The 4X Haddock Resource: A Problem in Supply and Demand

by

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ABSTRACT

This evaluation of 4X haddock stock size uses both a Survivor Analysis and a Cohort Analysis to determine 1983 fishing mortality. Contrary to previous practice, the Cohort Analysis uses only the minimization of the last point residual to optimize the fit. Since 1982, the fishery has been unable to take the TAC. In 1984, the predicted catch of 20,000 t fell far short of the TAC of 32,000 t. Much of this decline in catch is due to falling offshore trawler fishing effort and a decline in inshore dragger catch rates. At present, age 4 and 5 individuals comprise over 50% of the catch in numbers and weight. Both survey and commercial catch rates show declines in population size, the latter more so than the former. As well, recruitment in recent years is average to below average. Both the Survivor and Cohort Analysis indicate a 1983 age 5+ fishing mortality of 0.65. In addition, the comparison of the two approaches shows that Cohort Analysis has seriously underestimated fishing mortality since 1977. No reason for this is obvious. These analyses indicate that fishing mortality in recent years has been very high, often in the region of F_{max}. The declining stock size is a direct result of this. Catch projections at $F_{0.1}$ in 1985 indicate that the TAC should be set in the region of 10,000 t to lower fishing effort on this stock. Although this would result in a 69% cut in the TAC, it must be kept in mind that the 1983 catch will probably not exceed 20,000 t, making the rationale for a cut in TAC more obvious.

Résumé

La présente évaluation de la taille du stock d'aiglefins de 4X fait appel à la fois à une analyse des survivants et à l'analyse de cohortes pour déterminer la mortalité par pêche en 1983. Contrairement à la pratique antérieure, l'analyse de cohortes n'utilise que la minimisation du résidu au dernier point pour optimiser l'ajustement. Depuis 1982, les pêcheurs sont incapables d'atteindre le TPA. En 1984, la prise prévue de 20 000 t était de beaucoup inférieure au TPA de 32 000 t. Cette diminution de la prise est due en grande partie à une diminution de l'effort de pêche des chalutiers hauturiers et à une diminution des taux de capture des petits chalutiers côtiers. A l'heure actuelle, les poissons d'âge 4 et 5 constituent plus de 50 % de la prise, tant en nombre qu'en poids. Les taux de capture par les navires de recherche et les bateaux commerciaux montrent tous deux une diminution de la taille de la population, baisse qui est plus évidente dans le cas des bateaux commerciaux. De même, le recrutement au cours des dernières années varie entre moyen et inférieur à la moyenne. L'analyse des survivants et l'analyse des cohortes indiquent un mortalité par pêche chez les poissons d'âge 5+ de 0,65 en 1983. De plus, une comparaison des deux méthodes montre que l'analyse de cohortes a entraîné une sous-estimation importante de la mortalité par pêche depuis 1977. Il n'y a aucune raison évidente pour expliquer cette situation. Ces analyses indiquent que la mortalité par pêche a été très élevée au cours des dernières années, souvent dans la région du F_{max}. La diminution de la taille du stock en est la conséquence directe. Les prévisions de capture à $F_{0,1}$ en 1985 indiquent que le TPA devrait être fixé aux environs de 10 000 t afin de réduire l'effort de pêche dirigé sur ce stock. Bien qu'ils s'agisse d'une réduction de 69 % du TPA, il faut garder à l'esprit que la prise de 1983 ne dépassera probablement pas 20 000 t, ce qui justifie encore davantage la réduction du TPA.

INTRODUCTION

Cohort analyses have been used to determine the size of the haddock population in NAFO Division 4X since 1974. The criteria used to tune the analysis have included the maximization of the chosen relationship's R^2 and proximity of the intercept to the origin. Recent work (Mohn, 1983) has shown that the most appropriate tuning criterion is the minimization of the residual of the last point. This method was used to tune the cohort analysis in this paper, which represents a significant departure from previous practice. As in recent years, a Survivor Analysis (Doubleday, 1981) was also conducted to determine population size. Stock sizes for 1962 to 1983 are determined and yield projected to 1985, under $F_{0.1}$ conditions.

TRENDS IN REPORTED LANDINGS

Annual Trends

The long-term average annual reported catch for 4X haddock is about 20,000 t. This level has rarely been maintained for long periods. Prior to the mid-1960s, Canadian and US fishing vessels landed 15,000-20,000 t annually. In 1965-66, the Canadian offshore fleet expanded dramatically and displaced U.S. fishing effort. As well, landings by the USSR substantially increased (Figure 1). The high exploitation rates caused a sharp stock decline which provoked the establishment of quotas and closed spawning areas in 1970 in an attempt to curb fishing effort.

The resource showed signs of recovery in the mid-1970s and yield steadily increased to reach a maximum of almost 31,000 t by 1981. During this recovery period, TACs were consistently overrun (Table 1). In 1982, the TAC was set high in anticipation of high stock abundance but in both 1982 and 1983, the catch fell substantially short of the TAC. This is predicted to occur in 1984 as well. Most of the shortfall is occurring in the inshore and offshore mobile gear fleets (Table 2).

Canadian Fishery by Gear Type, Tonnage Class, and Unit Area

The large offshore trawlers which entered the fishery in the mid-1960s have rarely fished in 4X (Figure 2) since 1982. These vessels are under the Enterprise Allocation (EA) system and the apparent scarcity of haddock in 4X has caused them to fish elsewhere. Their effort has been replaced by that of the small (tonnage class 1-3) draggers operating out of southwestern Nova Scotia. Landings by this gear sector are now the predominant part of the fishery (Table 3). Longliner effort, although increasing, has not kept up with that of the draggers.

AGE COMPOSITION OF THE COMMERCIAL CATCH

Sampling Intensity

Since 1970, sampling coverage by gear type has generally been good (Table 3). However, prior to 1981, most effort was directed toward the offshore fleet, to the detriment of inshore fleet sampling coverage. This has since been rectified and now about one sample is taken per 200 t fish landed, regardless of gear sector.

1983 Aging

A summary of the 1983 sampling and aging is provided in Table 4. Of 119 samples taken, 60 (51%) were aged. This low percentage was due to a change in aging staff which necessitated a learning period which in turn reduced overall aging time available.

When the 1983 calculated catch at age was compared to that predicted by O'Boyle et al. (1983), substantial differences were observed, particularly in the strength of the 1978 year-class (Table 5). An aging problem was suspected and 22 of the samples were re-aged. These samples were taken from those collected during the first two quarters of the year, at which time the problem was thought to be maximal, due to the presence of otolith checks caused by spawning activity.

The re-aging caused only minor changes to the catch at age (Table 6) and thus the projected and observed catch at age remain substantially different (Figure 3). If the aging is correct then the problem lies in the determination of the partial recruitment values.

The 1962-83 Catch-at-Age Matrix

Construction of the catch-at-age matrix prior to 1978 is discussed by O'Boyle (1981a). A key point is that no adjustment has been made for the USSR catches in the mid-1960s. The length frequency of the landings by this country was assumed to be the same as that for Canada. This is probably a bad assumption and efforts are presently underway to rectify this analysis. However, this should be kept in mind when analysing the present data set for recruitment studies.

The 1978-79 catch at age was reconstructed as per O'Boyle (1981a). The 1980-81 catch at age was reconstructed using gear (otter trawler, longliner, and miscellaneous gear), area (mnopu and qr), and quarter for stratification (unit area "u" is "unit area unknown").

In 1982, tonnage class was added to the stratification scheme and seasonally adjusted length-weight relationships (O'Boyle et al., 1983) were used in converting sample numbers to catch numbers. For 1978-83 only Canadian sampling was used as no foreign sampling data was available. No correction for discarding has been applied.

In terms of both numbers and weight, the 1979 year-class dominated the 1983 catch (Tables 7 and 8). Over 50% of the yield came from ages 4 and 5.

On a weight basis, the partially recruited age groups (ages 1-4) have not substantially increased their contribution to the total catch since 1978 (Figure 4a). However, both the average age and weight of a fish in the catch have been declining since 1980 (Figure 4b and 4c). As well both are more comparable to those one would see in a population exploited at F_{max} rather than $F_{0.1}$.

STOCK ABUNDANCE TRENDS

Groundfish Bottom Trawl Surveys

Canadian summer bottom trawl surveys have been conducted in 4X (Figure 5) since 1970. The vessel used during 1970-81 was the A.T. Cameron. In 1982 and 1983 the Lady Hammond and Alfred Needler respectively were used. Preliminary results (Fanning, pers. comm.) of comparative fishing experiments indicate that the fishing power of both the Lady Hammond and Alfred Needler is 1.22 times higher than that of the A.T. Cameron. Consequently, the Lady Hammond and A. Needler catch rates were adjusted downward to make them comparable to those of the A.T. Cameron. These are presented in Table 9.

The median smoothed abundance trends show asymptotic numbers since 1980 and slightly declining biomass since 1980 (Figure 6). The abundance of age 2-5 individuals has stopped its dramatic increase while the abundance of 6+ individuals is falling.

A recruitment index was developed as per O'Boyle (1981b) using the age one and two catch rate information. The 1979 and 1980 year-classes appear to be strong while those of 1981 and 1982 are average and below average respectively (Table 10).

Commercial Catch Rates

Use of commercial catch rate indices has been discouraged in the past due to both reporting problems and bias in the data due to the recent rapid technological change in the fishery. Nevertheless, they are examined to discern gross changes in stock abundance as well as to obtain an understanding of the industry's view of stock size.

Catch rate indices were developed for draggers (TC 2-3) operating in 4Xq-r during May-August, and large trawlers (TC 4-5) operating in 4Xm-p during Jan-March and April-June. These data (Table 12) indicate very substantial declines in fishable biomass since 1977 for the small boats and 1979 for the large ones. Present catch rates are comparable to those observed in the mid-late 1970s (Figure 7).

The multiplicative model (Gavaris, 1980) was fit using monthly observations to estimate the parameters for the categories given in Table 11a. Using the

total catch (ages 1-13+) produced a trend (Table 11c, Figure 8b) which was not consistent with the trends found in the research surveys or SPA fishable biomass. The multiplicative model analysis for a combined ages assumes that the gear selection patterns are similar across all the categories. It is known that age selection patterns for haddock vary across seasons and areas. Thus a satisfactory analysis may not be possible unless the catch biomass is partitioned into age groupings with similar age selection coefficients for each category. The appropriate data were not available. In order to test the hypothesis, a preliminary analysis was conducted using data for ages 7-10 (Figure 8a, Table 11b). Although not suitable for use in quantitative analyses, the trend appears more consistent with other information. In particular, the series clearly shows the entry of the 1963 year-class at age 7 in 1970. The combined ages analysis suggests much greater recruitment in the late 1970s than can be explained using sequential population methods.

SEQUENTIAL POPULATION ANALYSIS

Survivor Analysis

O'Boyle (1981a) used Survivor Analysis (Doubleday, 1981) for the first time in the 4X haddock stock evaluation. The method has the advantage of fitting the survey data to the population numbers derived from an SPA and is thus objective. Its main weaknesses are: 1) it assumes these data are log normally distributed and 2) there is a linear relationship between survey catch rate and stock biomass. This model is not suitable for age groups which are not well sampled by the survey. Thus O'Boyle (1981a) restricted his analysis to the age 3 to 8 individuals. As a consequence, the method cannot generate 0+ population numbers but does provide a terminal fully recruited fishing mortality (F_t) which can be used in a cohort analysis.

In order to obtain some idea of how well the Survivor Analysis is predicting terminal fishing mortality, a comparison was made between Survivor estimates and those from O'Boyle et al., (1983) for the 1975-82 period (Table 13). The Survivor Analysis was run separately on the 1970-75, 1970-76, 1970-77, etc. data sets, thus simulating a real assessment situation. The size of the calibration block was set for ages 3 to 7 and one year less than the time span in the data set. K, the calibration constant, was set to level off at age 6.

Although there was a large amount of variability in the comparisons, it appeared that the cohort analysis was underestimating the F values for 1981 and 1982. This was particularly evident when these data were aggregated into partially recruited (ages 3 to 5) and fully recruited (ages 6 to 7) age groups. The conclusion was the same whether or not the estimates were unweighted or weighted averages (Table 14).

Discrepancies in the 1975-77 data set were also observed. The F values from the cohort analysis are converged and thus probably reflect reality to a greater extent than the Survivor Analysis. For these years, the latter had relatively low Root Mean Square (RMS) values and coefficients of variation (Table 15). However, the analysis in both 1975 and 1976 had converged relatively slowly, indicating stability problems in the analysis, perhaps due to a short time series. Indeed, for 1982, convergence took only nine iterations, indicating that the longer the time series, the faster the convergence.

Notwithstanding the problems in the Survivor Analysis for the 1975-77 period, it seems likely that this analysis is providing a realistic view of stock size for 1978-1982. If this is the case, then the cohort analysis is seriously underestimating terminal fishing mortality for the current year.

The results of the Survivor Analysis on the 1970-83 data set (Table 16) provided an unweighted ages 6-7 fishing mortality in 1983 of 0.648 (weighted estimate of 0.623). This is substantially higher than recent survivor estimates for these age groups (Table 14).

Cohort Analysis

Determination of the age 12 and 13+ fishing mortalities for 1962-83 followed the procedure outlined in O'Boyle et al., (1983). The age of full recruitment was estimated by dividing the catch at age by the survey abundance at age. This provided an estimate of age 5, which is consistent with both the catch curve and the Survivor Analysis. The peak catch in the catch curve occurs at age 4.

In past analyses the criteria for tuning have been 1) maximization of r, and 2) proximity of the origin to zero. Mohn (1983) criticized the use of these. This analysis used only the minimization of the last point residual as the criterion for tuning.

The fully recruited (age 5+) fishing mortality was determined thus:

a) an ordinary least squares regression of cohort analysis age 5+ numbers on age 5+ survey numbers per tow was calculated, using all points except the last three. These are affected by the input data and thus were not be used in the analysis;

b) the residuals for the last three points were normalized by the regression's standard deviation; and then

c) the last three residuals were summed. The fully recruited fishing mortality which minimized this summed residual was 0.65. Figure 9 presents this data fit.

The fishing mortalities for ages 2 to 4 were calculated by minimizing the last point residual only i.e. putting last point on line.

The age 4 fishing mortality was computed first (Figure 10) as F = 0.437. This fixed the age 3 1981 and 1982 estimates. Next the 1983, age 3 estimate of 0.155 was calculated (Figure 11) followed by that of 0.005 for age 2 (Figure 12).

Final Cohort Analysis

The final cohort analysis results are presented in Table 17, with cumulative Fs and partial recruitment estimates, calculated at per O'Boyle (1981b), given

in Table 18. The former indicates that the analysis is not completely converged until at least 1980. The latter shows that during 1978-79, the age of full recruitment switched from about age 7 to age 5. This is having dramatic yield consequences for the resource.

