	.11	.08	.13	.12	.17	.10	.21	.39	.10	.08	.14	.00	.32	.00	1.26

	1986	1987
1	4.24	.00
2	7.35	2.26
3	13.00	3.70
4	24.15	1.90
5	22.17	2.68
6	20.07	2.81
7	9.34	5.39
8	1.95	2.61
9	.00	.63
10	.55	.55

Table 18 : Calibration results using OTB CPUE and otter trawl fishable biomass. SRES is the sum of the last 5 residuals standardized to the mean squared error, squared.

F	0.1	0.15	0.175	0.2	0.225	0.25	0.3	0.35	0.4
r	0.834	0.86	0.867	0.87	0.867	0.859	0.829	0.783	0.727
a	-106148	-38531	-19196	-4688	6601	15635	29193	38883	46153
b	493.8	324.1	275.6	239.2	210.8	188.1	154.1	129.8	111.5
SRES	12.905	12.66	11.937	10.771	9.276	7.663	4.869	3.161	2.341
				Residuals					
RES85	-0.504	-0.583	-0.615	-0.634	-0.639	-0.63	-0.58	-0.514	-0.452
RES86	0.58	0.409	0.296	0.169	0.036	-0.094	-0.317	-0.475	-0.579
RES87	2.765	2.571	2.385	2.134	1.829	1.492	0.822	0.264	-0.156

Table 19 : Calibration of 5+ RV mean numbers per tow and 5+ SPA mean numbers (1979 - 1987) SRES is the sum of the last 5 residuals standardized to the mean squared error squared.

F	0.2	0.3	0.4	0.5	0.55	0.6	0.65	0.675	0.7
r	0.535	0.598	0.683	0.776	0.806	0.8	0.747	0.703	0.653
a	46.98	9.78	-55.23	-161.16	-220.03	-258.64	-254.62	-235.66	-208.65
b	0.00022	0.00044	0.00086	0.00156	0.00197	0.00227	0.0023	0.0022	0.00205
SRES	5.736	5.787	5.829	5.519	4.815	3.816	3.402	3.497	3.701
				Residuals					
RES85	1.724	1.647	1.51	1.276	1.143	1.078	1.145	1.219	1.305
RES86	0.501	0.472	0.473	0.633	0.856	1.142	1.342	1.387	1.403
RES87	-1.483	-1.633	-1.814	-1.85	-1.586	-1.003	-0.355	-0.117	0.046

Table 20: Summary table for the first calibration using non-linear least squares for cod in 4T-Vn (Jan.-Apr.).

Parameters estimated

Parameter index	Type	Description
1	Year-class estimate (N)	Age 4 in 1988
2	"	Age 5 in 1988
3	Calibration constant for RV numbers	Age 3
4	"	Age 4
5	"	Age 5
6	Calibration constant for CPUE (q)	Fishable biomass

Structure imposed

-Partial recruitment vector applied on 1987 (page 6)
-F on age 10+ set equal to age 9
-F for oldest age set equal to weighted (by population) F on age 9-10
-Model did not include an intercept

Input data

-Catch at age (C [i,t], i= age 3 to 15, t= 1971-1987)
-RV mean number per tow at age (RV [i,t], i= age 3 to 10+, t= 1971-1987)
-Otter trawl CPUE (CPUE [t], t= 1971-1987)
-Standard errors for RV and CPUE for weighting

Objective function

-residuals weighted by inverse of standard error
-no penalty function
-minimization of residual sum of squares on calibrations

Summary

-number of observations = 68

Table 21: Results of the first calibration using non-linear least squares for the 4T-Vn (Jan.-Apr.) cod stock (Parameter indices as in Table 20).

APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

ORTHOGONALITY OFFSET..... 0.007908
MEAN SQUARE RESIDUALS 5.596143

Parameter Index	PAR. EST.	STD. ERR.	T-STATISTIC
1	1.55637E0005	7.04821E0004	2.20818E0000
2	1.11309E0005	1.25902E0004	8.84093E0000
3	1.16398E-004	1.39917E-005	8.31905E0000
4	2.00273E-004	2.21327E-005	9.04872E0000
5	3.09363E-004	1.67804E-005	1.84360E0001
6	4.32863E-006	2.69732E-007	1.60479E0001

CORRELATION MATRIX OF PARAMETERS

	1	2	3	4	5	6
1	1.00	.05	-.27	-.02	-.01	-.01
2	.05	1.00	-.17	-.41	-.30	-.21
3	-.27	-.17	1.00	.07	.05	.04
4	-.02	-.41	.07	1.00	.12	.09
5	-.01	-.30	.05	.12	1.00	.06
6	-.01	-.21	.04	.09	.06	1.00

WEIGHTED RESIDUALS

	1971	1972	1973	1974	1975	1976	1977	1978	1979
3	-4.609	1.304	2.592	3.549	-.089	3.321	-.863	1.129	2.785
4	.522	.687	.541	1.354	-.112	2.220	-2.002	.151	3.579
5	-2.550	-2.322	-.845	-1.073	-.208	-.983	-.154	-.631	.817
6	-5.670	-1.253	-1.241	1.389	-.222	2.936	1.093	1.865	-1.523

	1980	1981	1982	1983	1984	1985	1986	1987
3	2.264	2.862	-.019	1.797	-.737	1.009	1.577	.000
4	1.353	3.439	1.694	2.343	-1.479	1.248	.658	-3.706
5	1.749	5.216	3.663	4.583	2.714	2.173	2.174	-2.621
6	1.717	-.958	-.661	3.883	3.191	2.510	2.190	.983

Table 22: Summary table for the second calibration using non-linear least squares for cod in 4T-Vn (Jan.-Apr.).

Parameters estimated

Parameter index	Type	Description
1	Year-class estimate (N)	Age 4 in 1988
2	"	Age 5 in 1988
3	"	Age 6 in 1988
4	"	Age 7 in 1988
5	"	Age 8 in 1988
6	"	Age 9 in 1988
7	"	Age 10 in 1988
8	"	Age 11 in 1988
9	Calibration constant for RV numbers	Age 3
10	"	Age 4
11	"	Age 5
12	"	Age 6
13	"	Age 7
14	"	Age 8
15	"	Age 9
16	"	Age 10 +
17	Calibration constant for CPUE (q)	Fishable biomass

Structure imposed

-F on age 11+ in 1987 set equal to age 10
-F for oldest age set equal to weighted (by population) F on age 9-10
-Model did not include an intercept

Input data

-Catch at age (C [i,t], i= age 3 to 15, t= 1971-1987)
-RV mean number per tow at age (RV [i,t], i= age 3 to 10+, t= 1971-1987)
-Otter trawl CPUE (CPUE [t], t= 1971-1987)
-Standard errors for RV and CPUE for weighting

Objective function

-residuals weighted by inverse of standard error
-no penalty function
-minimization of residual sum of squares on calibrations

Summary

-number of observations = 153

Table 23: Results of the second calibration using non-linear least squares for cod in 4T-Vn (Jan.-Apr.) (Parameter indices as in Table 22).

APPROXIMATE STATISTICS ASSUMING LINEARITY NEAR SOLUTION

ORTHOGONALITY OFFSET.......... [illegible]9189
MEAN SQUARE RESIDUALS .... [illegible].033515

Parameter Index	PAR. EST.	STD. ERR.	T-STATISTIC
1	[illegible].55866E[illegible]05	3.97907E0004	2.24179E[illegible]
2	[illegible].62738E[illegible]04	1.34631E0004	3.74422E[illegible]
3	3.04571E[illegible]04	2.13599E0004	3.74660E[illegible]
4	5.59264E[illegible]04	1.55123E0004	3.32651E[illegible]
5	5.33579E[illegible]04	2.05010E0004	2.5536[illegible]E[illegible]
6	3.13918E[illegible]04	3.39650E0003	3.0740[illegible]E[illegible]
7	1.59745E[illegible]04	3.66674E0003	3.7273[illegible]E[illegible]
8	6.92072E[illegible]	1.23359E0003	5.61023E[illegible]
9	1.15356E[illegible]04	1.38291E[illegible]05	8.37769E[illegible]
10	2.23061E[illegible]04	2.40404E[illegible]05	9.27980E[illegible]
11	2.30921E[illegible]04	3.09026E[illegible]05	9.09054E0000
12	3.33712E[illegible]04	2.59347E[illegible]05	1.09335E[illegible]
13	3.13612E[illegible]04	2.80969E[illegible]05	1.13397E[illegible]01
14	3.23535E[illegible]04	2.82530E[illegible]05	1.15655E[illegible]
15	1.39349E[illegible]04	2.19553E[illegible]05	8.62732E[illegible]
16	3.54774E[illegible]04	3.91914E[illegible]05	9.28938E[illegible]
17	4.03453E[illegible]	2.59373E[illegible]07	1.55542E[illegible]

CORRELATION MATRIX OF PARAMETERS

	1	2	3	4	5	6	7	8	9	10	11	12
1	1.00	.00	.01	.05	.02	.01	.01	.01	-.27	-.01	-.01	-.01
2	.00	1.00	.00	.01	.08	.02	.01	.02	-.01	-.40	-.01	-.01
3	.01	.00	1.00	.01	.00	.02	.07	.01	-.03	-.01	-.41	-.01
4	.05	.01	.01	1.00	.02	.01	.03	.03	-.19	-.02	-.02	-.21
5	.02	.08	.00	.02	1.00	-.18	-.02	.04	-.08	-.19	.00	-.02
6	.01	.02	.02	.01	-.18	1.00	-.04	.02	-.04	-.05	-.04	.00
7	.01	.01	.07	.03	-.02	-.04	1.00	-.08	-.04	-.03	-.18	-.11
8	.01	.02	.01	.03	.04	.02	-.08	1.00	-.03	-.04	-.02	-.13
9	-.27	-.01	-.03	-.19	-.08	-.04	-.04	-.03	1.00	.03	-.02	.05
10	-.01	-.40	-.01	-.02	-.19	-.05	-.03	-.04	.03	1.00	.01	.02
11	-.01	-.01	-.41	-.02	.00	-.04	-.18	-.02	.02	.01	1.00	.03
12	-.01	-.01	-.01	-.21	-.02	.00	-.11	-.13	.05	.02	.03	1.00
13	.00	-.01	.00	-.01	-.10	.00	.01	-.27	.02	.03	.01	.04
14	.00	.00	-.01	-.01	.01	-.10	-.04	-.11	.01	.01	.02	.02
15	.00	.00	-.01	-.01	.00	.00	-.12	-.03	.01	.01	.02	.02
16	.00	-.01	.00	-.01	-.02	-.01	.02	-.43	.01	.02	.01	.06
17	-.01	-.02	-.02	-.02	-.07	-.13	-.14	-.30	.03	.04	.04	.05