A comparison of partial recruitment values calculated in recent years is given in Table 19. The long-term average, as calculated with a separable VPA (SVPA) shows full recruitment at age 6. O'Boyle et al., (1983) also had age 6 as fully recruited. The major differences between the present and earlier analyses were the recruitment estimates for ages 2 to 4, which here are higher for ages 3 and 4 and lower for age 2 than calculated in 1983.

These differences produce lower estimates of age 1 recruitment compared to those made previously (Table 20). The largest changes are in the size of the 1979 and 1980 year-classes, which are now 43% and 52% of those provided by O'Boyle et al., (1983) when an F_t of 0.4 was used.

The fully recruited fishing mortality (F_t) was at a minimum in 1967, and steadily increased to a peak of 0.73 in 1977 (Figure 13). Thereafter it fell briefly to a low of 0.46 before rising to its current level of 0.65, which is close to F_{max}.

In addition to high exploitation rates, short-term recruitment prospects do not look good. The 1975 year-class was the last good year-class with 1977 and 1980 slightly lower. The 1981 and 82 year-classes are average and below average respectively (Figure 14). The 1977 year-class shows up stronger here than in the survey data (Table 10).

CATCH PROJECTIONS

The yield per recruit analysis presented to CAFSAC in May 1983 is given in Table 21. Using a long-term recruitment estimate of 28,500 x 10^3 and an $F_{0.1}$ yield of 0.596 kg, one can expect almost 17,000 t of catch from this stock as a long-term average. This is substantially lower than recent reported landings. Thus current yield levels are unsustainable in the long-term.

Catch projections were run to 1985 using starting population conditions as given in Table 22. An age 1, 1983 value of 20,000 x 10^3 fish was calculated from the relationship of 1969-81 year-class age 1 cohort analysis numbers with the equivalent survey numbers per tow (Table 23) estimates.

Two assumptions were considered for 1984: $F_{0.1}$ caught and 20,000 t caught. The 1985 exploitation was at $F_{0.1}$. Under these conditions, the 1985 catch would be 12,089 and 9,894 t respectively (Table 24).

These short-term projections are very dependent on the reliability of the recruitment estimates. Table 25 illustrates this in qualitative terms. For the 1985 5+ ages, the catch projection is solely based on the cohort analysis results. The age 4 estimate is dependent on the accuracy of the 1983 age 2 partial recruitment value. Yield for ages 1-3 are essentially guesses. In terms of catch, about 2,406 of the 9,894 t (24%) has a high degree of uncertainty.

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Table 1. Reported nominal catch (t round) of haddock from NAFO Division 4X (excluding unit area 4Xs) by country. The numbers in brackets represent the number of commercial samples in that year.

YEAR	CANADA (MQ)	CANADA (Nfld)	USA	USSR	SPAIN	OTHER	TOTAL	TAC
1968	27277 (48)	-	2856	335	116	36	30620	-
1969	27413 (55)	-	1707	-	473	19	29612	-
1970	15560 (26)	-	1639	2	370	12	17583	18000
1971	16067 (29)	-	656	97	347	1	17168	18000
1972	12391 (36)	-	411	10	470	1	13283	9000
1973	12536 (30)	-	268	14	134	6	12958	9000
1974	12246 (25)	-	662	35	97	-	13040	-
1975	15991 (56)	-	2109	39	7	2	18148	15000
1976	16294 (45)	-	972	-	95	5	17366	15000
1977	19561 (79)	-	1649	2	-	12	21224	15000
1978	25300 (62)	114	1135	2	-	27	26578	21500
1979	24287 (49)	268	69	3	-	15	24642	26000
1980	28215 (56)	75	256	38	-	37	28621	28000
1981	30156 (82)	113	342	-	-	16	30627	27850
1982	23216 (92)	28	767	-	-	4	24015	32000
1983	24446(119)	44	479	17	-	7	24993	32000

Long-term averages:

A. 1931 - 60 = 16854 t
B. 1931 - 83 = 20000 t
C. 1961 - 83 = 24405 t

Table 2. Recent Canadian fishery allocations and the respective reported catch (t) of 4X haddock. Information from Atlantic Quota Reports.[1]

Year	Report Date	Fleet	Allocation	Reported[2] Catch	%
1976		All Vessels	13300	15715	118
1977		All Vessels	13400	20220	151
1978		All Vessels	21500	25518	119
1979		125'	17500	17949	103
		125'	8500	6471	76
1980		125'	22500	23585	105
		125'	5500	5095	93
1981	31/12	125'	22350	25102	112
		125'	5500	5380	98
1982	31/12	FG. 65'	8850	8168	92 (66)
		MG. 65'	15000	12909	86 (60)
		FG. 65-100'	100	124	124(119)
		MG. 65-100'	1000	567	57 (45)
		MG. 100'	7050	2829	40 (31)
1983	21/12	FG. 65'	8850	8753	99 (66)
		MG. 65'	15000	12809	85 (70)
		FG. 65-100'	100	106	106(106)
		MG. 65-100'	1000	206	21 (20)
		MG. 100'	7050	2394	34 (31)
1984	12/9	FG. 65'	8850	4728	- (53)
		MG. 65'	15000	8896	- (59)
		FG. 65-100'	100	2	- (2)
		MG. 65-100'	1000	33	- (3)
		MG. 100'	7050	530	- (8)

[1] Numbers in brackets indicate percentage of allocation landed by mid-September of that year.

[2] These figures are based on hail information and thus are unofficial statistics and are not comparable to those in Table 1.

Table 3. Reported nominal catch (t round) of haddock from NAFO Division 4X (excluding unit area 4Xs) landed in the Maritimes split by tonnage class and gear type. The numbers in brackets represent the mean weight landed per age/size sample collected.

YEAR	TONNAGE CLASS 1-3 OT	1-3 LL	1-3 MISC	4-5 OT	4-5 LL	4-5 MISC	TOTAL
1970	4894 (979)	2754	1295	6500 (295)	113	3	15559
1971	4289 (715)	3019(1006)	954	7712 (454)	93	0	16067
1972	2741 (914)	3904 (558)	933 (933)	4750 (238)	63	0	12391
1973	1822 (304)	5714 (635)	701	4228 (302)	70	0	12535
1974	3949 (790)	6106 (611)	509 (509)	1623 (325)	56	0	12243
1975	6091 (338)	4917 (615)	548 (548)	4409 (457)	26	0	15991
1976	4348(1087)	4591 (765)	1159 (580)	6144 (486)	46	6	16294
1977	6185(1031)	3918 (490)	960	8345 (130)	117	35	19560
1978	9213(9213)	5957 (596)	1947 (487)	8093 (169)	92	0	25302
1979	9870(4935)	4292 (358)	1435 (718)	8634 (262)	56	0	24287
1980	12655(1266)	5635 (331)	2403 (601)	7440 (310)	82	0	28215
1981	14599 (348)	6925 (266)	1915 (274)	6647 (950)	70	0	30156
1982	11495 (235)	6708 (335)	1888 (135)	3091 (309)	32	0	23214
1983	12315 (209)	7759 (210)	1821 (228)	2537 (181)	15	0	24447

Table 4. Summary of commercial sampling for the 4X haddock fishery in 1983 - tons landed (no. of samples*).

	Otter Trawler Landings			
	m n o p u		q r	
Quarter	TC 1-3	TC 4-5	TC 1-3	TC 4-5
1	2044(**10**-9)	2103(**14**-11)	115(**2**-2)	0
2	3327(**15**-7)	144	2078(**8**-4)	12
3	1088(**8**-2)	53	2405(**11**-5)	12
4	500(**3**-1)	168	758(**2**-1)	45
Total	6959(**36**-19)	2468(**14**-11)	5356(**23**-12)	69

	Longliner Landings			
	m n o p u		q r	
Quarter	TC 1-3	TC 4-5	TC-1-3	TC 4-5
1	2301(**4**-4)	15	34	0
2	1306(**8**-3)	0	98	0
3	2320(**16**-5)	0	160	0
4	1518(**9**-3)	0	22	0
Total	7445(**37**-15)	15	314	0

	Miscellaneous Gear Landings			
	m n o p u		q r	
Quarter	TC 1-3	TC 4-5	TC 1-3	TC 4-5
1	22	0	0	0
2	593(**4**-2)	0	46	0
3	883(**3**-1)	0	107	0
4	169(**1**-0)	0	1	0
Total	1667(**8**-3)	0	154	0

* - number in bold represents the total number of samples collected and used in analysis.
  - the following number represents the actual number of samples aged.

Table 5. Comparison of 1983 catch at age as projected by O'Boyle et al (1983) and as observed in 1983 fishery.

Age	Observed Initial		Observed Re-aged		O'Boyle et al (1983)	
	No.	%	No.	%	No.	%
1	0	0	0	0	1	0
2	86	0.52	87	0.52	117	0.76
3	3287	20.01	3385	20.46	2326	15.13
4	5307	32.31	5354	32.36	6399	41.61
5	3904	23.77	3792	22.92	1811	11.78
6	2130	12.97	2204	13.32	2889	18.79
7	894	5.44	909	5.49	815	5.30
8	400	2.43	400	2.42	690	4.49
9	180	1.10	177	1.07	166	1.08
10	114	0.69	116	0.70	88	0.57
11	67	0.41	68	0.41	45	0.29
12	26	0.16	25	0.15	22	0.14
13+	28	0.17	27	0.16	9	0.06
No (000's)	16423		16544		15378	
Catch (t)	24993		24993		25000	

Table 6. The old and new ages (respectively) read for all the re-aged 1983 4X haddock commercial samples.

Sample #	AGE 1	2	3	4	5	6	7	8	9	10+
17	-	4	10	6	4	1	-	-	1	-
		3	10	7	4	1			1	
27	-	8	8	4	3	-	-	-	-	-
		7	9	3	4					
28	-	8	10	6	4	2	-	-	-	-
		8	10	6	4	2				
37	-	7	7	4	4	6	3	3	-	-
		7	7	4	4	6	3	3		
38	-	3	10	5	3	1	1	-	-	-
		3	10	5	3	1	1			
50	-	4	11	9	5	2	-	-	-	-
		4	11	9	5	2				
51	-	6	10	11	3	3	1	1	-	2
		6	10	11	3	3	1	1		2
52	-	2	12	5	8	2	-	1	2	-
		2	12	5	8	2		1	2	
65	-	5	9	8	6	2	-	3	-	-
		5	9	6	8	2		2	1	
79	-	-	2	9	9	5	5	3	-	-
			2	10	6	7	5	3		
100	-	-	7	9	7	2	2	1	4	1
			6	9	7	3	2	1	4	1
112	-	-	1	7	8	4	4	2	1	
			1	7	7	5	4	2	1	
135	-	-	10	6	5	7	2	-	2	1
			10	6	5	7	2		2	1
136	-	-	2	10	7	3	4	-	1	-
			2	11	6	3	4		1	
170	-	-	6	7	8	5	5	7	-	-
			6	7	8	5	5	7		
188	-	-	7	9	11	4	3	1		1
			7	8	10	4	3	2		1
213	-	2	13	9	-	1	-	-	-	-
		2	13	9		1				
91	-	-	10	8	6	5	4	-	2	4
			10	8	5	6	4		2	4
445	-	-	-	3	12	4	7	3	2	3
			1	2	12	4	7	3	2	3
502	-	-	7	8	6	5	7	2	3	1
			6	8	6	5	8	2	3	1
597	-	-	-	-	9	4	-	2	-	-
					9	4		2		
777	-	1	9	9	9	6	1	-	-	-
			9	9	10	6	1			
All Samples	-	50	161	152	140	72	48	29	18	13
Combined		47	161	150	134	79	50	29	19	13

Table 7. Landings (A) and weight (B) at age of haddock caught in NAFO Division 4X (excluding 4Xs)

LANDINGS AT AGE (0005) OF HADDOCK CAUGHT IN UNIT AREAS 4XM+4XR, EXCLUDING DISCARDS

A.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0	0	0	0	0	0	0	0	0	0	41	150	1	37	18	2	0	0	18	1	0	0
2	139	713	155	70	219	22	665	10	1055	788	22	3077	694	2175	1296	1285	75	81	155	1142	493	87
3	4524	2013	1272	3038	18341	515	297	2016	724	1617	3434	113	4653	4568	1644	3126	3354	1158	2305	2173	3756	3385
4	1415	7185	4286	1981	9796	20380	1164	1968	1502	788	1841	2247	309	5164	4261	2019	7014	6709	2997	6174	2456	5354
5	1778	3087	9337	3153	3167	9148	17448	1621	379	1422	509	1067	1779	485	3682	3193	2094	3881	5430	4178	4582	3792
6	1708	1649	3018	5409	2149	1039	4684	11243	524	404	645	527	509	1103	434	2881	2832	1070	3538	3189	1672	2204
7	1648	1415	1492	1973	3747	735	713	3220	4536	69	90	600	189	247	807	360	1040	1244	505	1168	1414	909
8	973	593	1370	1000	840	1052	518	455	1863	3316	57	322	269	172	154	389	137	263	625	373	336	400
9	645	478	612	745	409	187	672	249	133	1020	1166	259	186	62	71	107	107	57	170	326	181	177
10	232	152	416	288	424	102	190	194	96	163	512	614	269	32	95	72	26	68	33	97	93	116
11	205	113	297	203	88	90	131	172	175	181	26	55	552	165	39	23	9	11	22	13	46	68
12	64	59	168	114	62	23	65	94	27	146	193	13	24	229	103	8	6	1	4	22	18	25
13	100	43	36	113	84	81	89	69	37	105	92	6	4	11	157	87	48	18	16	11	15	27

MEAN WEIGHT (KG) AT AGE OF HADDOCK CAUGHT IN UNIT AREAS 4XM-4XR

B.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.27	0.18	0.23	0.23	0.28	0.29	0.29	0.15	0.23	0.22	0.22
2	0.56	0.50	0.50	0.36	0.31	0.32	0.37	0.56	0.57	0.50	0.45	0.51	0.46	0.52	0.52	0.46	0.44	0.51	0.52	0.59	0.49	0.38
3	0.75	0.78	0.75	0.65	0.67	0.62	0.62	0.75	0.90	0.96	0.90	0.75	0.82	0.82	0.81	0.71	0.87	0.87	0.88	0.88	0.90	0.75
4	1.15	1.05	1.00	1.00	0.85	0.85	0.90	0.88	1.05	1.25	1.35	1.25	1.10	1.20	1.19	1.22	1.33	1.33	1.33	1.26	1.29	1.14
5	1.40	1.45	1.30	1.20	1.23	1.05	1.10	1.15	1.16	1.40	1.60	1.80	1.70	1.55	1.60	1.72	1.85	1.84	1.78	1.72	1.66	1.75
6	1.60	1.70	1.70	1.56	1.50	1.45	1.30	1.35	1.43	1.50	1.75	2.00	2.30	2.25	2.10	2.20	2.33	2.36	2.36	2.22	2.14	2.16
7	2.20	1.85	1.95	1.95	1.80	1.80	1.70	1.60	1.65	1.75	1.90	2.20	2.50	2.85	2.95	2.94	2.70	2.83	2.90	2.65	2.58	2.61
8	2.12	2.35	2.04	2.20	2.18	2.05	2.05	2.00	1.95	1.95	2.10	2.30	2.60	3.00	3.50	3.30	3.39	3.30	3.28	3.15	2.96	2.88
9	1.90	2.25	2.50	2.30	2.50	2.36	2.30	2.45	2.30	2.30	2.30	2.50	2.80	3.20	3.60	3.57	3.77	4.03	3.82	3.60	3.48	3.07
10	2.40	2.20	2.40	2.63	2.50	2.70	2.52	2.50	2.82	2.65	2.80	2.70	2.95	3.45	3.80	3.77	4.17	4.15	4.34	3.71	4.05	3.54
11	2.86	2.70	2.42	2.50	2.75	2.70	3.00	2.70	2.80	3.25	3.00	3.30	3.20	3.50	4.10	3.69	4.03	4.96	4.21	4.51	3.96	3.75
12	2.70	3.20	3.00	2.70	2.60	2.89	2.90	3.30	2.85	3.00	3.70	3.40	3.80	3.70	4.00	3.94	3.62	6.00	4.84	4.83	4.14	3.81
13	3.99	3.25	3.61	3.30	3.00	2.80	2.95	3.06	3.60	3.00	3.30	4.20	3.90	4.40	4.20	3.91	4.63	5.68	4.97	5.04	5.03	4.31

Table 8. Percent age composition by numbers (A) and weight (B) of 4X haddock landings.

A. PERCENT COMPOSITION BY NUMBERS OF HADDOCK CAUGHT

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48	1.66	0.01	0.26	0.14	0.01	0.00	0.00	0.11	0.01	0.00	0.00
2	1.03	4.07	0.69	0.39	0.56	0.07	2.50	0.05	9.55	7.87	0.25	34.00	7.35	15.05	10.16	9.48	0.45	0.56	0.98	6.05	3.28	0.52
3	33.68	11.50	5.66	16.80	46.64	1.54	1.12	9.46	6.55	16.14	39.80	1.25	49.30	31.61	12.88	23.07	20.03	7.95	14.57	11.52	24.94	20.46
4	10.54	41.06	19.08	10.95	24.91	61.07	4.37	9.23	13.59	7.87	21.34	24.83	3.27	35.74	33.39	14.90	41.89	46.08	18.95	32.73	16.31	32.36
5	13.24	17.64	41.57	17.43	8.05	27.41	65.51	7.61	3.43	14.19	5.90	11.79	18.85	3.36	28.85	23.56	12.51	26.65	34.33	22.15	30.42	22.92
6	12.72	9.42	13.44	29.91	5.46	3.11	17.59	52.76	4.74	4.03	7.48	5.82	5.39	7.63	3.40	21.26	16.92	7.35	22.37	16.90	11.10	13.32
7	12.27	8.09	6.64	10.91	9.53	2.20	2.68	15.11	41.05	0.69	1.04	6.63	2.00	1.71	6.32	2.66	6.21	8.54	3.19	6.19	9.39	5.49
8	7.24	3.39	6.10	5.53	2.14	3.15	1.94	2.14	16.86	33.10	0.66	3.56	2.85	1.19	1.21	2.87	0.82	1.81	3.95	1.98	2.23	2.42
9	4.80	2.73	2.72	4.12	1.04	0.56	2.52	1.17	1.20	10.18	13.51	2.86	1.97	0.43	0.56	0.79	0.64	0.39	1.07	1.73	1.20	1.07
10	1.73	0.87	1.85	1.59	1.08	0.31	0.71	0.91	0.87	1.63	5.93	6.78	2.85	0.22	0.74	0.53	0.16	0.47	0.21	0.51	0.62	0.70
11	1.53	0.65	1.32	1.12	0.22	0.27	0.49	0.81	1.58	1.81	0.30	0.61	5.85	1.14	0.31	0.17	0.05	0.08	0.14	0.07	0.31	0.41
12	0.48	0.34	0.75	0.63	0.16	0.07	0.24	0.44	0.24	1.46	2.24	0.14	0.25	1.58	0.81	0.06	0.04	0.01	0.03	0.12	0.12	0.15
13	0.74	0.25	0.16	0.62	0.21	0.24	0.33	0.32	0.33	1.05	1.07	0.07	0.04	0.08	1.23	0.64	0.29	0.12	0.10	0.06	0.10	0.16

B. PERCENT COMPOSITION BY WEIGHT OF HADDOCK CAUGHT

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.33	0.00	0.05	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00
2	0.41	1.56	0.24	0.10	0.17	0.02	0.77	0.02	3.66	2.43	0.08	12.97	2.45	6.53	3.61	2.88	0.12	0.17	0.28	2.21	1.01	0.13
3	17.91	6.89	2.97	7.62	31.42	0.95	0.58	5.32	3.97	9.56	23.70	0.70	29.28	21.63	7.14	10.80	10.83	4.10	7.09	6.27	14.16	10.19
4	8.59	33.08	13.32	7.65	21.29	51.72	3.28	6.09	9.61	6.07	19.06	23.22	2.61	35.78	27.19	11.98	34.86	36.06	13.93	25.35	13.27	24.37
5	13.14	19.63	37.73	14.60	9.96	28.68	60.16	6.56	2.68	12.26	6.24	15.88	23.21	4.34	31.59	26.72	14.46	28.95	33.78	23.43	31.68	26.49
6	14.42	12.29	15.95	32.57	8.24	4.50	19.09	53.38	4.57	3.73	8.65	8.71	8.99	14.33	4.89	30.83	24.57	10.23	29.18	23.08	14.91	19.02
7	19.13	11.48	9.04	14.85	17.24	3.95	3.80	18.12	45.60	0.74	1.31	10.91	3.63	4.06	12.76	5.15	10.46	14.25	5.12	10.10	15.24	9.49
8	10.89	6.11	8.69	8.49	4.68	6.44	3.33	3.20	22.13	39.83	0.92	6.12	5.37	2.98	2.89	6.24	1.73	3.52	7.16	3.83	4.16	4.61
9	6.47	4.72	4.76	6.61	2.61	1.32	4.84	2.15	1.86	14.45	20.56	5.35	4.00	1.15	1.37	1.86	1.50	0.93	2.27	3.83	2.62	2.18
10	2.94	1.47	3.10	2.92	2.71	0.82	1.50	1.71	1.65	2.66	10.99	13.71	6.09	0.64	1.94	1.32	0.40	1.14	0.50	1.18	1.58	1.65
11	3.09	1.34	2.23	1.96	0.62	0.73	1.23	1.63	2.99	3.62	0.60	1.50	13.56	3.33	0.86	0.41	0.14	0.22	0.32	0.19	0.77	1.02
12	0.91	0.83	1.57	1.19	0.41	0.20	0.59	1.09	0.47	2.70	5.48	0.37	0.70	4.89	2.21	0.15	0.08	0.02	0.07	0.35	0.31	0.39
13	2.11	0.61	0.40	1.44	0.64	0.68	0.82	0.74	0.81	1.94	2.33	0.21	0.12	0.28	3.54	1.65	0.83	0.41	0.28	0.18	0.31	0.46

Table 9. Stratified mean catch per standard tow (in numbers weighted by stratum area) of haddock caught during Canadian summer bottom trawl survey (strata 70-91, 95) 1970-81 - A. T. Cameron; 1982 - Lady Hammond, includes Lady Hammond correction in 1982; 1983 - Alfred Needler, includes correction.

AGE	1970	1971	1972	1973	1974[4]	1975	1976	1977[3]	1978	1979	1980	1981	1982[2]	1983[5]	1984[5]
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.352	0.024	0.510	0.115	0.286	
1	4.872	0.099	4.404	4.976	8.153	5.518	4.617	5.278	5.391	1.636	18.511	11.740[1]	10.664	5.618	
2	3.921	9.263	0.195	19.053	17.942	3.466	5.272	20.246	4.660	11.528	6.028	23.780	23.442	3.717	
3	1.148	3.933	2.732	0.479	21.220	4.383	3.394	13.077	9.544	6.605	13.179	5.860	10.492	11.837	
4	2.167	1.729	1.160	2.466	0.768	6.013	3.405	3.868	2.870	7.919	6.841	7.320	3.819	4.774	
5	0.881	2.489	0.761	1.131	3.578	0.394	6.175	5.557	1.400	4.009	10.472	2.770	5.451	2.915	
6	1.982	1.131	0.825	0.423	0.775	1.417	0.467	3.456	2.615	1.605	3.527	3.040	2.073	1.962	
7	5.073	1.746	0.543	0.569	0.438	0.510	0.553	0.466	0.988	2.524	1.298	1.030	2.049	0.787	
8	0.704	4.424	0.808	0.429	0.505	0.287	0.101	0.558	0.025	0.949	1.056	0.210	0.270	0.264	
9	0.293	0.504	1.106	0.287	0.268	0.136	0.026	0.121	0.158	0.208	0.510	0.370	0.155	0.238	
10	0.258	0.078	0.037	0.371	0.202	0.043	0.033	0.095	0.000	0.026	0.202	0.240	0.041	0.170	
11	0.069	0.035	0.005	0.018	0.287	0.246	0.008	0.008	0.035	0.000	0.031	0.120	0.025	0.074	
12+	0.017	0.053	0.070	0.008	0.000	0.153	0.358	0.223	0.318	0.099	0.000	0.040	0.000	0.071	
NK	0.000	0.000	0.066	0.000	0.000	0.000	0.074	0.007	0.088	0.121	0.000	0.010	0.098	0.040	
TOTAL	21.39	25.48	12.71	30.21	54.14	22.57	24.48	52.97	28.09	37.58	61.68	57.04	58.70	32.75	
2+	16.51	25.39	8.31	25.23	45.98	17.05	19.87	47.68	22.61	35.59	43.14	44.79	47.92	26.81	57.44
5+	9.28	10.46	4.22	3.24	6.05	3.19	7.80	10.48	5.53	9.54	17.10	7.83	10.16	6.48	
Z5+/6+		0.15	1.11	0.69	0.27	0.77	0.67	0.46	0.93	0.00	0.36	1.22	0.51	1.05	
TOTAL Kg/tow	22.95	27.50	13.24	12.77	39.46	21.29	22.21	47.77	26.46	41.98	57.1	37.65	39.32	25.30	38.36

[1] Set 66 (stratum 90) was changed to equal the numbers per tow in the next lowest set. This was done for age 1 fish only. Leaving set 66 as it was gives an estimate (numbers per tow) of 30.86 for age 1 and a total of 76.16.
[2] Adjusted for differences in Lady Hammond and A.T. Cameron selectivity.
[3] Set 42 (stratum 76) was excluded.
[4] Set 13 (stratum 90) was excluded.
[5] Adjusted for differences in Alfred Needler and A.T. Cameron selectivity.

Table 10. Recruitment indicies for the 4X haddock stock, based on ages one and two catch-per-tow in Canadian summer groundfish surveys.

Year Class	Standardized No. per tow
1969	0.774
1970	0.016
1971	1.167
1972	1.162
1973	0.769
1974	0.648
1975	1.235
1976	0.603
1977	0.912
1978	0.388
1979	2.442
1980	1.914
1981	0.970
1982	0.851[1]

[1] Based on age one information only.

Table 11a. Variables used in Multiplicative analysis of commercial catch rate information for 4X haddock 1968-83

Type	Variable Number	Code	
Gear	-	OTB1	(Reference)
	1	OTB2	
Tonnage Class	-	2	(Reference)
	2	3	
	3	4	
	4	5	
Quarter	-	1	(Reference)
	5	2	
	6	3	
	7	4	
Year	8-22	1968 - 83	(1968 was reference)
Unit Area	-	M	(Reference)
	23	N	
	24	O	
	25	P	

Table 11b. Results of Multiplicative analysis on data identified in Table 11a for ages 7 to 10.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R.....0.779
MULTIPLE R SQUARED.....0.607

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	6.662E3	6.662E3	
REGRESSION	25	2.510E2	1.004E1	58.092
TYPE 1	1	8.153E1	8.153E1	471.678
TYPE 2	3	1.395E1	4.650E0	26.900
TYPE 3	3	5.916E1	1.972E1	114.085
TYPE 4	15	1.614E2	1.076E1	62.245
TYPE 5	3	4.700E0	1.567E0	9.063
RESIDUALS	940	1.625E2	1.728E-1	
TOTAL	966	7.076E3		

REGRESSION COEFFICIENTS

VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
INTERCEPT	-2.976	0.137	966
1	0.130	0.037	615
2	0.374	0.046	198
3	0.387	0.049	381
4	0.703	0.049	237
5	-0.072	0.035	280
6	-0.340	0.041	181
7	-0.428	0.043	147
8	0.573	0.076	59
9	1.503	0.086	38
10	1.037	0.086	37
11	0.382	0.090	33
12	0.612	0.112	18
13	0.233	0.142	10
14	-0.475	0.076	61
15	0.339	0.081	48
16	0.232	0.069	90
17	0.459	0.071	82
18	0.723	0.068	105
19	0.457	0.067	115
20	0.692	0.072	85
21	0.614	0.077	68
22	0.196	0.081	54
23	-0.510	0.111	381
24	-0.487	0.112	297
25	-0.318	0.113	273

Table 11c. Results of Multiplicative analysis on data identified in Table 11a for ages 1 to 13+.

REGRESSION OF MULTIPLICATIVE MODEL

MULTIPLE R.....0.659
MULTIPLE R SQUARED.....0.434

ANALYSIS OF VARIANCE

SOURCE OF VARIATION	DF	SUMS OF SQUARES	MEAN SQUARES	F-VALUE
INTERCEPT	1	9.212E2	9.212E2	
REGRESSION	25	1.247E2	4.988E0	28.857
TYPE 1	1	8.695E0	8.695E0	50.305
TYPE 2	3	1.395E1	4.650E0	26.900
TYPE 3	3	5.916E1	1.972E1	114.085
TYPE 4	15	6.330E1	4.220E0	24.416
TYPE 5	3	3.831E0	1.277E0	7.389
RESIDUALS	940	1.625E2	1.728E-1	
TOTAL	966	1.208E3		

REGRESSION COEFFICIENTS

VARIABLE	COEFFICIENT	STD. ERROR	NO. OBS.
INTERCEPT	-0.972	0.137	966
1	0.130	0.037	615
2	0.374	0.046	199
3	0.387	0.049	381
4	0.703	0.049	237
5	-0.072	0.035	280
6	-0.340	0.041	181
7	-0.428	0.043	147
8	-0.052	0.076	59
9	-0.163	0.086	38
10	-0.417	0.086	37
11	-0.537	0.090	33
12	-0.374	0.112	18
13	-0.115	0.142	10
14	-0.052	0.076	61
15	-0.003	0.081	48
16	0.154	0.069	90
17	0.414	0.071	82
18	0.336	0.068	105
19	0.346	0.067	115
20	0.351	0.072	85
21	0.054	0.077	68
22	-0.089	0.081	54
23	-0.510	0.111	381
24	-0.487	0.112	297
25	-0.318	0.113	273

Table 12. Commercial abundance indices for 4X haddock showing CPUE calculated from raw data and CPUE generated through the multiplicative model.