	13	14	15	16	17
1	.00	.00	.00	.00	-.01
2	-.01	.00	.00	-.01	-.02
3	.00	-.01	-.01	.00	-.02
4	-.01	-.01	-.01	-.01	-.02
5	-.10	.01	.00	-.02	-.07
6	.00	-.10	.00	-.01	-.13
7	.01	-.04	-.12	.02	-.14
8	-.27	-.11	-.03	-.43	-.30
9	.02	.01	.01	.01	.03
10	.03	.01	.01	.02	.04
11	.01	.02	.02	.01	.04
12	.04	.02	.02	.06	.06
13	1.00	.03	.02	.12	.09
14	.03	1.00	.02	.05	.06
15	.02	.02	1.00	.03	.04
16	.12	.05	.03	1.00	.13
17	.09	.06	.04	.13	1.00

WEIGHTED RESIDUALS

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	-.343	.274	.543	.740	-.022	.663	-.192	.314	.531	.433
4	-.037	.309	-.002	.364	-.279	.319	-.636	-.041	.621	.135
5	.037	-.135	-.170	-.181	-.039	.034	-.101	-.163	.258	.367
6	-.249	.083	.165	-.121	.077	-.185	-.058	.147	-.100	.201
7	-.343	-.318	.066	.322	-.087	-.237	.000	.214	.602	-.113
8	-.809	-.570	.009	-.152	.188	-.349	.195	-.050	.539	.126
9	-1.744	-.357	.469	1.471	.241	.286	.386	.240	.939	.495
10	-.438	-.564	.070	.059	.138	.342	.743	.371	.614	.364
11	-.954	-.102	-.104	.407	.095	.702	.333	.464	-.219	.405

	1981	1982	1983	1984	1985	1986	1987
3	.382	-.136	.453	-.127	.443	.425	.000
4	.633	.041	.212	-.344	.228	.215	-.039
5	.573	.115	.013	.277	.204	.236	-.121
6	.673	.554	-.065	.141	.332	.236	.014
7	.514	.454	.315	-.606	.220	.404	.094
8	.795	.381	.433	.643	.120	.189	-.177
9	1.220	.615	.752	.394	.372	-.111	-.290
10	1.223	.041	1.185	-.074	.376	.162	-.964
11	-.155	-.114	.780	.562	.214	-.393	-.187

Table 24: Population numbers for 4T-Vn (Jan.-Apr.) cod (1971 - 1987).

	1971	1972	1973	1974	1975	1976	1977	1978	1979
3	88321	34376	46334	52769	42195	120408	168069	172604	128241
4	39074	72306	25270	36725	40732	33138	98160	137109	140829
5	31062	30145	39155	14457	25562	25403	24001	77329	103339
6	30926	19024	13982	19094	7517	14811	12718	15927	53696
7	18566	17160	9657	6704	7124	3904	6188	7821	9001
8	5936	10002	7334	4605	2787	2903	1756	3540	4060
9	3224	2800	5052	3529	2146	1112	1347	1070	1935
10	1625	1531	1461	2504	1349	758	507	840	662
11	488	869	775	708	1114	389	381	252	470
12	548	282	391	338	339	305	196	200	112
13	145	136	128	233	101	142	123	111	98
14	296	52	67	44	114	35	75	47	51
15	587	425	304	231	183	110	88	116	112
3+	220798	189109	149909	141941	131262	203417	313609	416965	442606

	1980	1981	1982	1983	1984	1985	1986	1987	1988
3	136290	119833	185226	266900	159349	162610	110046	107000	*
4	104866	111301	98024	151314	218490	130442	132985	89981	87544
5	110814	84030	87722	79130	122914	177800	105461	105802	72874
6	70554	77154	62214	62681	59329	97106	136599	79432	80457
7	34049	44959	46121	42313	40766	42204	64423	92273	55926
8	4301	19244	25171	26235	24393	25389	27181	44348	59358
9	1813	2369	10303	14555	14944	13876	15380	18909	30392
10	829	852	1155	6484	7332	7655	7807	10133	13675
11	278	389	307	651	3066	3405	4253	4409	6921
12	161	116	146	152	438	1668	1935	2517	3009
13	34	110	37	67	88	219	1052	903	1718
14	51	13	17	25	42	25	159	717	616
15	99	82	61	57	55	61	53	154	592
3+	464140	460453	516502	650563	651206	662460	607335	556579	

* Not estimated

Table 25: Mean population biomass for 4T-Vn cod (1971-1987).

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	60835	10416	18853	27941	18030	70680	81050	62471	58662	69583
4	28050	30266	12915	23968	23928	21102	66197	81331	88407	64716
5	27377	19272	25699	11439	22497	19637	24591	66740	86250	85440
6	32767	18388	12614	18029	9722	14869	18220	20159	60985	68499
7	29712	17524	11482	8743	11111	5833	11555	12970	14085	38193
8	15362	18422	11969	8623	5017	5746	4864	7480	9196	8562
9	8720	10132	12974	6559	4297	2480	4555	3699	5302	3685
10	6346	6583	5723	7167	2856	2120	1565	2966	3158	2073
11	2258	4262	3159	3036	2783	1338	1425	1123	2024	1474
12	1411	1572	2412	1422	1573	1013	822	938	440	777
13	620	858	485	1377	569	654	534	482	338	229
14	1535	408	221	167	375	247	562	205	335	244
15	3324	1924	2306	1816	1064	1031	815	1103	1381	684
3+	218317	140026	120812	120286	103823	146751	216754	261668	330562	344160

	1981	1982	1983	1984	1985	1986	1987
3	54608	119569	78372	64697	65107	43559	24625
4	66756	66710	83613	129328	67568	71563	39022
5	61545	72340	60779	86070	119097	74935	65064
6	68274	60867	57970	54405	78933	114572	57346
7	47145	51039	42165	44455	48553	68978	73938
8	26218	32365	31238	30071	33267	39733	46386
9	5323	17408	18086	22424	19226	24596	28522
10	2200	2704	8881	11601	12283	11097	18190
11	1106	847	2657	6989	6186	8555	8158
12	386	378	872	1541	3755	3010	6510
13	299	209	453	283	1583	2692	2712
14	79	127	213	295	111	600	2398
15	229	222	626	510	564	705	1539
3+	334168	424787	385926	452669	456232	464596	374408

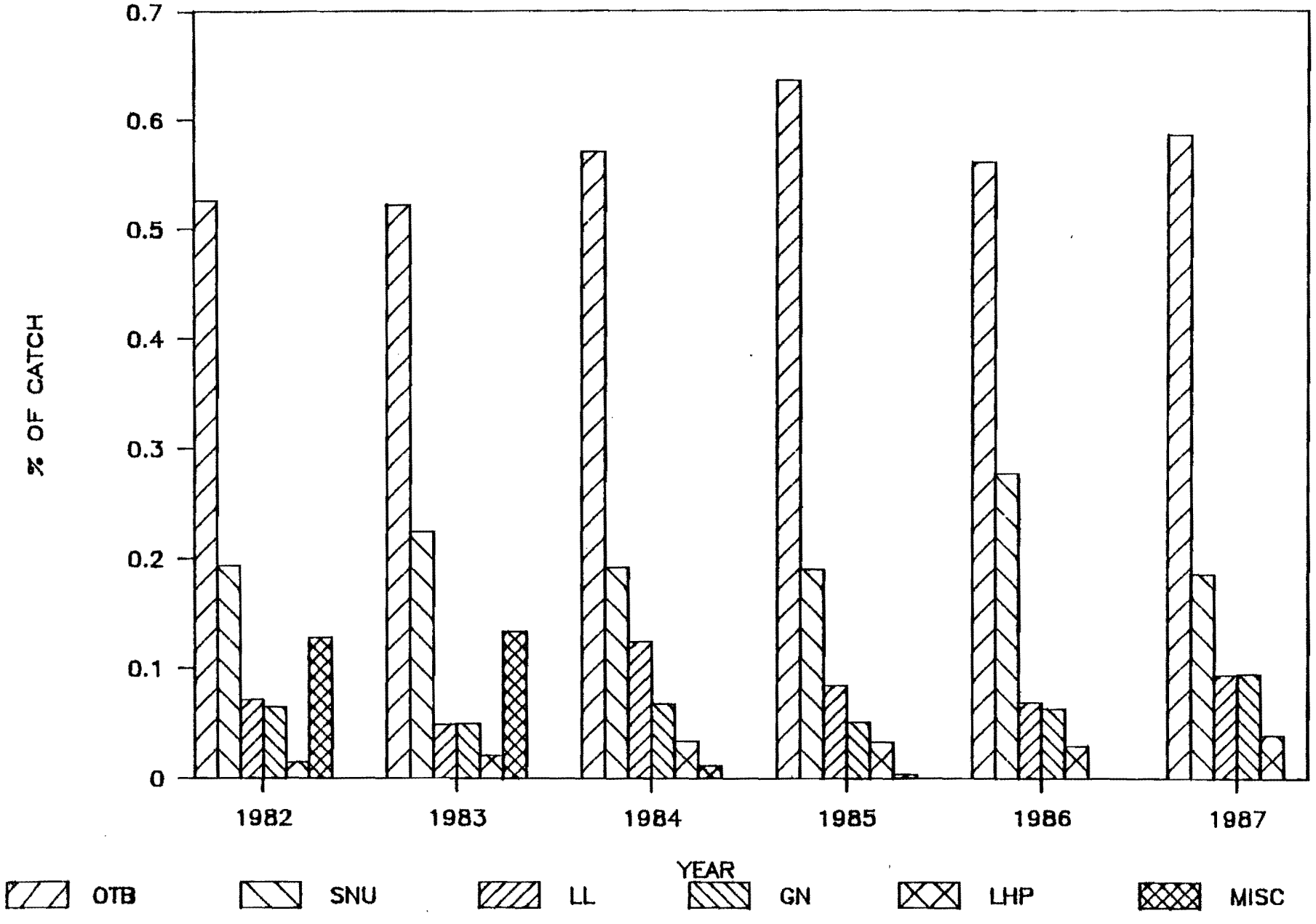
Table 26: Fishing mortality for 4T-Vn cod (1971-1987).

	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	.000	.108	.032	.059	.042	.004	.004	.003	.001	.003	.001	.002	.000
4	.059	.413	.358	.162	.272	.123	.039	.083	.040	.022	.038	.014	.008
5	.290	.568	.518	.454	.346	.492	.210	.165	.182	.162	.101	.136	.088
6	.389	.478	.535	.786	.455	.673	.286	.371	.256	.251	.315	.185	.230
7	.419	.650	.540	.678	.698	.599	.358	.455	.538	.371	.380	.364	.351
8	.551	.483	.532	.563	.719	.568	.295	.404	.606	.397	.425	.348	.363
9	.545	.451	.502	.761	.840	.586	.273	.281	.648	.555	.518	.263	.486
10	.426	.481	.525	.610	1.044	.488	.498	.381	.666	.556	.822	.374	.549
11	.346	.598	.631	.537	1.096	.484	.446	.609	.871	.678	.776	.505	.196
12	1.196	.591	.320	1.009	.672	.708	.371	.508	.993	.180	.945	.576	.345
13	.815	.509	.863	.517	.870	.433	.756	.577	.463	.732	1.679	.199	.282
14	.575	.350	1.432	1.048	1.273	.593	.176	.124	.393	.191	.180	.220	.375
15	.503	.461	.507	.696	.915	.545	.330	.324	.653	.556	.591	.274	.505

	1984	1985	1986	1987
3	.000	.001	.001	.001
4	.006	.013	.029	.011
5	.036	.064	.083	.074
6	.141	.210	.192	.151
7	.274	.240	.173	.241
8	.364	.301	.163	.178
9	.469	.375	.217	.124
10	.567	.388	.371	.181
11	.409	.365	.325	.182
12	.492	.261	.562	.182
13	1.060	.118	.183	.182
14	.205	.371	.125	.182
15	.500	.380	.267	.144

Table 27: 4T-Vn (Jan.- Apr.) cod projections for 1989 assuming a 1988 catch of 49,000 t and fishing at F0.1 in 1989.

Age	Population Numbers ('000)	Catch Numbers ('000)	Catch Biomass (t)	Population Biomass (t)	Fishing Mortality
3	107,000	29	11	36,653	0.000
4	87,580	506	280	43,761	0.006
5	71,261	2,272	1,727	48,247	0.036
6	57,763	5,303	5,059	47,459	0.107
7	59,819	7,147	8,805	62,446	0.141
8	40,301	6,643	10,330	51,652	0.200
9	40,481	6,673	12,331	61,657	0.200
10	20,923	3,449	7,067	35,334	0.200
11	9,336	1,539	3,687	18,437	0.200
12	4,730	780	2,117	10,583	0.200
13	2,056	339	1,709	8,547	0.200
14	1,174	194	921	4,604	0.200
15	422	70	901	4,505	0.200



(OTB - otter trawl, SNU - seines, LL - longlines, GN - gillnets, LHP - handlines, MISC - all other gears including unknowns)

Figure 1: Percent of 4T-Vn (Jan.-Apr.) cod catch by gear (1982 - 1987).

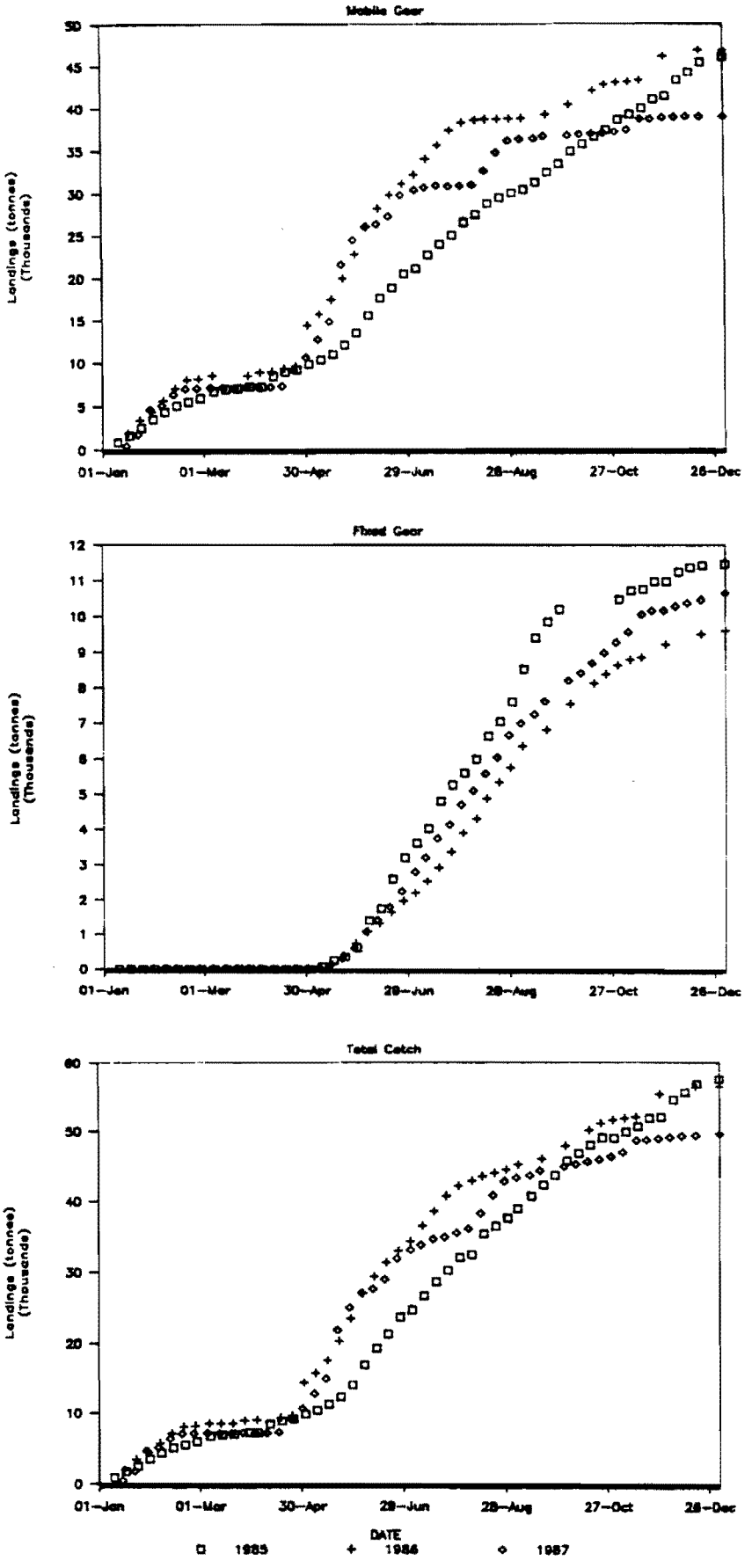


Figure 2 : Cumulative landings of cod in 4TVn (1985 - 1987).
(Source: Canadian Atlantic Quota Report, DFO)