	Raw Catch Rates (t/hr)			Multiplicative Catch Rates (t/hr)	
	OTB2 TC 2-3 4Xq-r	OTB2 TC 4-5 4Xm-p		OTB2 TC 5 4Xp Apr-June	
Year	May-Aug	Jan-Mar	Apr-June	Age 7-10	Age 1-13+
1968	-	-	-	0.086	0.641
1969	-	-	-	0.153	0.609
1970	0.201	0.333	0.651	0.388	0.545
1971	0.098	0.281	0.380	0.244	0.422
1972	0.114	0.309	0.389	0.126	0.374
1973	0.091	0.292	0.229	0.159	0.440
1974	0.185	0.330	0.308	0.108	0.567
1975	0.199	0.422	0.408	0.054	0.609
1976	0.163	0.443	0.352	0.121	0.639
1977	0.274	0.484	0.450	0.109	0.748
1978	0.247	0.548	0.631	0.137	0.970
1979	0.242	0.894	0.493	0.178	0.897
1980	0.208	0.794	0.275	0.136	0.906
1981	0.218	0.845	0.728	0.173	0.911
1982	0.190	0.604	0.451	0.160	0.676
1983	0.180	0.606	0.333	0.105	0.585
1984	-	0.410	0.496	-	-

Table 13. Comparison of SPA-generated (O'Boyle et al., 1983) and Survivor-generated fishing mortality estimates for 1975-82.

Survivor Analysis (SU)

Age	1975	1976	1977	1978	1979	1980	1981	1982
3	.163	.133	.052	.095	.044	.042	.103	.100
4	.127	.450	.164	.762	.252	.132	.233	.186
5	.240	.278	.378	.585	.614	.263	.577	.330
6	.134	.953	.291	.745	.415	.736	.496	.456
7	.073	.701	.839	.420	.393	.270	.646	.405
8	.082	.646	.366	3.928	.136	.285	.895	.639

Cohort Analysis (CA)

Age	1975	1976	1977	1978	1979	1980	1981	1982
3	.188	.129	.110	.094	.052	.057	.107	.054
4	.339	.268	.231	.382	.274	.186	.214	.162
5	.232	.434	.331	.399	.378	.373	.427	.231
6	.411	.336	.732	.552	.365	.717	.392	.300
7	.433	.606	.517	.647	.503	.293	.549	.300
8	.583	.532	.675	.378	.330	.514	.366	.300

((SU - CA) ÷ CA) x 100

Age	1975	1976	1977	1978	1979	1980	1981	1982
3	-13	3	-53	1	-15	-26	-4	85
4	-63	68	-29	99	-8	-29	9	15
5	3	-36	14	47	62	-29	35	43
6	-67	184	-60	35	14	3	27	52
7	-83	16	62	-35	-22	-8	18	35
8	-86	21	-46	939	-59	-45	145	113

Table 14. Comparison of SPA-generated (O'Boyle et al., 1983) and Survivor-generated fishing mortality estimates for 1975-82, using different weightings and ages.

A. Unweighted

Ages	1975	1976	1977	1978	1979	1980	1981	1982
Survivor								
3-5	.177	.287	.198	.481	.303	.146	.304	.205
6-7	.104	.827	.565	.583	.404	.503	.571	.431
Cohort								
3-5	.253	.277	.224	.292	.235	.205	.249	.149
6-7	.422	.471	.625	.600	.434	.505	.471	.300

B. Weighted by Population Numbers

Ages	1975	1976	1977	1978	1979	1980	1981	1982
Survivor								
3-5	.145	.281	.108	.296	.213	.113	.239	.171
6-7	.116	.778	.320	.628	.403	.624	.531	.431
Cohort								
3-5	.248	.264	.182	.220	.214	.159	.218	.105
6-7	.415	.481	.702	.575	.430	.622	.426	.300

Table 15. Diagnostics of survivor runs used in comparisons made with SPA results.

Ages	1975	1976	1977	1978	1979	1980	1981	1982
A. % CV.								
3	53.0	52.1	55.9	68.1	63.8	61.7	57.7	54.9
4	42.5	52.5	45.8	90.0	55.3	48.5	47.4	43.8
5	38.3	42.3	57.2	69.8	86.6	50.7	56.7	44.7
6	35.3	86.9	44.1	94.3	65.2	84.8	55.1	53.3
7	30.6	59.2	93.6	62.4	71.4	57.0	69.8	51.3
8	?	56.0	53.1	1294.6	47.2	54.4	77.9	65.1
B. No. Iterations to Convergence								
	106	33	18	15	14	12	12	9
C. RMS upon Convergence								
	.214	.217	.276	.394	.368	.347	.285	.259

Table 16. 4X haddock population numbers, survivors, variance of survivors, weighted survivors, and fishing mortalities estimated using the survivor analysis. The calibration block was 1970-82; ages 3-7 and K levels off at age 6.

INTEGRATED SURVIVORS 24/ 9/84

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	588	315	772	4	2931	3147	549	832	763	1982	4846	6809	16583	36854
4	799	482	258	632	3	2400	2576	450	681	625	1623	3967	5574	13577
5	821	654	394	211	517	3	1965	2109	368	558	511	1328	3248	4564
6	2407	672	535	323	173	423	2	1609	1727	301	457	419	1088	2659
7	4203	1971	551	438	264	141	347	2	1317	1414	247	374	343	890
8	192	3441	1613	451	359	216	116	294	1	1078	1158	202	306	281

POPULATION NUMBERS 24/ 9/84

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	4545	6911	12856	3134	25491	25177	11107	26832	28910	17578	24482	16623	25108	38634
4	5987	3035	4086	7978	2370	16410	16619	7425	17285	19033	12467	16114	11505	16392
5	2237	3578	1903	2045	4718	1577	9460	10253	4213	9285	10111	6929	8355	6558
6	2852	1476	2010	1088	973	2572	875	4799	5672	2039	4248	4423	3079	3818
7	10646	2077	992	1083	574	460	1247	359	2186	2833	968	1399	1576	1368
8	1162	5185	1643	620	500	307	197	488	73	1217	1486	398	483	491

ESTIMATED SURVIVORS 24/ 9/84

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	0	2077	0	0	15544	0	173	5552	999	2423	11608	5648	19052	33344
4	561	1093	0	52	0	1714	0	1931	0	2275	4912	6090	4183	10545
5	222	1160	49	276	1669	0	2758	1788	0	0	6223	154	4751	3769
6	1713	644	0	0	290	114	0	1529	223	552	1229	613	1059	1826
7	1427	2055	337	218	306	387	9	305	564	2033	1052	499	1590	742
8	164	5023	1179	487	626	347	77	648	0	1291	1279	136	244	203

ESTIMATED VARIANCE OF SURVIVORS

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	420595	4936605	2382000	73224	143704780	6130888	3676242	54575372	29069751	20770354	123361874	36385560	174011940	318584068
4	1928344	1227600	552564	2497197	242208	14847356	4761030	6143837	3382443	25751789	28669736	48969365	19888302	44694213
5	231142	1944915	172463	380936	3812477	46229	11355349	9196178	583691	4786286	32657717	3408819	19694185	9099175
6	1063207	346207	184212	48427	162560	543438	59026	3232645	1850776	697205	3366832	2501253	1735851	2154762
7	10019909	1186923	114798	126055	74693	101269	119065	84548	380056	2480349	655969	413056	1634389	359712
8	287870	11367948	379205	106897	148127	47843	5925	180851	363	523099	647709	25615	42497	40436

WEIGHTED SURVIVORS 24/ 9/84

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	0	2	0	0	22	0	1	4	1	31	173	771	3893	33344
4	14	14	0	1	0	23	0	7	0	3	46	229	1045	8390
5	38	30	4	4	26	0	48	65	0	0	7	12	444	2313
6	364	74	0	0	9	13	0	94	41	18	14	9	163	1559
7	758	392	116	82	64	20	4	1	296	276	36	45	38	553
8	164	2354	703	180	200	113	69	213	0	492	665	120	214	195

RMS=0.2510786926

Table 16. Continued

ESTIMATED SURVIVORS FOR AGE 8 (WEIGHTED)

YEAR	SURVIVORS	VARIANCE	STANDARD ERROR	C.V.(8/8)	F
1970	164	287870	537	326.54	2.3869
1971	3113	5325723	2308	74.14	0.6688
1972	1460	226236	476	32.59	0.0347
1973	408	39556	199	48.78	0.5348
1974	325	47230	217	66.96	0.5550
1975	196	15642	125	63.90	0.5801
1976	105	5279	73	69.40	0.8376
1977	257	59344	244	94.91	0.8544
1978	1	354	19	1472.60	4.5267
1979	975	199418	447	45.78	0.2173
1980	1047	336783	580	55.42	0.4288
1981	183	22652	151	82.35	1.0337
1982	277	37353	193	69.80	0.7338
1983	254	38691	197	77.48	0.8769

ESTIMATED SURVIVORS FOR 1983 (WEIGHTED)

AGE	SURVIVORS	VARIANCE	STANDARD ERROR	C.V.(8/8)	F
3	33344	318584068	17849	53.53	0.0876
4	12284	35560621	5963	48.55	0.3304
5	4129	4969349	2229	53.99	0.5996
6	2405	1840293	1357	56.40	0.5987
7	805	267919	518	64.27	0.6970
8	254	38691	197	77.48	0.8769

FINAL ESTIMATION FOR K

AGE	K	LN(K)	VAR(LN(K)	STANDARD ERROR	D.F
3	3263.75	7.9712	0.2390	0.1356	1
4	3031.11	7.9496	0.1341	0.1016	1
5	2113.75	7.5813	0.1494	0.1072	1
6	1649.51	7.2828	0.2508	0.0982	25
7	1649.51	7.2828	0.2508	0.0982	25
8	1649.51	7.2828	0.2508	0.0982	25

RESIDUALS 24/ 9/84

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	-0.1931	0.6192	-0.3659	-0.6954	0.9995	-0.5653	-0.0027	0.4641	0.0746	0.2040	-0.5636	0.1403	-0.3103	0.0001
4	0.0927	0.5464	-0.1502	-0.0652	-0.0179	0.1050	-0.4764	0.4568	-0.6866	0.2320	0.5087	0.3198	0.0062	-0.1248
5	-0.1836	0.3853	-0.1683	0.1560	0.4717	-0.6384	0.3217	0.1358	-0.3535	-0.0916	0.7834	-0.1686	0.3213	-0.0627
6	0.1366	0.2341	-0.3903	-0.4444	0.2733	-0.0957	-0.1280	0.1742	-0.2738	0.2612	0.3145	0.1255	0.1052	-0.1839
7	-0.2407	0.3271	-0.1020	-0.1430	0.2299	0.6044	-0.3126	0.7623	-0.2936	0.3851	0.7934	0.1943	0.7630	-0.0527
8	-0.0002	0.3417	-0.2095	0.1321	0.5099	0.4337	-0.1662	0.6337	-0.5773	0.2520	0.1587	-0.1391	-0.0790	-0.1208

MEAN OF RESIDUALS=0.08917289713
STANDARD DEVIATION OF RESIDUALS=0.3658105845

OUTLIERS OF RESIDUALS 24/ 9/84

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	0.00	0.00	0.00	-0.70	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.69	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 17. Results of SPA (cohort analysis) using F_{5+} in 1983 of 0.65.

POPULATION NUMBERS (000S) 9/ 1/85

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	24933	91807	199274	16473	10108	17370	8064	14495	25297	6307	47457	44500	24198	49041	52623	30238	41299	28012	37950	39444	24481	0
2	32197	20413	75166	163152	13487	8276	14222	6602	11867	20711	5163	38818	36298	19810	40118	43068	24755	33813	22934	31054	32292	20044
3	59975	26235	16068	61400	133514	10844	6756	11042	5396	8762	16244	4208	28997	29090	14251	31673	34098	20200	27610	18636	24392	25992
4	19198	45010	19658	12004	47521	92716	8412	5262	7216	3763	5710	10192	3343	19531	19684	10181	23103	24882	15491	20520	13292	16572
5	11487	14437	30350	12216	8036	30043	57469	5834	2528	4549	2368	3009	6311	2457	11318	12260	6508	12569	14301	9971	11213	8660
6	9621	7796	9027	16400	7149	3714	16320	31264	3310	1727	2438	1478	1498	3558	1573	5935	7149	3434	6779	6796	4383	5035
7	4630	6331	4890	4660	8533	3909	2100	9123	15424	2236	1048	1412	733	766	1915	895	2252	3290	1843	2349	2679	2076
8	3140	2300	3903	2654	2030	3595	2535	1074	4556	8524	1768	777	613	429	404	837	407	903	1568	1052	866	914
9	2006	1690	1346	1956	1268	902	1992	1607	468	2044	3978	1396	344	259	196	191	334	209	501	718	524	405
10	1089	1058	951	549	927	668	569	1023	1090	263	751	2202	909	114	156	96	60	176	120	256	293	266
11	473	682	729	402	189	376	455	294	662	806	68	152	1247	501	64	42	14	25	83	68	122	156
12	231	202	456	328	146	75	226	254	85	383	496	32	74	522	260	17	13	3	11	48	44	58
13	361	147	98	325	197	263	310	186	117	276	236	15	12	25	397	187	106	53	43	24	37	61

FISHING MORTALITY 9/ 1/85

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.004	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
2	0.005	0.039	0.002	0.000	0.018	0.003	0.053	0.002	0.103	0.043	0.005	0.092	0.021	0.129	0.036	0.034	0.003	0.003	0.007	0.041	0.017	0.005
3	0.087	0.089	0.092	0.056	0.165	0.054	0.050	0.225	0.160	0.228	0.266	0.030	0.195	0.191	0.136	0.115	0.115	0.065	0.097	0.138	0.187	0.155
4	0.085	0.194	0.276	0.201	0.259	0.278	0.166	0.533	0.261	0.263	0.441	0.279	0.108	0.346	0.273	0.247	0.409	0.354	0.241	0.404	0.228	0.437
5	0.188	0.270	0.416	0.336	0.572	0.410	0.409	0.367	0.181	0.424	0.271	0.497	0.373	0.246	0.446	0.339	0.439	0.417	0.544	0.622	0.601	0.650
6	0.218	0.266	0.461	0.453	0.404	0.370	0.382	0.507	0.192	0.299	0.346	0.501	0.471	0.420	0.364	0.769	0.576	0.422	0.860	0.731	0.547	0.650
7	0.500	0.284	0.411	0.631	0.664	0.233	0.470	0.494	0.393	0.035	0.100	0.634	0.335	0.440	0.627	0.588	0.714	0.541	0.361	0.797	0.875	0.650
8	0.419	0.335	0.491	0.539	0.611	0.391	0.256	0.631	0.601	0.562	0.036	0.613	0.663	0.585	0.547	0.720	0.465	0.389	0.581	0.497	0.560	0.650
9	0.439	0.375	0.698	0.546	0.441	0.260	0.467	0.188	0.377	0.802	0.391	0.229	0.908	0.308	0.512	0.963	0.438	0.358	0.470	0.695	0.479	0.650
10	0.268	0.173	0.660	0.868	0.704	0.185	0.460	0.235	0.102	1.157	1.401	0.368	0.396	0.373	1.121	1.759	0.655	0.555	0.363	0.542	0.433	0.650
11	0.652	0.202	0.598	0.815	0.725	0.308	0.383	1.039	0.346	0.285	0.553	0.513	0.672	0.453	1.114	0.945	1.322	0.651	0.347	0.240	0.544	0.650
12	0.362	0.386	0.516	0.478	0.625	0.411	0.379	0.520	0.426	0.538	0.554	0.590	0.437	0.652	0.566	0.706	0.682	0.462	0.516	0.692	0.579	0.650
13	0.362	0.386	0.516	0.478	0.625	0.411	0.379	0.520	0.426	0.538	0.554	0.590	0.437	0.652	0.566	0.706	0.682	0.462	0.516	0.692	0.579	0.650

Table 18. Cumulative fishing mortalities (A) and partial recruitment values generaged by SPA with F_{5+}, 1983 of 0.65. Boxed-in area in Table A indicates F values greater than 2.0.

A. CUMULATIVE FISHING MORTALITIES

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	5.489	6.009	4.964	3.219	5.562	6.123	6.688	6.206	5.340	3.996	5.157	4.304	3.361	3.846	3.303	2.129	1.755	1.024	0.665	0.172	0.005	0.000
2	3.318	5.489	6.009	4.964	3.219	5.562	6.123	6.688	6.206	5.340	3.996	5.156	4.300	3.361	3.845	3.303	2.129	1.755	1.024	0.665	0.172	0.005
3	4.345	3.313	5.450	6.006	4.963	3.201	5.559	6.070	6.686	6.102	5.297	3.991	5.064	4.279	3.232	3.809	3.269	2.125	1.752	1.016	0.623	0.155
4	4.782	4.258	3.224	5.358	5.950	4.799	3.147	5.509	5.845	6.526	5.874	5.031	3.961	4.869	4.088	3.096	3.693	3.154	2.060	1.655	0.878	0.437
5	3.359	4.697	4.064	2.949	5.157	5.691	4.520	2.981	4.976	5.583	6.263	5.433	4.752	3.853	4.523	3.815	2.848	3.284	2.800	1.819	1.251	0.650
6	3.449	3.171	4.427	3.648	2.613	4.585	5.281	4.111	2.614	4.795	5.160	5.992	4.936	4.378	3.607	4.078	3.476	2.409	2.867	2.256	1.197	0.650
7	3.916	3.231	2.905	3.966	3.195	2.209	4.215	4.900	3.605	2.422	4.496	4.814	5.491	4.465	3.959	3.244	3.309	2.900	1.987	2.007	1.525	0.650
8	3.306	3.416	2.947	2.493	3.335	2.531	1.976	3.745	4.405	3.212	2.387	4.396	4.180	5.155	4.025	3.332	2.656	2.595	2.359	1.626	1.210	0.650
9	2.313	2.886	3.080	2.456	1.955	2.724	2.140	1.720	3.114	3.804	2.650	2.351	3.783	3.517	4.571	3.478	2.612	2.191	2.206	1.778	1.129	0.650
10	1.465	1.874	2.511	2.383	1.910	1.514	2.464	1.674	1.532	2.737	3.002	2.258	2.121	2.875	3.209	4.059	2.515	2.174	1.832	1.736	1.083	0.650
11	1.554	1.197	1.701	1.851	1.515	1.206	1.329	2.004	1.438	1.430	1.580	1.602	1.890	1.725	2.502	2.089	2.300	1.859	1.619	1.469	1.194	0.650
12	0.749	0.902	0.994	1.103	1.036	0.790	0.898	0.946	0.965	1.093	1.144	1.027	1.089	1.218	1.272	1.388	1.144	0.978	1.209	1.272	1.229	0.650
13	0.362	0.386	0.516	0.478	0.625	0.411	0.379	0.520	0.426	0.538	0.554	0.590	0.437	0.652	0.566	0.706	0.682	0.462	0.516	0.692	0.579	0.650

B. PARTIAL RECRUITMENT VALUES

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.003	0.003	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.031	0.050	0.047	0.012	0.014	0.056	0.048	0.138	0.117	0.119	0.092	0.082	0.180	0.131	0.130	0.030	0.015	0.010	0.029	0.037	0.034	0.007
3	0.220	0.227	0.184	0.174	0.187	0.198	0.301	0.379	0.458	0.448	0.325	0.319	0.284	0.327	0.252	0.171	0.153	0.188	0.193	0.251	0.258	0.238
4	0.332	0.454	0.488	0.409	0.594	0.624	0.940	0.829	0.833	0.678	0.644	0.569	0.534	0.463	0.482	0.452	0.578	0.677	0.650	0.524	0.567	0.672
5	0.584	0.707	0.727	0.734	1.000	1.000	1.000	0.809	0.701	0.573	0.768	0.763	0.768	0.620	0.516	0.582	0.672	0.969	1.000	1.000	1.000	1.000
6	0.646	0.755	0.810	0.729	0.918	0.992	1.000	0.918	0.766	0.569	0.757	0.874	0.963	0.773	0.755	0.765	0.898	1.000	1.000	1.000	1.000	1.000
7	1.000	0.976	0.892	0.934	0.982	1.000	1.000	1.000	0.799	0.443	0.545	0.721	0.997	0.836	0.837	0.911	1.000	1.000	1.000	1.000	1.000	1.000
8	1.000	1.000	0.951	0.904	1.000	1.000	1.000	1.000	1.000	0.862	0.761	0.852	1.000	1.000	0.955	0.771	0.792	0.990	0.979	1.000	0.913	1.000
9	1.000	1.000	1.000	0.936	0.849	0.944	0.863	0.879	0.921	1.000	0.855	0.962	0.932	1.000	0.802	0.819	0.834	0.869	0.978	0.992	0.972	1.000
10	0.734	0.807	1.000	1.000	1.000	0.990	0.804	0.666	0.899	1.000	1.000	1.000	0.787	1.000	1.000	1.000	1.000	1.000	0.960	0.804	0.865	1.000
11	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.844	0.902	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.858	0.697	0.769	1.000
12	0.967	1.000	0.993	0.895	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.903	0.968	1.000	1.000	1.000	1.000	1.000
13	0.967	1.000	0.993	0.895	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.903	0.968	1.000	1.000	1.000	1.000	1.000

Table 19. Comparison of partial recruitment estimates calculated for 1983 with 1982 and long-term pattern, as derived by Separable VPA.

Age	1983 Estimates Minimization of Residuals	Survivor	1982 Estimates O'Boyle et al. (1983)	1971-1983 Estimates SVPA
1	0	-	0	0
2	0.007	-	0.021	0.039
3	0.238	0.14	0.180	0.250
4	0.672	0.524	0.541	0.559
5	1.000	0.95	0.770	0.830
6	1.000	1	1.0	1.000
7	1.000	1	1.0	0.923
8	1.000	1	1.0	1.015
9	1.000	-	1.0	1.114
10	1.000	-	1.0	1.322
11	1.000	-	1.0	1.074
12	1.000	-	1.0	1.000
13+	1.000	-	1.0	-

Table 20. Comparison of numbers (000's) at age 1 generated by CAFSAC assessments since 1976.

Assessment	F_t	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
O'Boyle unpublished assessment #1 1977	0.28	30810	7007	60391	49293	28861	33393	-	-	-	-	-	-	-	-
O'Boyle unpublished assessment #2 1978	0.33	20810	7007	60231	35308	14606	26889	44755	-	-	-	-	-	-	-
Res. Doc. 78/19	0.3	33077	10775	75014	56364	34737	43539	83036	29423	-	-	-	-	-	-
Res. Doc. 80/2	0.325	26436	7169	50301	53352	28948	56167	73480	41293	50339	-	-	-	-	-
Res. Doc. 81/24	0.300	25436	6504	48605	47176	26207	50577	81785	41959	76120	45299	100000	-	-	-
Res. Doc. 82/53	0.400	25524	6146	47857	46326	24960	54146	62978	38975	61878	31820	97036	91945	-	-
Res. Doc. 83/73	0.300	25452	6605	47994	45115	25379	51390	63675	37615	68601	35501	115809	93681	32367	-
Res. Doc. 83/73	0.400	25372	6457	47684	44602	24567	50130	59385	33466	56954	28185	87988	75471	30736	-
Present Document	0.65	25297	6307	47457	44500	24198	49041	52623	30238	41299	28012	37950	39444	24481	20000

Table 21. Yield per recruit calculations for 4X haddock using 16 age groups (CAFSAC Advisory Document 84/19).

	Fishing Mortality	Catch Number	Yield (KG)	Avg. Weight (KG)	Yield per Unit Effort
	0.060	0.11386	0.288	2.530	1.000
	0.120	0.18998	0.448	2.357	0.777
	0.180	0.24365	0.538	2.210	0.623
	0.240	0.28335	0.591	2.086	0.513
$F_{0.1}$ - -	0.248	0.28804	0.596	2.071	0.500
	0.300	0.31397	0.622	1.982	0.432
	0.360	0.33841	0.641	1.894	0.371
	0.420	0.35849	0.652	1.818	0.323
	0.480	0.37537	0.658	1.753	0.286
	0.540	0.38982	0.662	1.697	0.255
	0.600	0.40238	0.663	1.648	0.230
F_{MAX} - -	0.641	0.41005	0.663	1.617	0.216
	0.660	0.41345	0.663	1.604	0.209
	0.720	0.42330	0.662	1.565	0.192
	0.780	0.43216	0.661	1.530	0.177
	0.840	0.44017	0.659	1.498	0.164
	0.900	0.44749	0.658	1.469	0.152
	0.960	0.45419	0.655	1.443	0.142
	1.020	0.46038	0.653	1.419	0.133
	1.080	0.46612	0.651	1.397	0.126
	1.140	0.47145	0.649	1.376	0.119
	1.200	0.47644	0.647	1.357	0.112

Long term (1962-82) geometric mean recruitment = 28500 x 10^3 assuming F_t for 1983 = 0.65

Long term equilibruim yield at $F_{0.1}$ = 28500 x 0.596 = 16986

Table 22. 1983 population characteristics used in catch projections, based on F_{5+}, 1983 of 0.65.

Age	Population Nos. (000's)	Catch Nos. (000's)	Weight-at-Age (kg)[1]	Partial Recruitment
1	20000	0	0.220	0
2	20044	87	0.378	0.007
3	25992	3385	0.753	0.238
4	16572	5354	1.138	0.672
5	8660	3792	1.746	1.000
6	5035	2204	2.157	1.000
7	2076	909	2.609	1.000
8	914	400	2.881	1.000
9	405	177	3.067	1.000
10	266	116	3.540	1.000
11	156	68	3.751	1.000
12	58	25	3.811	1.000
13+	61	27	4.313	1.000

[1] observed in 1983 fishery.

Table 23. Parameters used to estimate age 1 population numbers from Canadian July Bottom Trawl Survey catch rates.

Year Class	Survey No./Tow	SPA Numbers (000's) F_{7-10} of 0.65
1969	4.872	25297
1970	0.099	6307
1971	4.404	47457
1972	4.976	44500
1973	8.153	24198
1974	5.518	49041
1975	4.617	52623
1976	5.278	30238
1977	5.391	41299
1978	1.636	28012
1979	18.511	37950
1980	11.740	39444
1981	10.664	24481
*1982	5.618	20867
B_0		0
B_1		3714.38

* Predicted using B_0 and B_1 (regression forced through zero).

Table 24. Catch projections with varying assumptions concerning the catch and fishing mortality in 1983[1].

Year	F_{7-10}	Catch Biomass ($t \times 10^{-3}$)	Mean Pop. Biomass ($t \times 10^{-3}$)
1983	0.650	24999	66377
1984	0.248	10352	66981
1985	0.248	12089	73163
1983	0.650	24999	66377
1984	0.536	20000	61802
1985	0.248	9894	64036

[1] 1984-86 recruitment (28467×10^3) was taken as geometric mean of age 1 numbers (000's) from SPA run for 1962-82.

Table 25. Degree of dependence of 1985 and 1986 population size estimates on 1982-84 age one recruitment estimates. E = survey estimate, CE = Crude survey estimate, G = Long-term geometric mean.