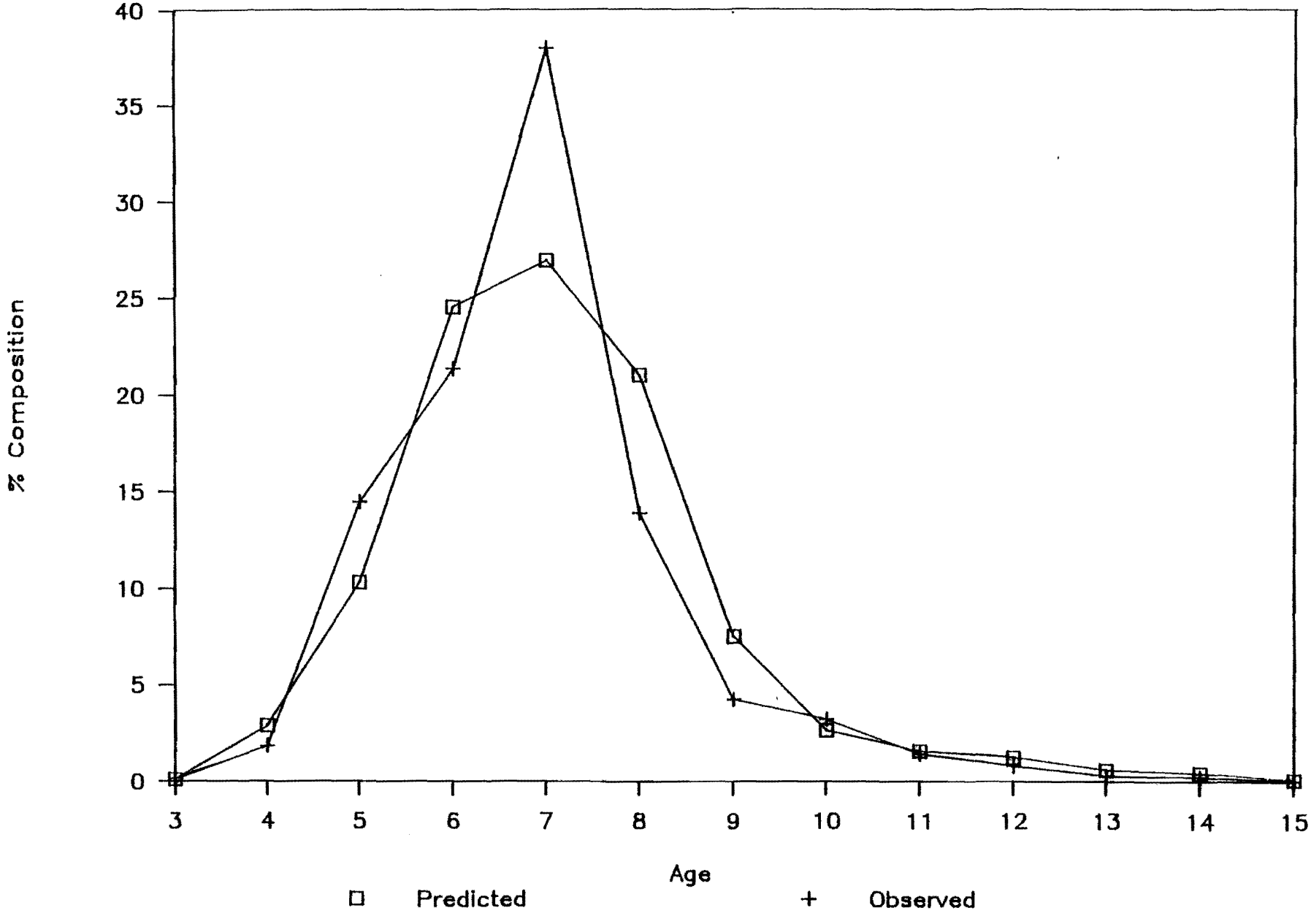
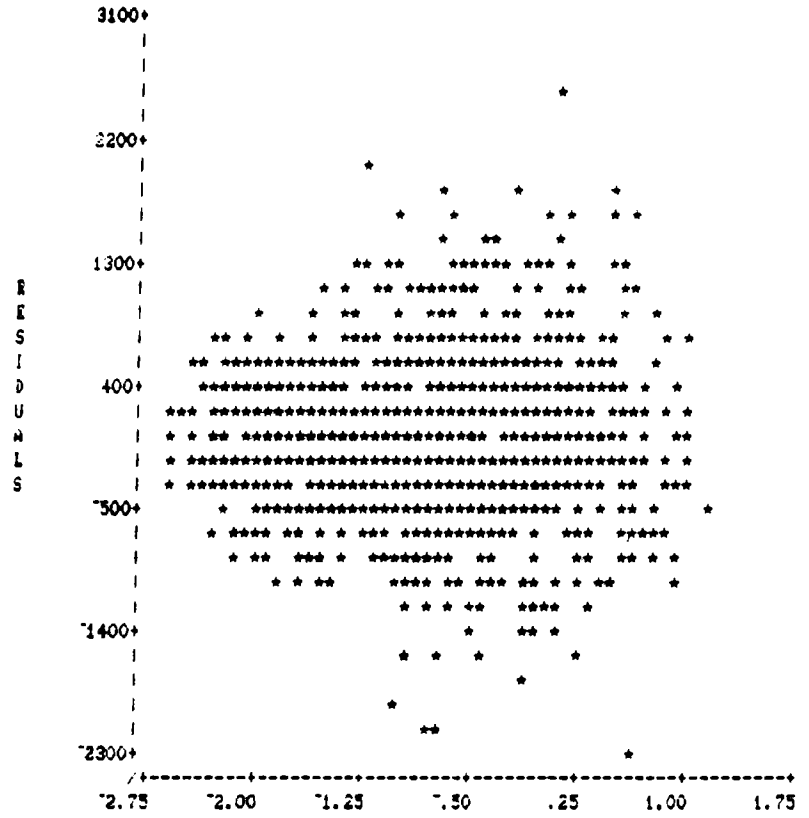


Figure 3 : Comparison of observed and predicted (CAFSAC 87/92) catch at age for 1987.



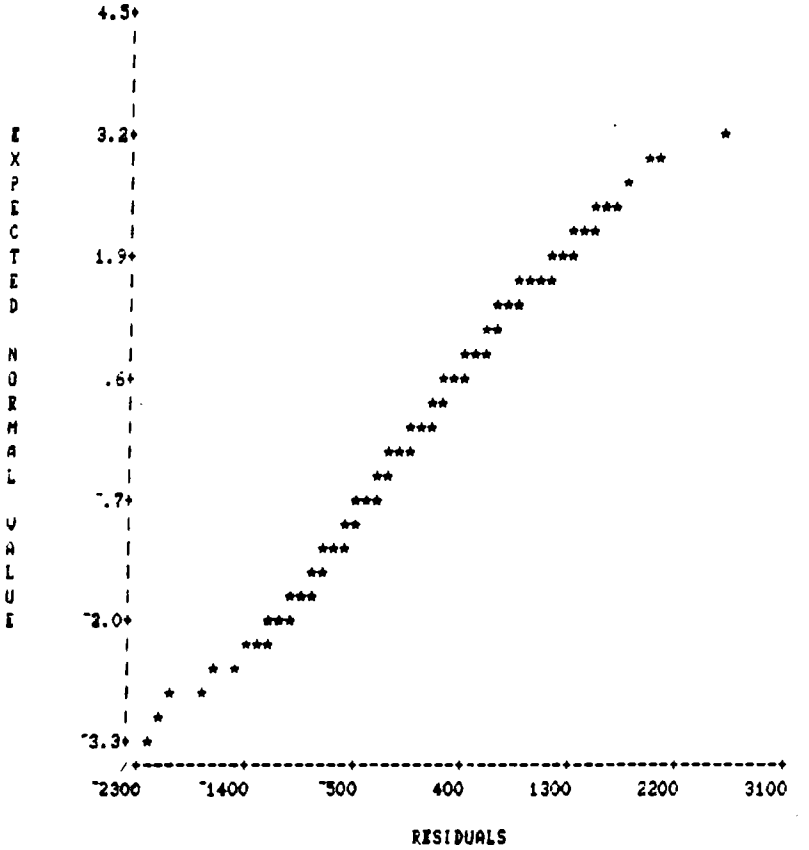


Figure 4 : Plots of Residuals for the multiplicative analysis of catch rates.

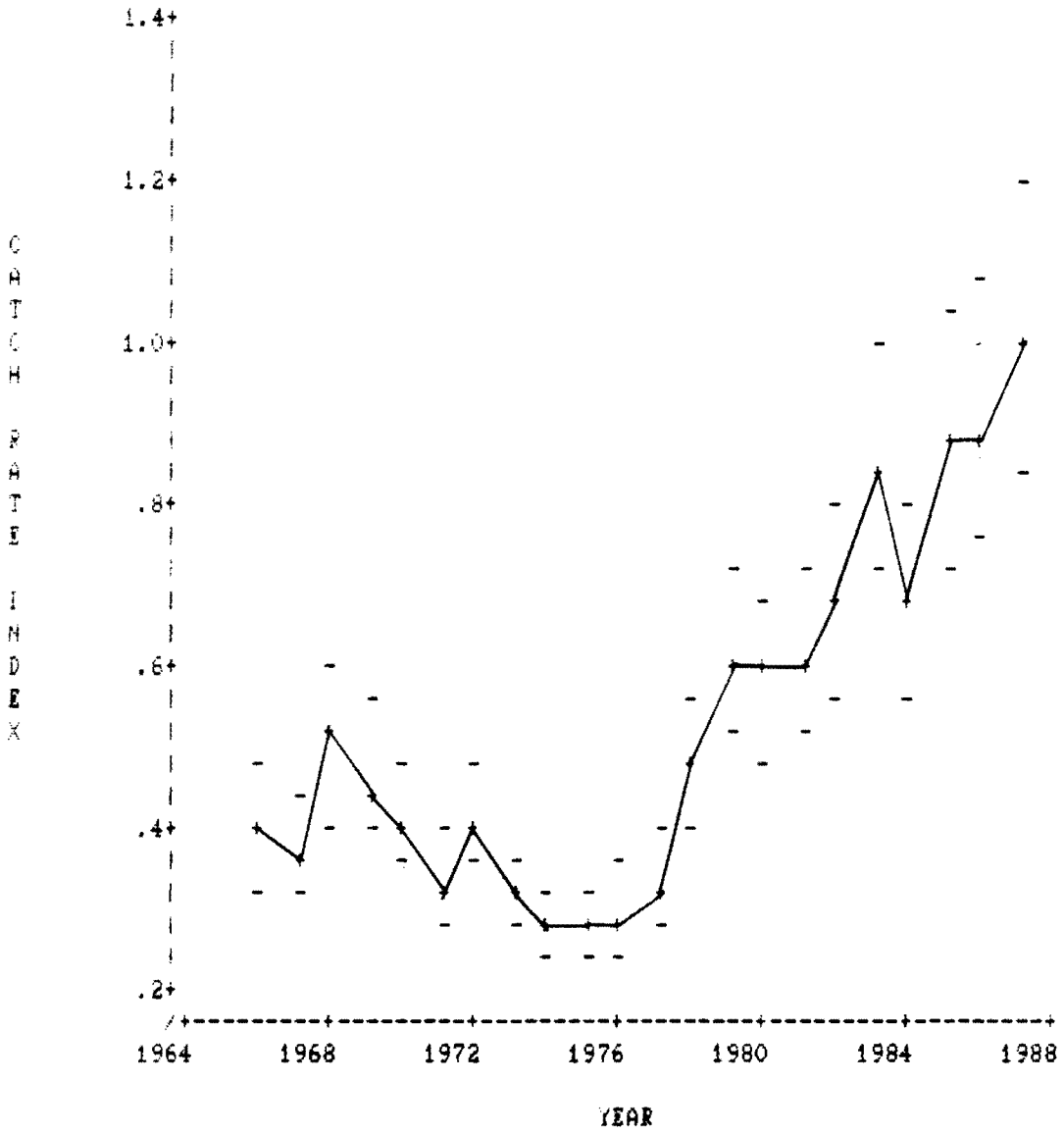


Figure 5 : Standardized otter trawl catch rate for 4TVn cod.

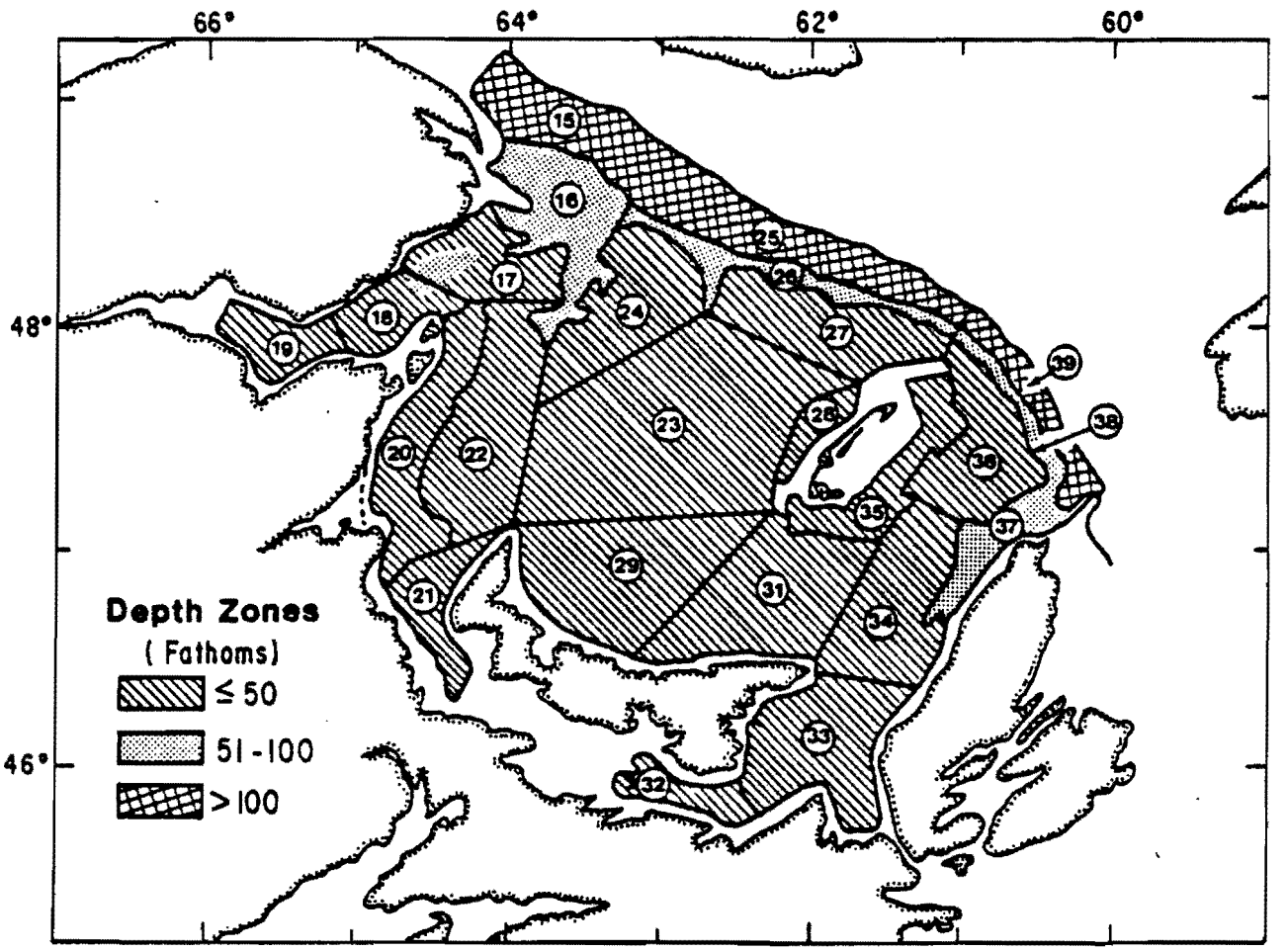
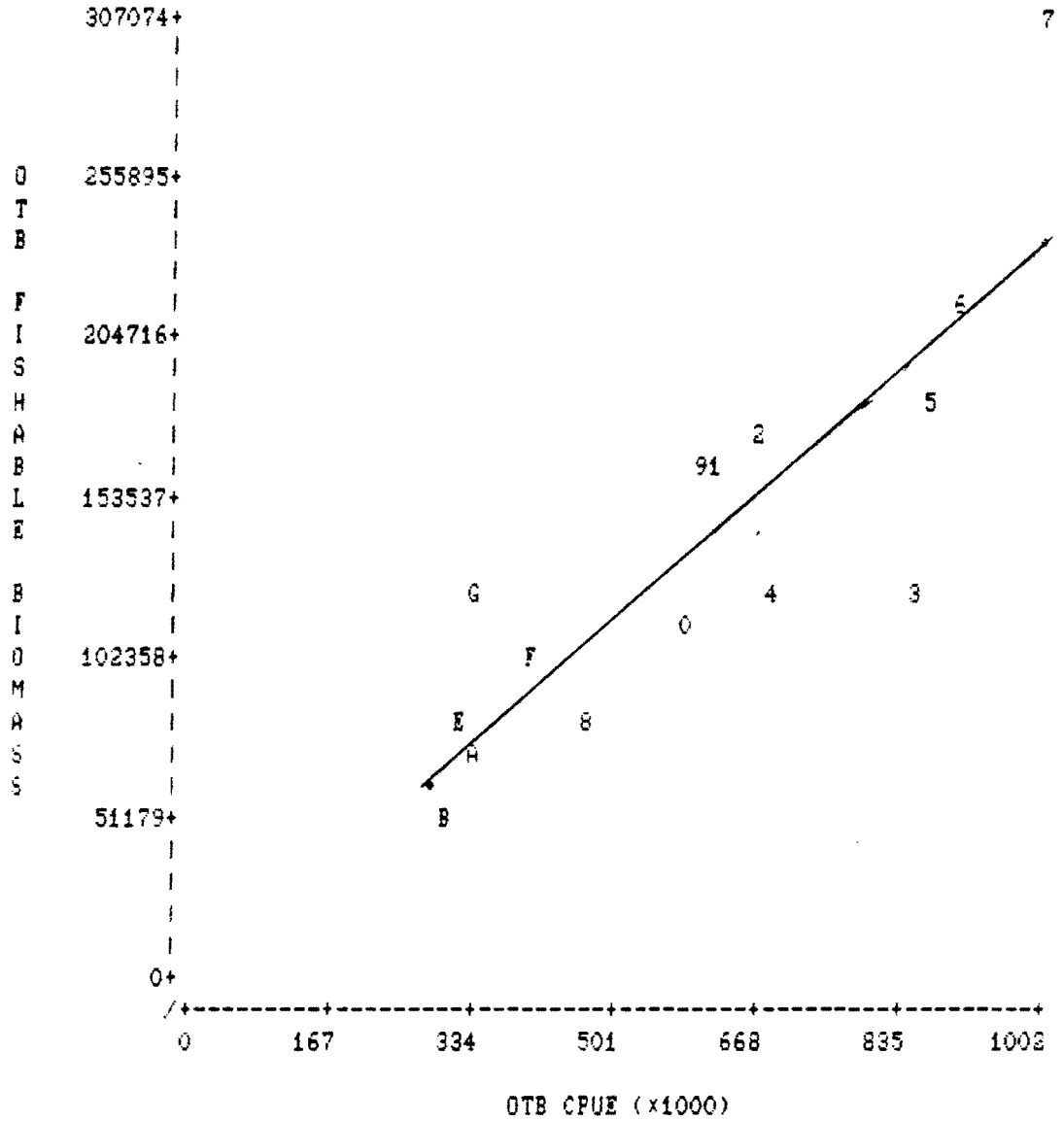


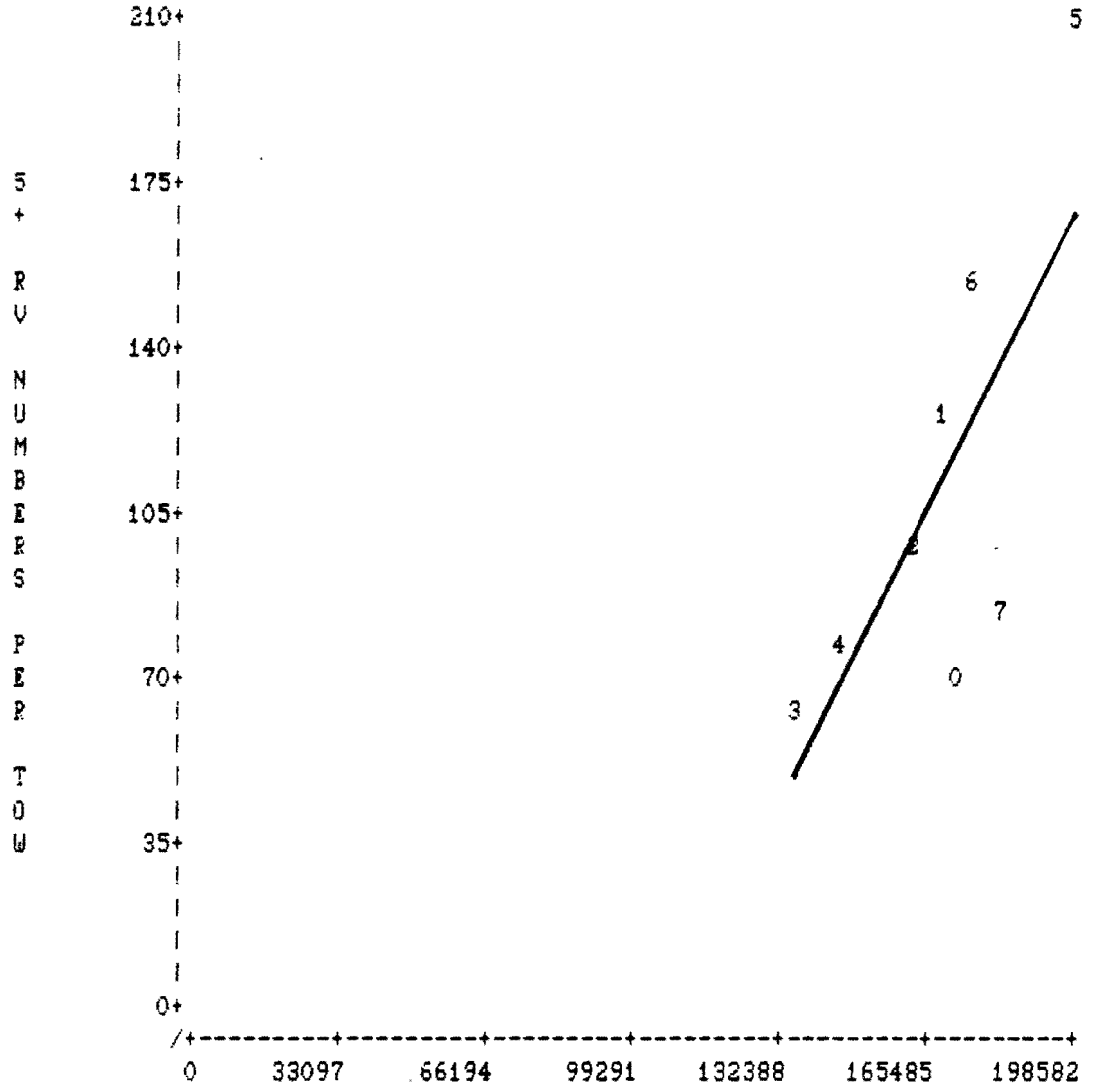
Figure 6 : Stratification scheme for the southern Gulf of St Lawrence research surveys