	Year of Projection Analysis				
Age	1982	1983	1984	1985	1986
1	E	CE	G	G	G
2	-	E	CE	G	G
3	-	-	E	CE	G
4	-	-	-	E	CE
5	-	-	-	-	E
6	-	-	-	-	-
7+	-	-	-	-	-

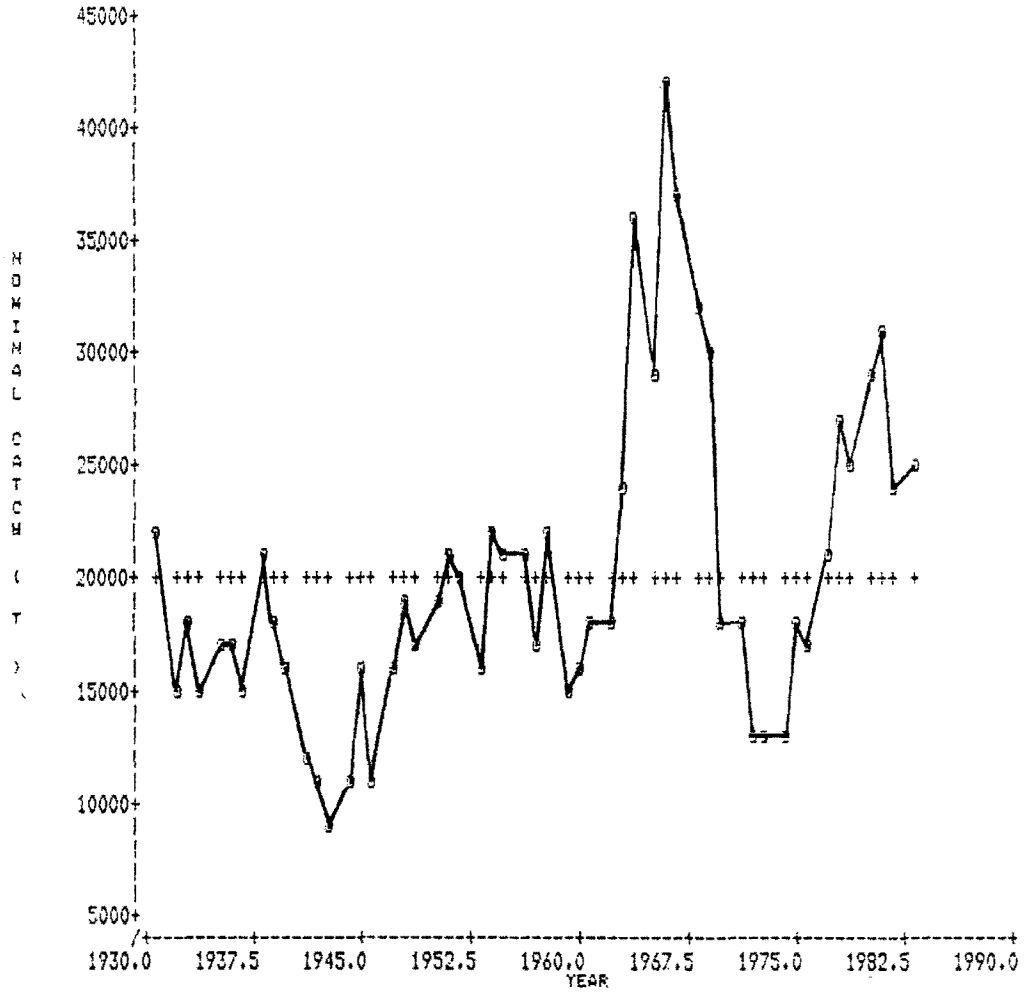


Figure 1. Trends in annual nominal catch (t) of haddock caught in NAFO Division 4X during 1931-83.

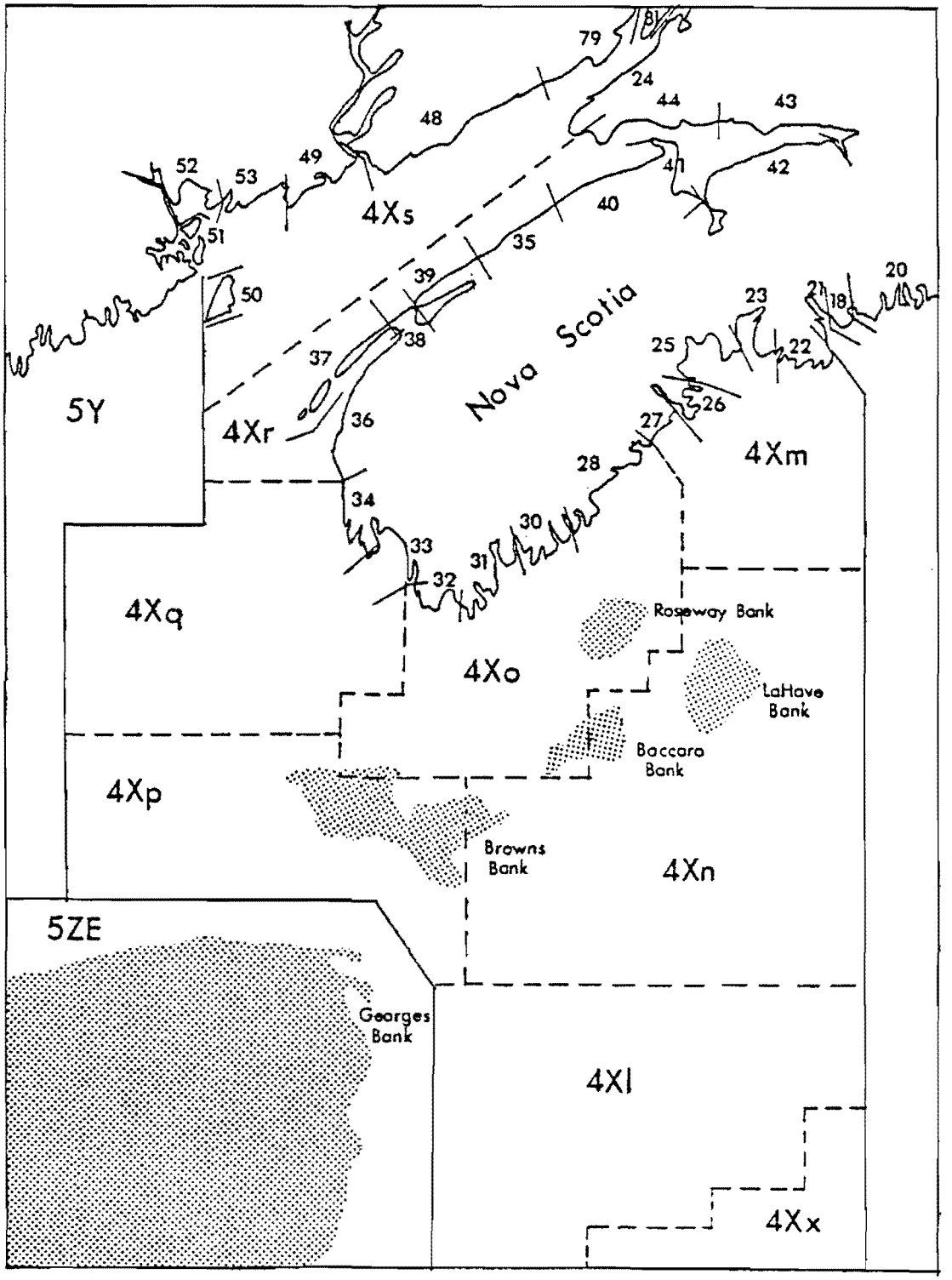
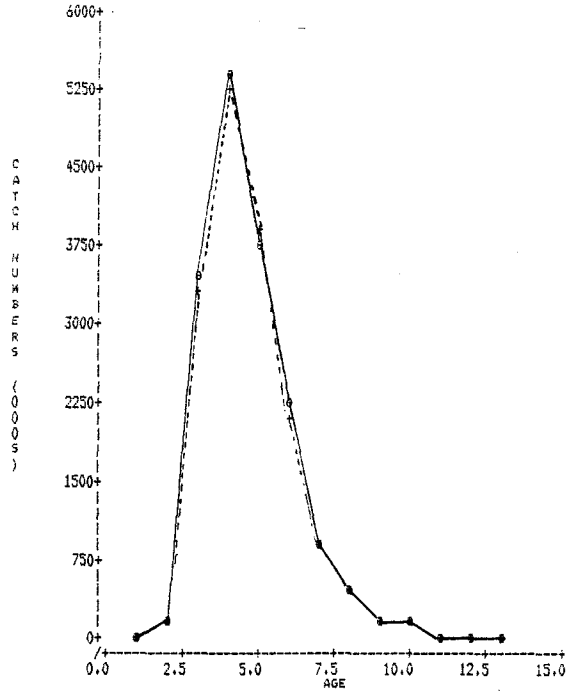


Figure 2. Canadian fisheries statistical unit areas in NAFO Division 4X.

A



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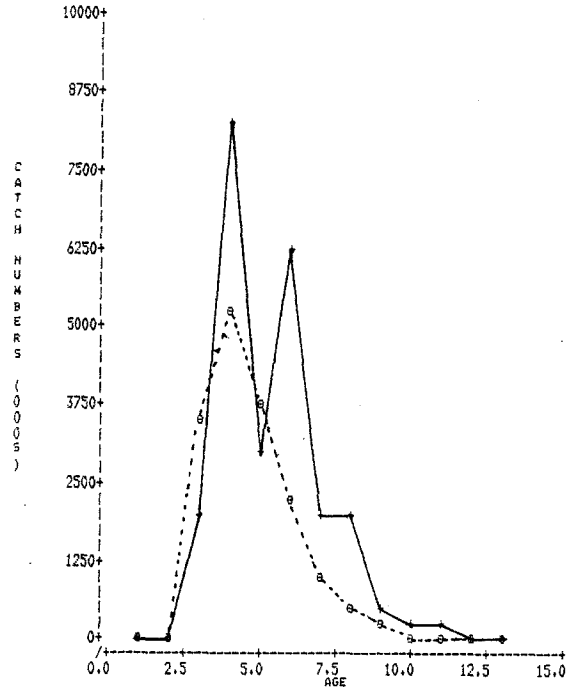


Figure 3. Catch numbers (000's) at age for 4X haddock.
A. Comparison of re-aged catch-at-age (0) with that presented in Spring (+).
B. Comparison of re-aged catch-at-age (0) with that projected, using 25,000 t in 1983, by O'Boyle et al., 1983.

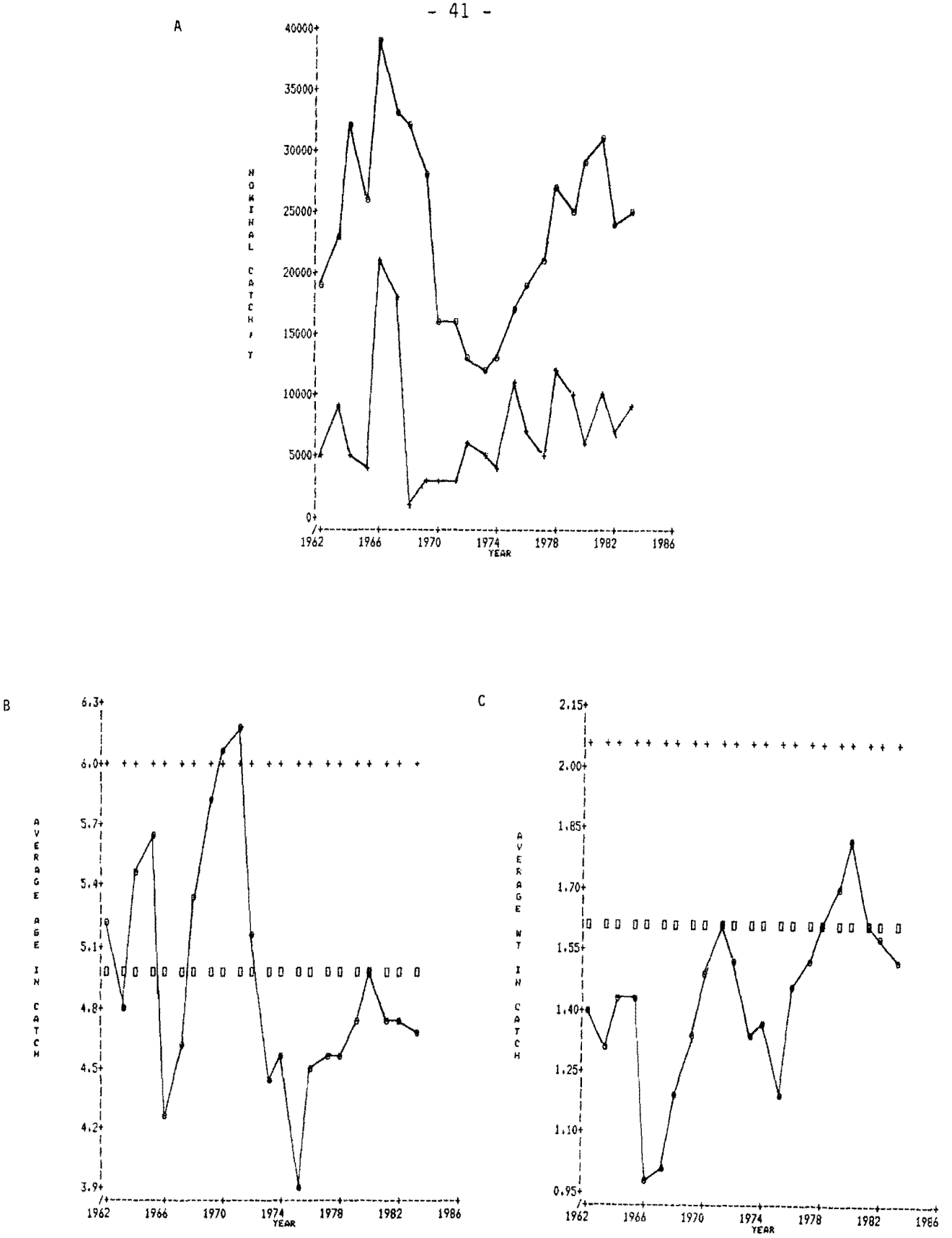


Figure 4. Age-size composition of landings.
A. Relative proportion of age 1 to 4 individuals in total catch. Top line represents total nominal catch. Bottom line represents catch of age 1 to 4 individuals.
B. Average age of 4X haddock in landings. + - average age at $F_{0.1}$, - average age at F_{max}.
C. Average weight (kg) of 4X haddock in landings. + - average weight at $F_{0.1}$, - average weight at F_{max}.

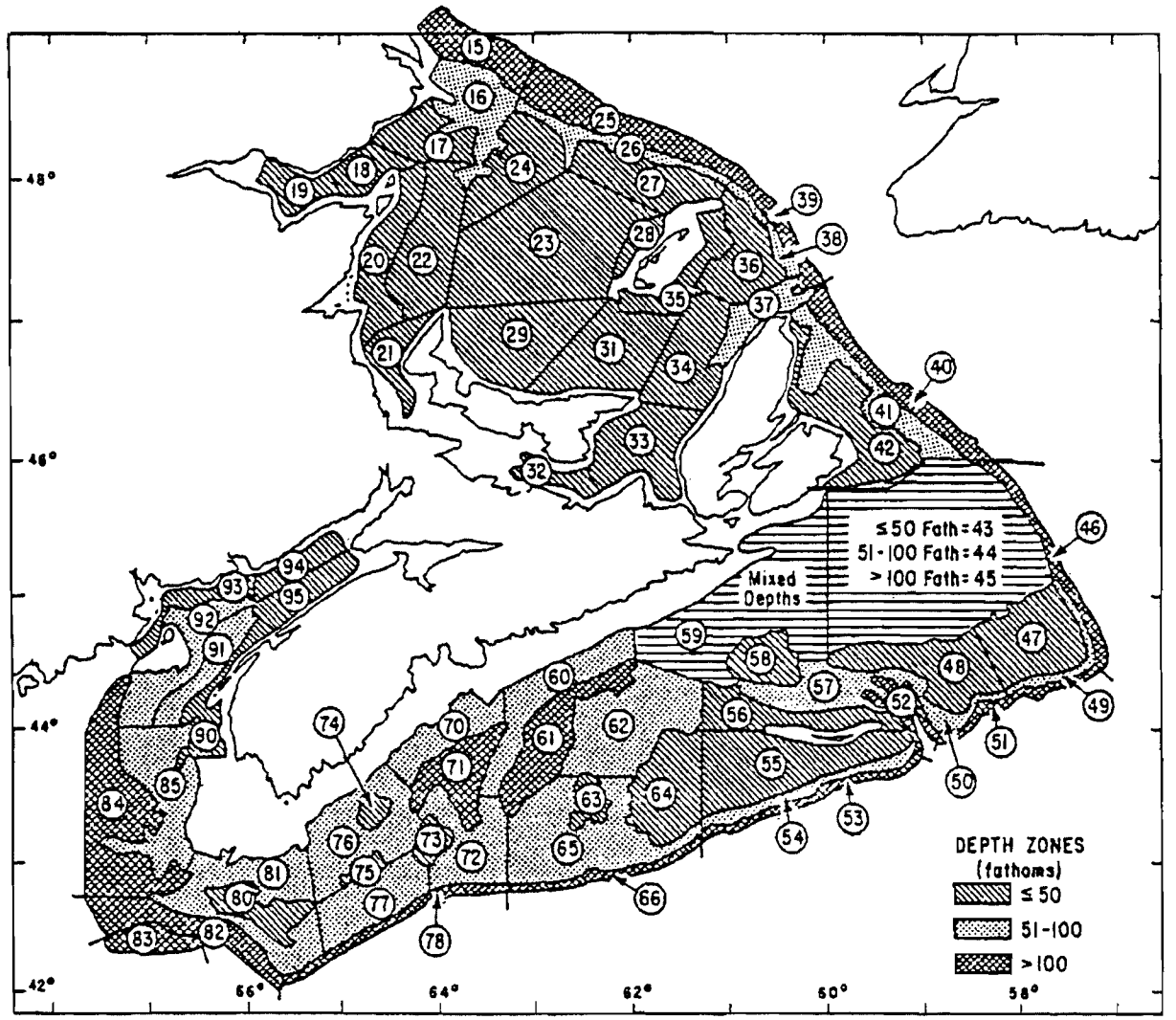


Figure 5. Stratification scheme used for the Canadian bottom-trawl surveys.