S	YEAR	RESIDUALS	IND	DEP
G	1971	1.300	334	119431
F	1972	.376	401	104004
E	1973	.328	321	83250
D	1974	-.206	286	56687
C	1975	.096	278	65068
B	1976	-.534	293	47234
A	1977	-.226	332	67025
8	1978	-.620	468	86144
9	1979	.706	608	164732
0	1980	-.669	588	113172
1	1981	.569	619	162700
2	1982	.498	675	173678
3	1983	-2.082	849	127537
4	1984	-1.205	685	118136
5	1985	-.634	872	182283
6	1986	.169	896	215349
7	1987	3.134	1000	307074

SSQ LAST 5 STAND RES 10.77078034

Figure 7 : Calibration of OTB fishable biomass vs OTB CPUE at Ft = 0.2.

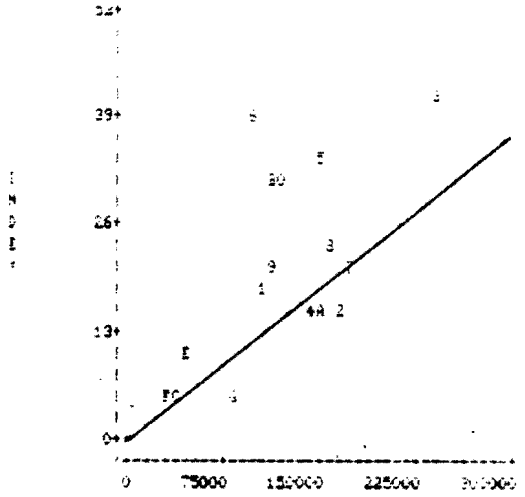


S	YEAR	RESIDUALS	IND	DEP
9	1979	-.045	135555	46
0	1980	-1.405	171554	72
1	1981	.440	167866	125
2	1982	-.125	161769	95
3	1983	.365	136908	62
4	1984	.358	146436	80
5	1985	1.143	198578	209
6	1986	.856	177050	157
7	1987	-1.586	181145	85

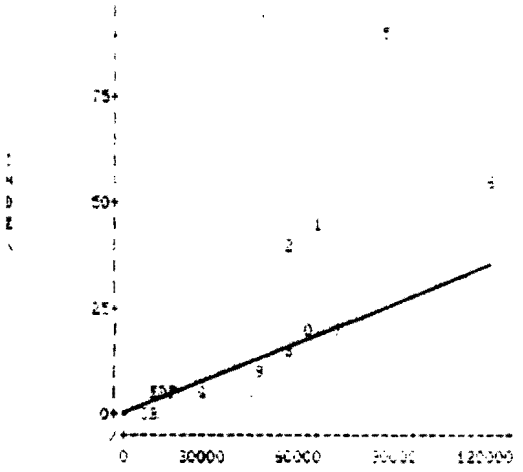
SSQ LAST 5 STAND RES 4.814561029

Figure 8: Calibration plot of 5+ RV numbers per tow vs 5+ SPA numbers at Ft=0.55. (1979 - 1987)

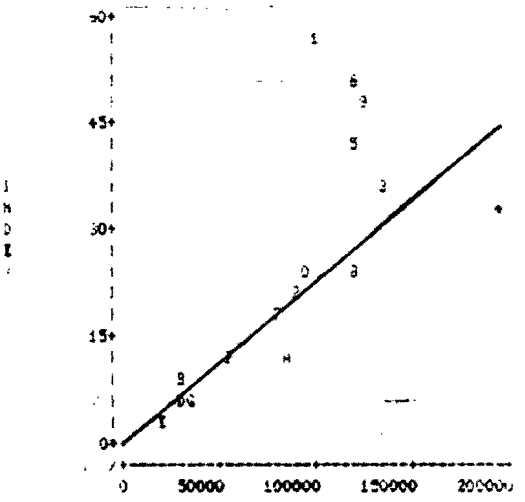
A) Age 3



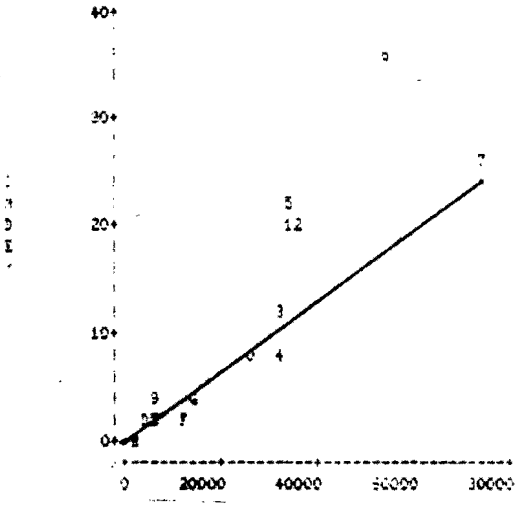
D) Age 6



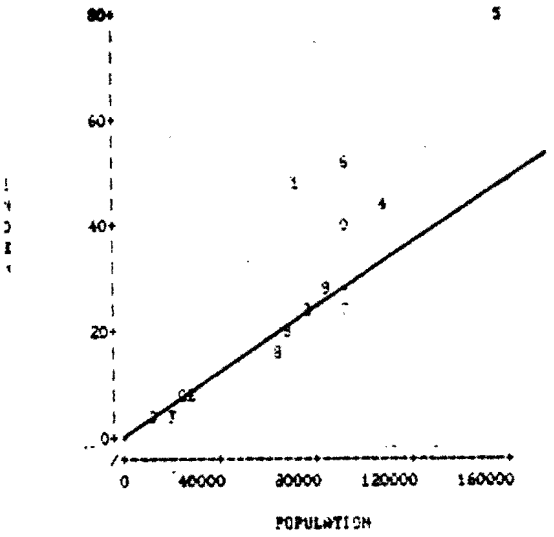
B) Age 4



E) Age 7



C) Age 5



F) Age 8

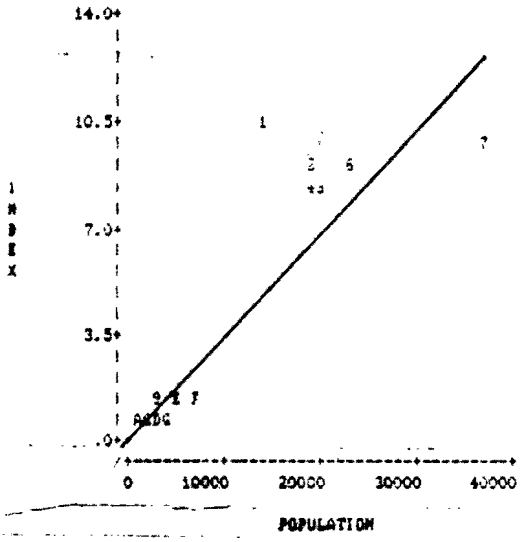
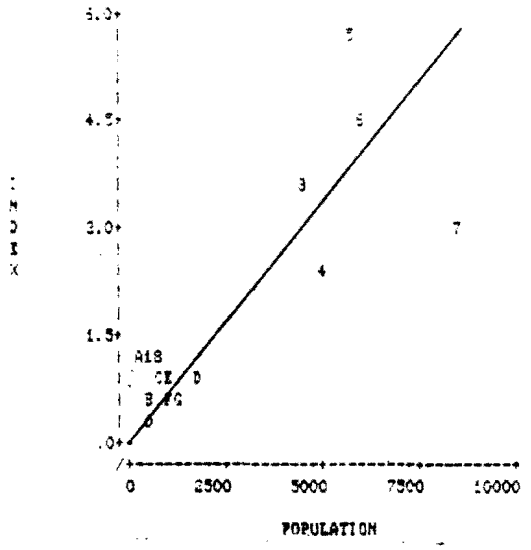
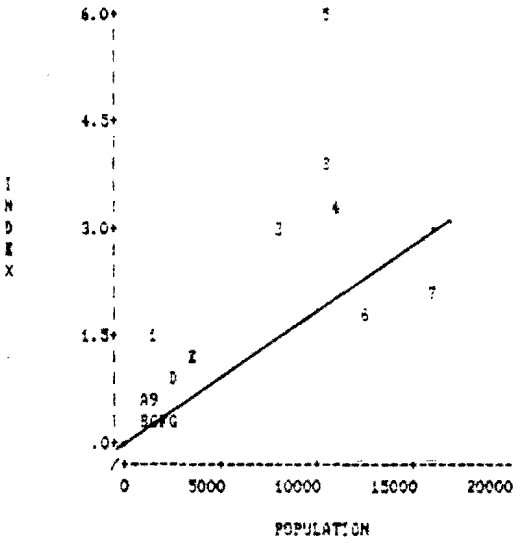


Figure 9: Plot of the relationships derived from the non-linear least squares calibration. A to H are age by age plots of RV mean numbers per tow and SPA estimates. I is plot of OTB-CPUE versus SPA fishable biomass estimates.

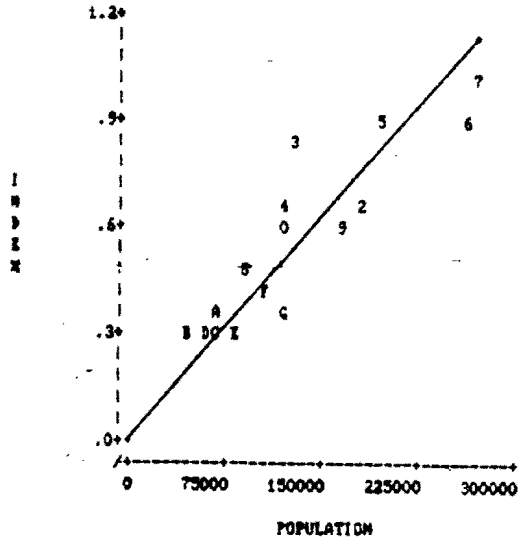
G) Age 9



H) Age 10



I) FISHABLE BIOMASS



Symbols

A	1971	1	1981
B	1972	2	1982
C	1973	3	1983
D	1974	4	1984
E	1975	5	1985
F	1976	6	1986
G	1977	7	1987
8	1978		
9	1979		
0	1980		

Figure 9 (cont'd)

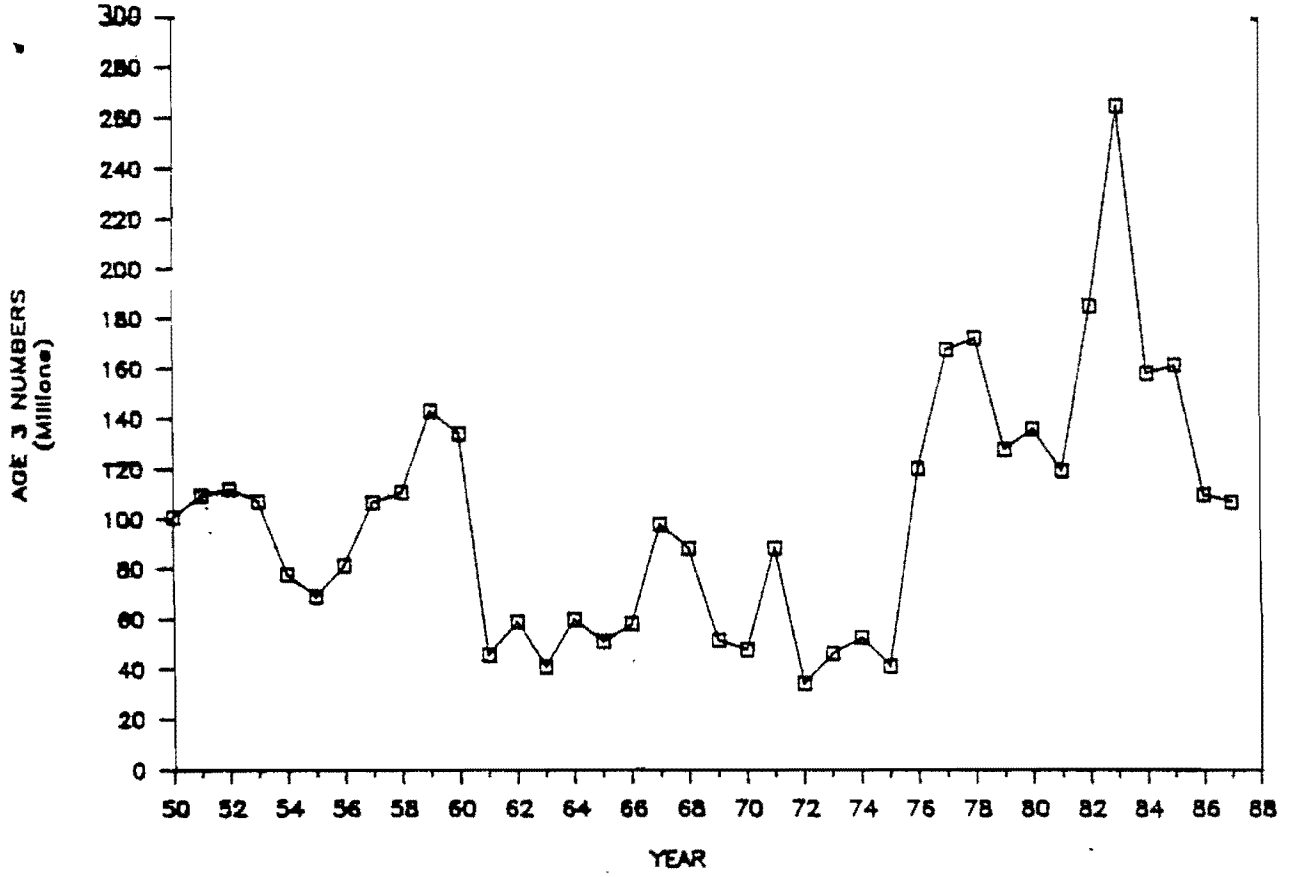


Figure 10: Recruitment (age 3 numbers) for the 4T-Vn cod stock (1950 - 1987).

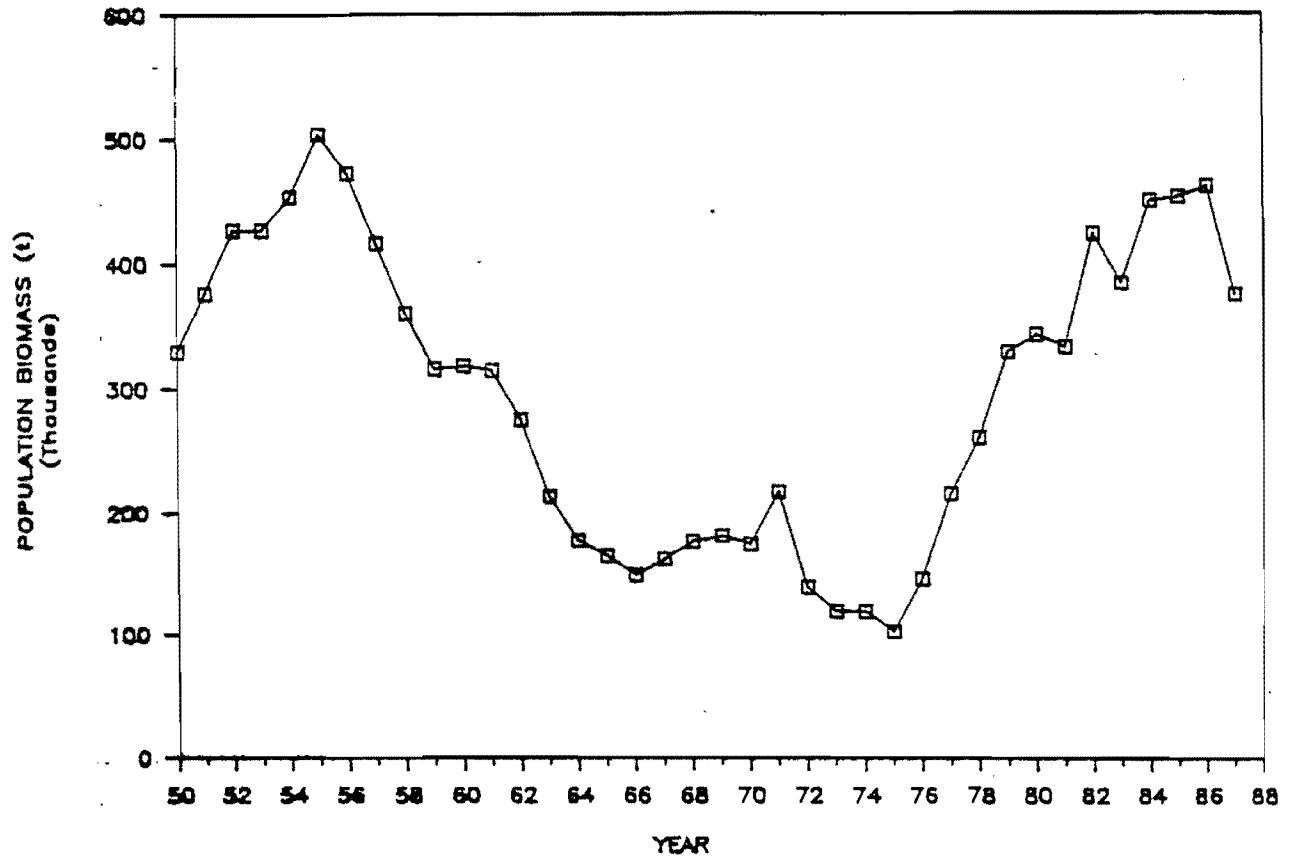


Figure 11: Population biomass for the 4T-Vn cod stock (1950 - 1987).