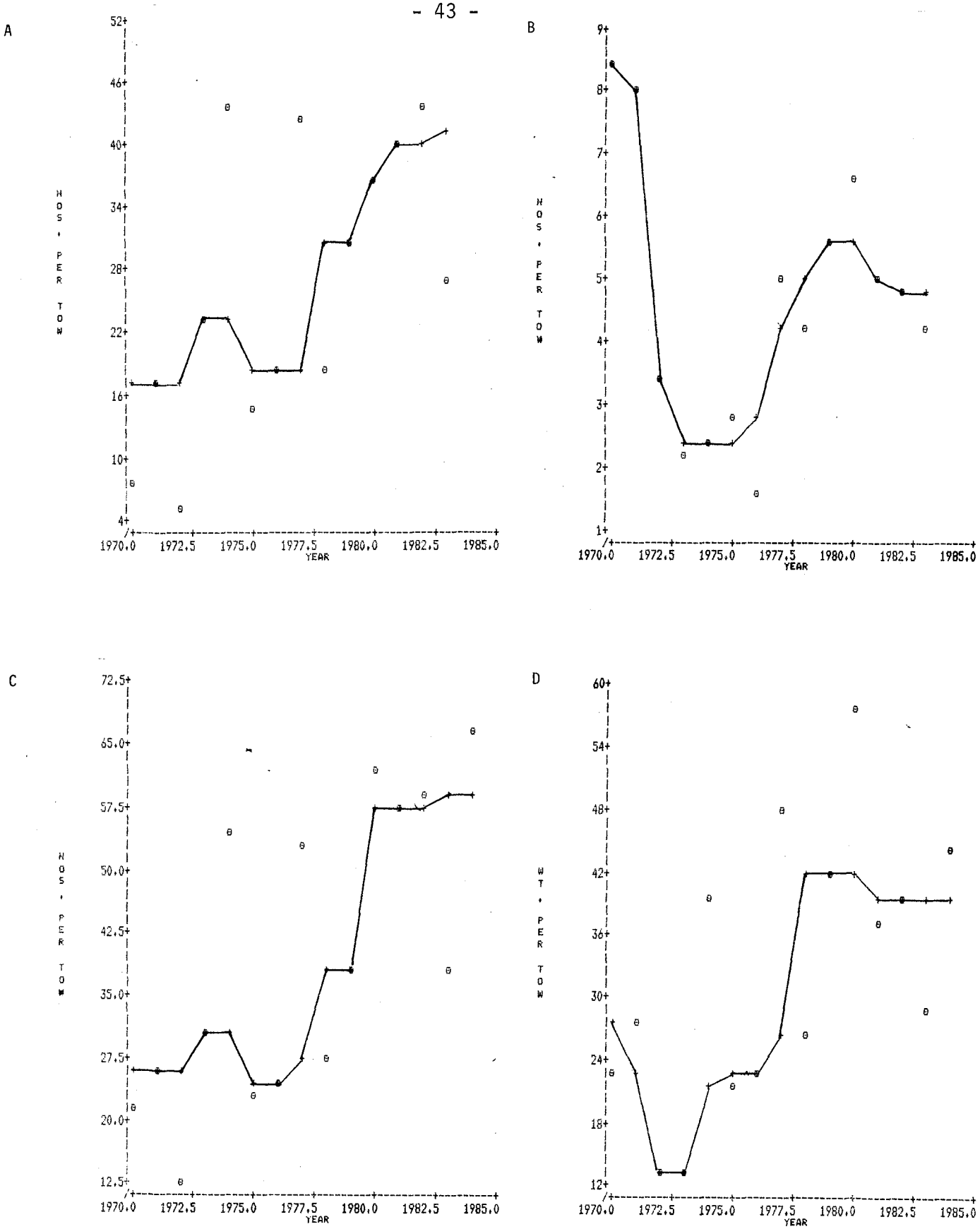
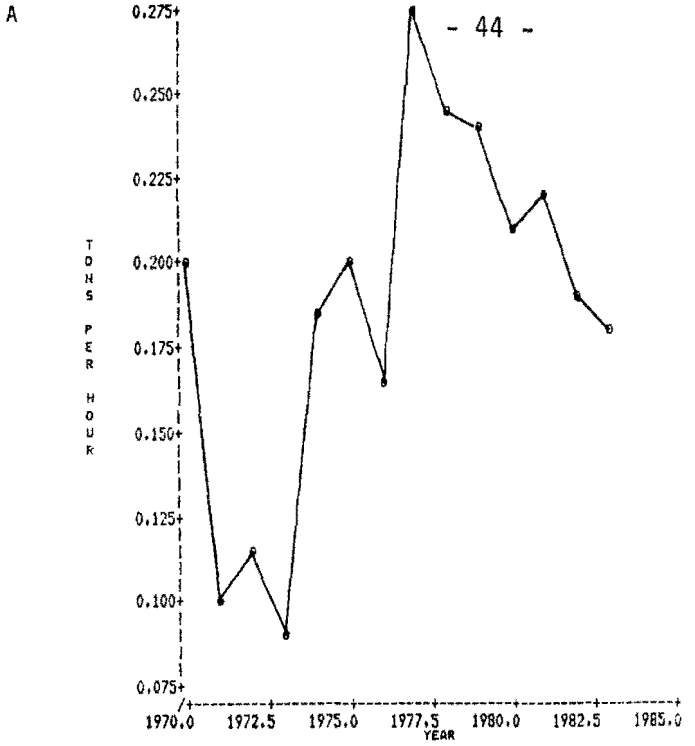
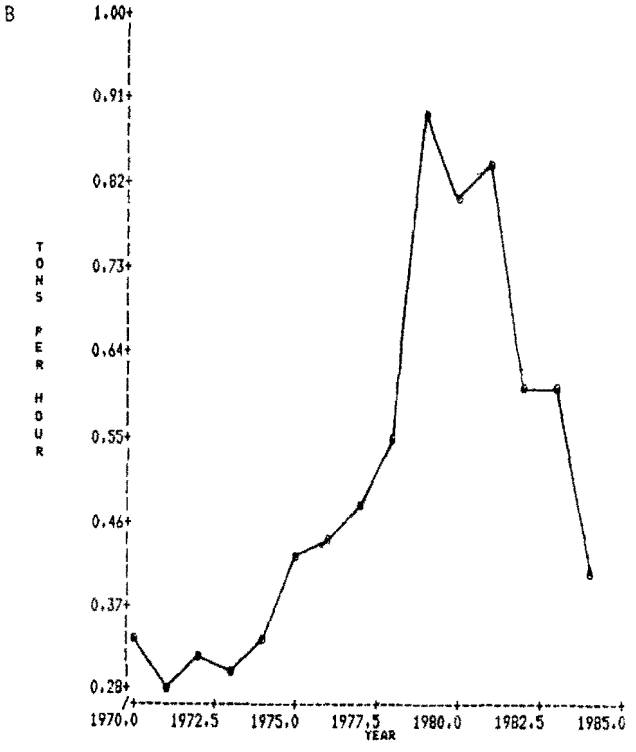


Figure 6. Research vessel catch rates of haddock from NAFO Division 4X (strata 70-85, 90, 91, 95) from 1970-1984. Solid line is median smoothed trend.
A. age 2-5 nos./tow.
B. age 6+ nos./tow.
C. total nos./tow.
D. total weight (kg)/tow.





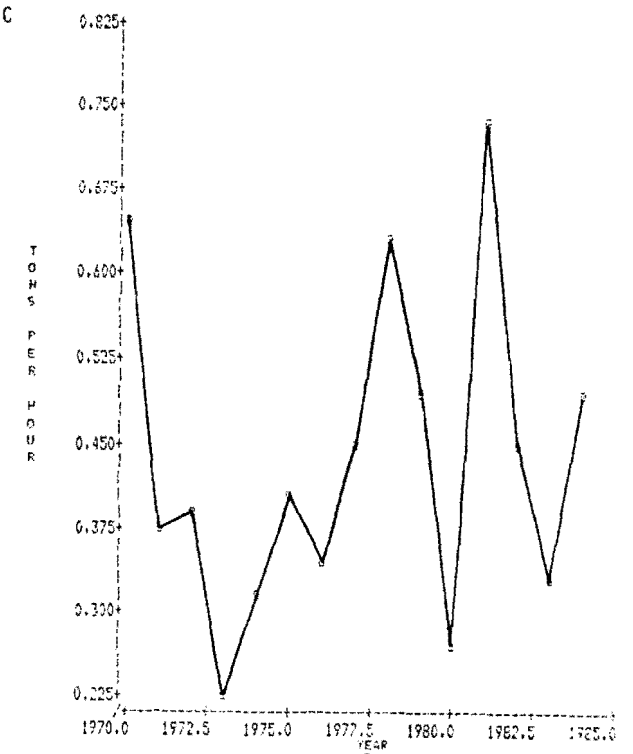
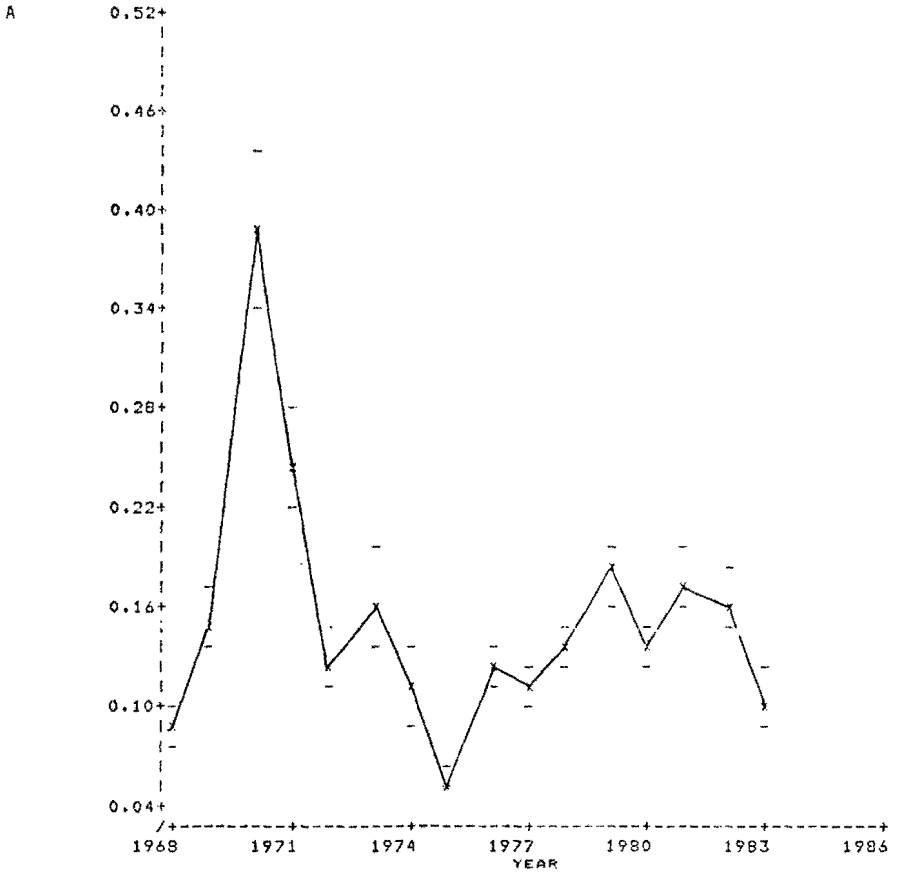
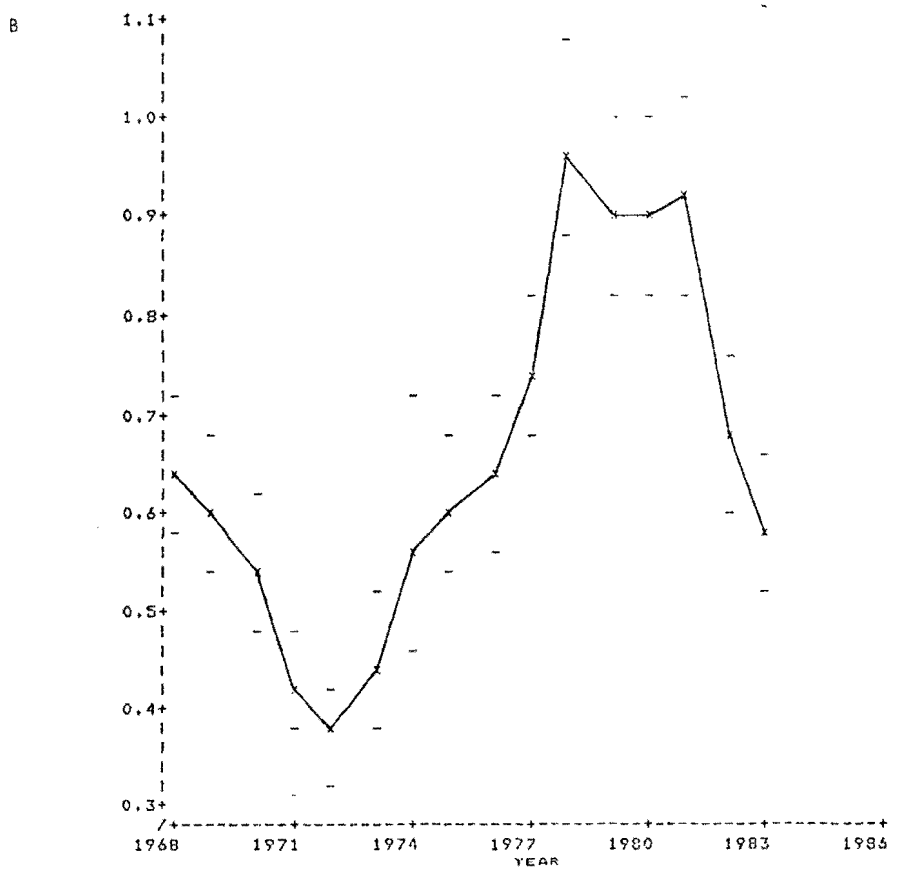


Figure 7. Commercial catch rates of haddock from NAFO Division 4X from 1970-1984. Solid line is median smoothed trend.
A. OTB2, TC 2-3, 4Xq-r, May-August.
B. OTB2, TC 4-5, 4Xm-p, January-March.
C. OTB2, TC 4-5, 4Xm-p, April-June.