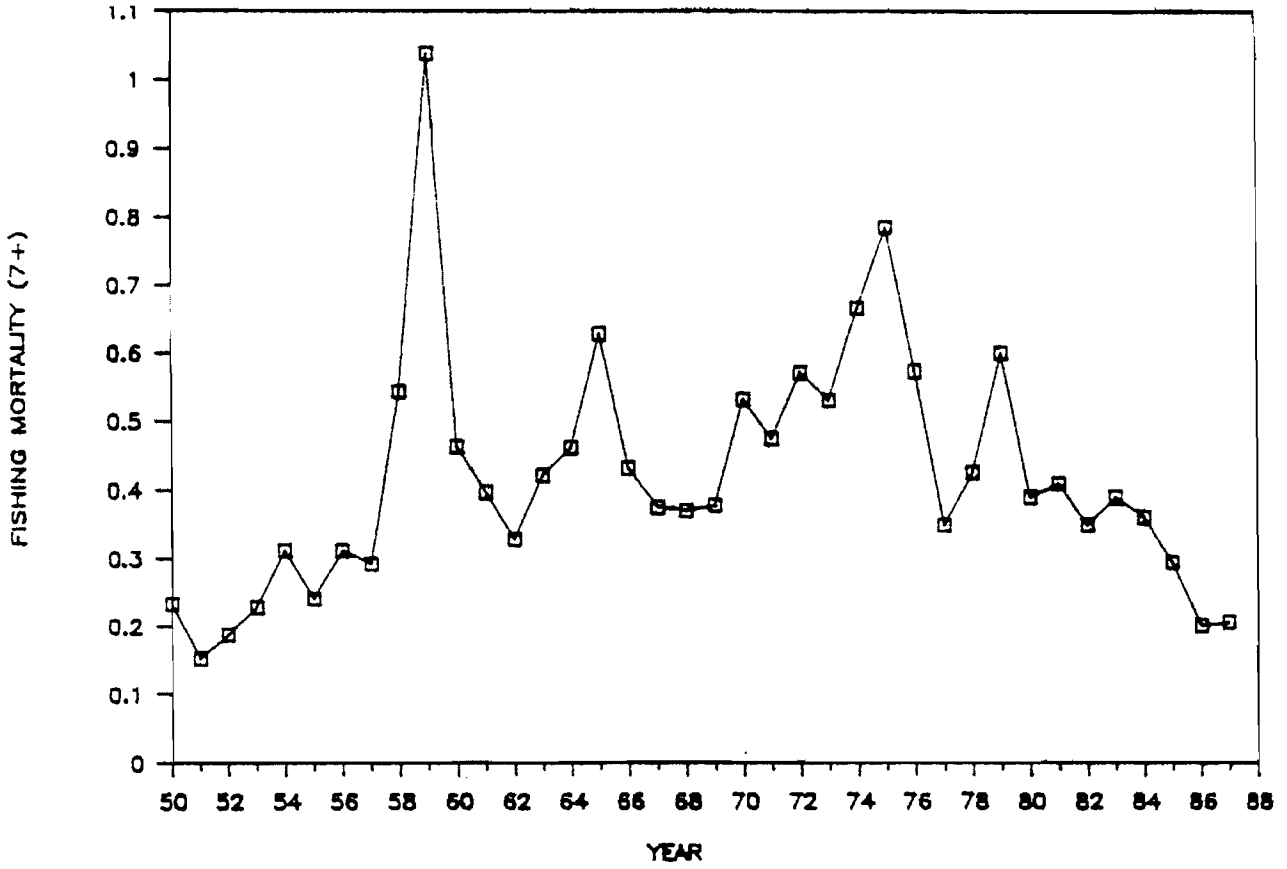


Figure 12: Fishing mortality for the 4T-Vn cod stock (1950 - 1987).

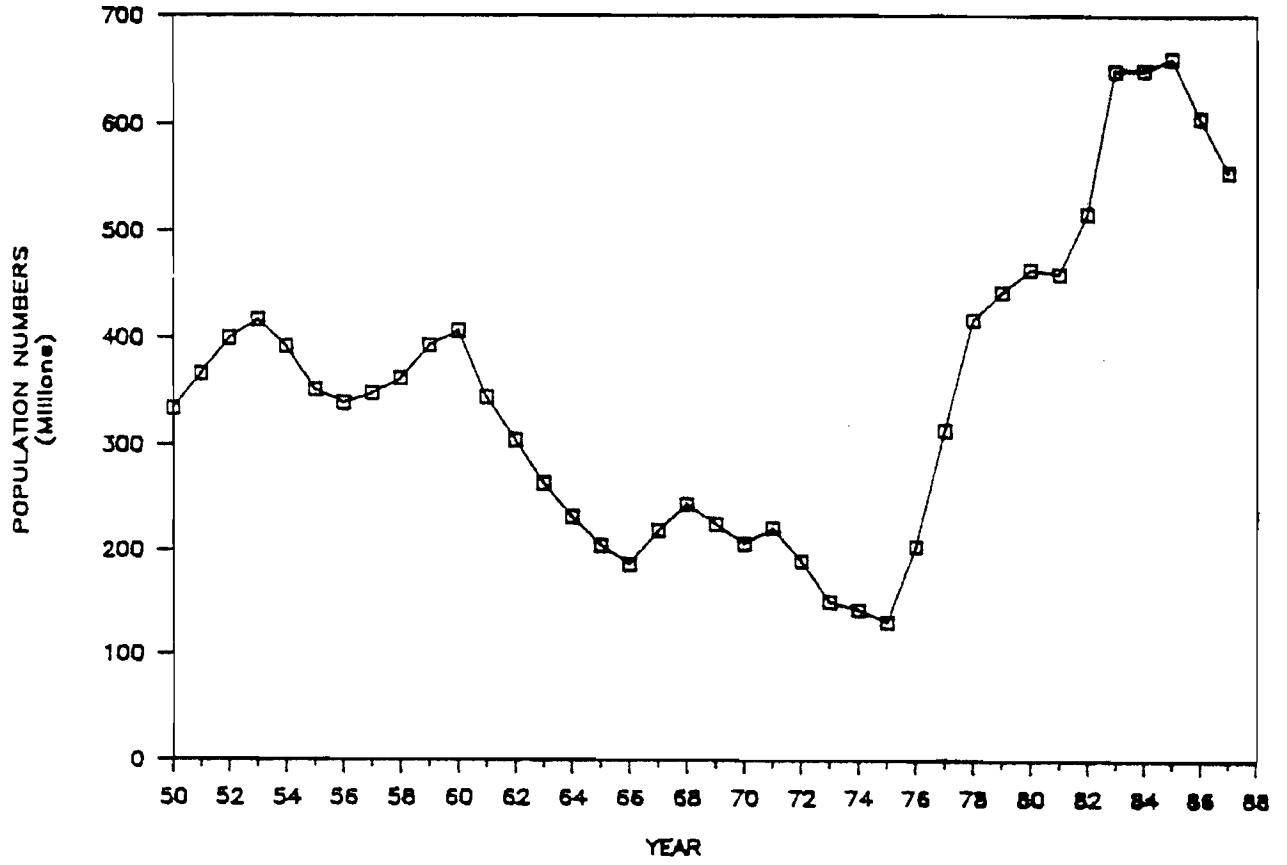


Figure 13: Population numbers for the 4T-Vn cod stock (1950 - 1987).

Appendix I : Final 4T cod catches (t round weight) during 1985 by gear type and month in Maritime Provinces, Newfoundland and Quebec.

MARITIMES

GEAR	MONTH J	F	M	A	M	J	J	A	S	O	N	D	TOTAL	% OF 4TVn (Jan-Apr) CATCH
Otter trawl					27	6	49		13	46	113		254	0.41
Otter trawl (side)		33			487	369	156	25	583	554	668	4	2879	4.63
Otter trawl (stern)	227			288	638	276	409	313	501	164	558	1153	4527	7.29
Danish seine				372	2223	1485	844	670	661	648	1743	935	9581	15.42
Scottish seine				93	801	472	155	47	59	92	311	77	2107	3.39
Pair seine					7	1	8	11	6	7	23	15	78	0.13
Gillnets (set)	1			5	152	138	571	433	327	243	60		1930	3.11
Drift gillnet				3	10	10	11	1					35	0.06
Set lines					2	39	88	73	90	55	447	91	885	1.42
Handlines					4	96	118	200	195	113	30	1	757	1.22
Miscellaneous	1				23	6	40	24	23	13	48	41	219	0.35
TOTAL	229	33	0	761	4374	2898	2449	1797	2458	1935	4001	2317	23252	37.42

NEWFOUNDLAND

Otter trawl (stern)	43	35	19	1072									1169	1.88
TOTAL	43	35	19	1072									1169	1.88

QUEBEC

Otter trawl				1	20	8		81	181	64	17		372	0.60
Otter trawl (side)				203	1787	2391	3120	1547	1856	1422	426		12752	20.52
Otter trawl (stern)				203	312	417	625	420	461	425	139		3002	4.83
Bottom pair trawl							22	109	66	29	26		252	0.41
Danish seine						17	7	2	2		28		56	0.09
Set gillnet				98	1055	758	589	594	172	51	4	1	3322	5.35
Set lines				23	138	377	401	567	514	295	7		2322	3.74
Handlines				3	49	203	339	283	285	127	14	1	1304	2.10
Miscellaneous						14	1			1			16	0.03
TOTAL	0	0	0	531	3361	4185	5104	3603	3537	2414	661	2	23398	37.65
TOTAL 4T	272	68	19	2364	7735	7083	7553	5400	5995	4349	4662	2319	47819	76.96

Appendix II : Provisional 4Vn (Jan.-Apr.) cod catches (t round weight) during 1985 by gear type and month for Maritime Provinces, Newfoundland, France and Japan.

GEAR TYPE	J	F	MONTH M	A	TOTAL	% OF 4TVn (Jan-Apr) CATCH
Maritimes						
Otter trawl (side)	951	837	543	229	2560	4.12
Otter trawl (stern)	1312	889	168	160	2529	4.07
Handlines				1	1	0.00
Set lines				1	1	0.00
TOTAL	2263	1726	711	391	5091	8.19
NEWFOUNDLAND						
Otter trawl (stern)	1090	932	375	67	2464	3.97
TOTAL	1090	932	375	67	2464	3.97
FRANCE						
Otter trawl (stern)	1877	4483		402	6762	10.88
Total	1877	4483		402	6762	10.88
JAPAN						
Otter trawl (stern)				2	2	0.00
Total				2	2	0.00
TOTAL 4Vn	5230	7141	1086	862	14319	23.04