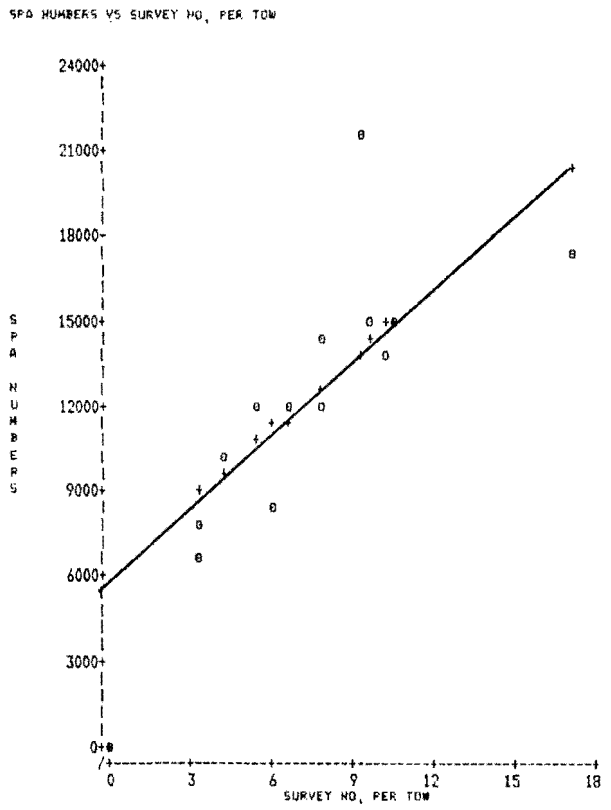
Figure 8. Commercial catch rates (t/hr) for OTB2, TC 5 vessels operating in 4Xmnop during April-June.

A. ages 7-10.
B. ages 1-13+.

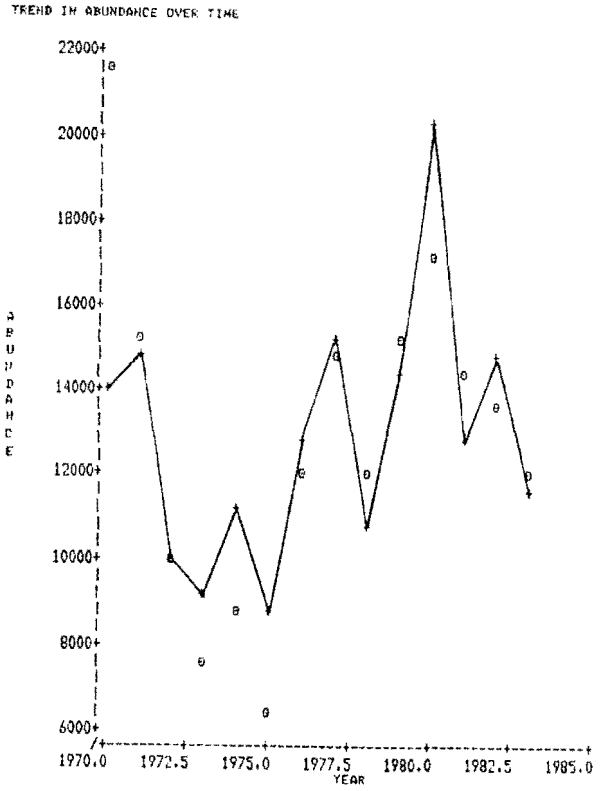




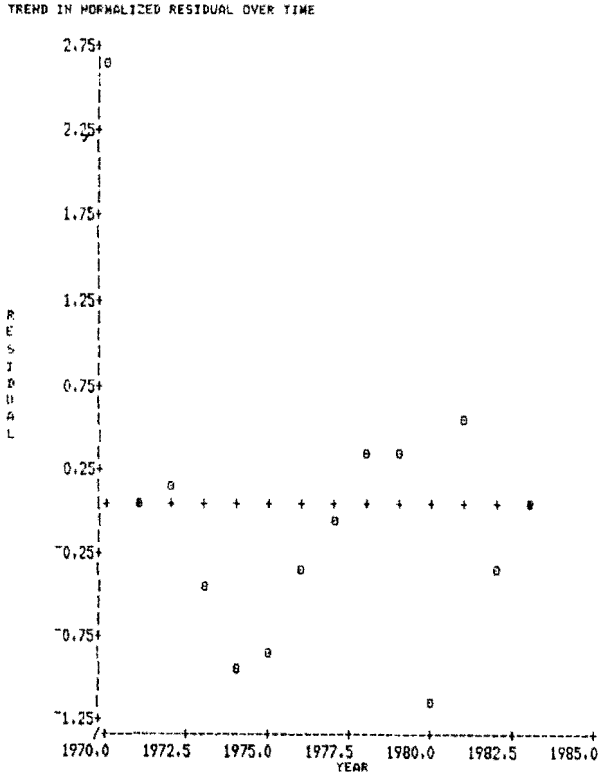
A.



B.



C.



D.

SUMMARY OF DATA FROM PLOT

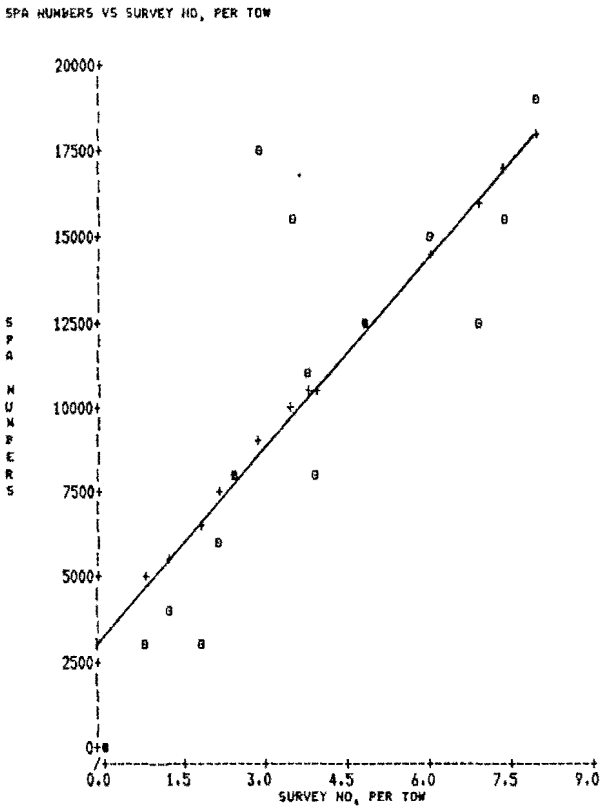
CARRIER VARIABLE: SURVEY
RESPONSE VARIABLE(S): POPULATION NOS - 0:OBSERVED, +:PREDICTED

INDEX	CARRIER	0	+	RANK
1970	9.277	2.157E4	1.400E4	1975
1971	10.46	1.524E4	1.498E4	1973
1972	4.221	1.019E4	9.819E3	1972
1973	3.236	7.674E3	9.004E3	1978
1974	6.053	8.663E3	1.133E4	1974
1975	3.186	6.522E3	8.963E3	1983
1976	7.795	1.185E4	1.278E4	1976
1977	10.491	1.476E4	1.501E4	1981
1978	5.527	1.193E4	1.090E4	1970
1979	9.541	1.528E4	1.422E4	1979
1980	17.096	1.733E4	2.047E4	1982
1981	7.83	1.422E4	1.280E4	1971
1982	10.164	1.379E4	1.473E4	1977
1983	6.485	1.188E4	1.169E4	1980

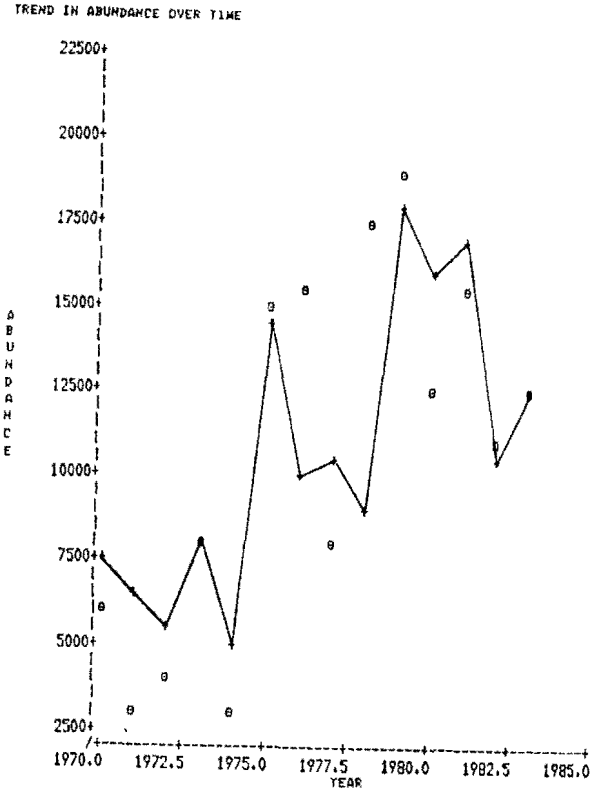
Figure 9. Ages 5+ tuning plots for F_{5+} of 0.65.

A. SPA numbers (000's) versus survey no. per tow.
B. Trend in observed (0) and predicted (+) abundance over time.
C. Trend in residual around ordinary least squares regression line fit over time.
D. Data used in plots: Carrier - survey no. per tow, o - observed SPA numbers (000's), + - predicted SPA numbers (000's).

A.



B.



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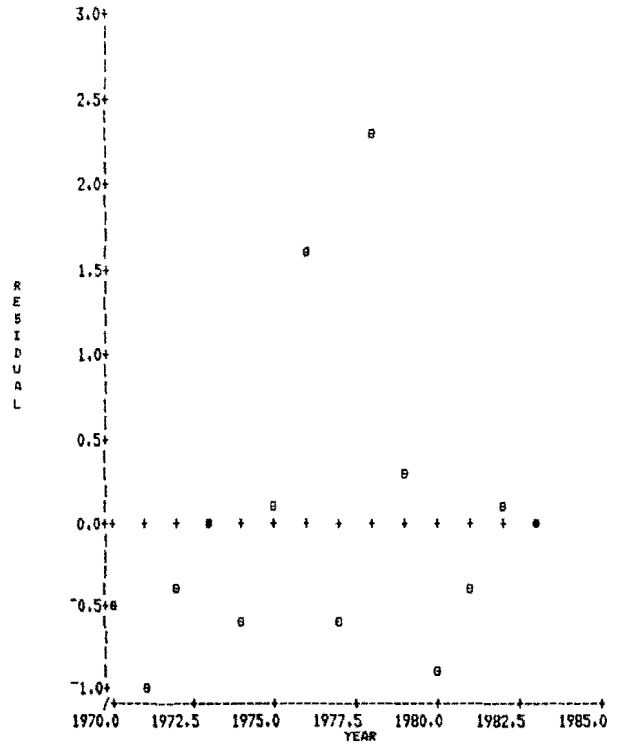


D.

SUMMARY OF DATA FROM PLOT

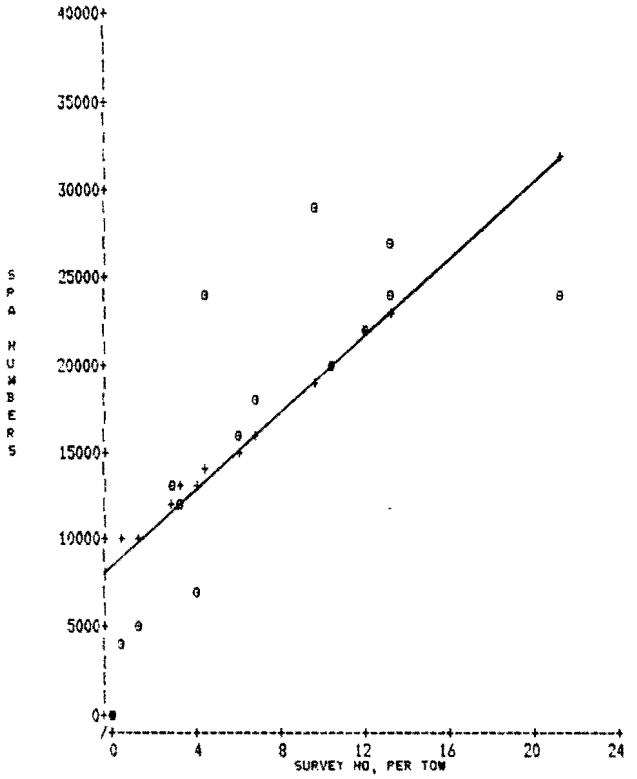
CARRIER VARIABLE: SURVEY
RESPONSE VARIABLE(S): POPULATION NOS - 0:OBSERVED, +:PREDICTED

INDEX	CARRIER	0	+	RANK
1970	2.167	5.781E3	7.512E3	1974
1971	1.729	3.012E3	6.714E3	1972
1972	1.16	4.217E3	5.676E3	1971
1973	2.466	8.097E3	8.057E3	1970
1974	0.768	2.877E3	4.962E3	1973
1975	6.013	1.505E4	1.452E4	1978
1976	3.405	1.568E4	9.769E3	1976
1977	3.868	8.208E3	1.061E4	1982
1978	2.87	1.730E4	8.793E3	1977
1979	7.919	1.911E4	1.800E4	1983
1980	6.841	1.253E4	1.603E4	1975
1981	7.32	1.540E4	1.690E4	1980
1982	3.819	1.081E4	1.052E4	1981
1983	4.774	1.226E4	1.226E4	1979

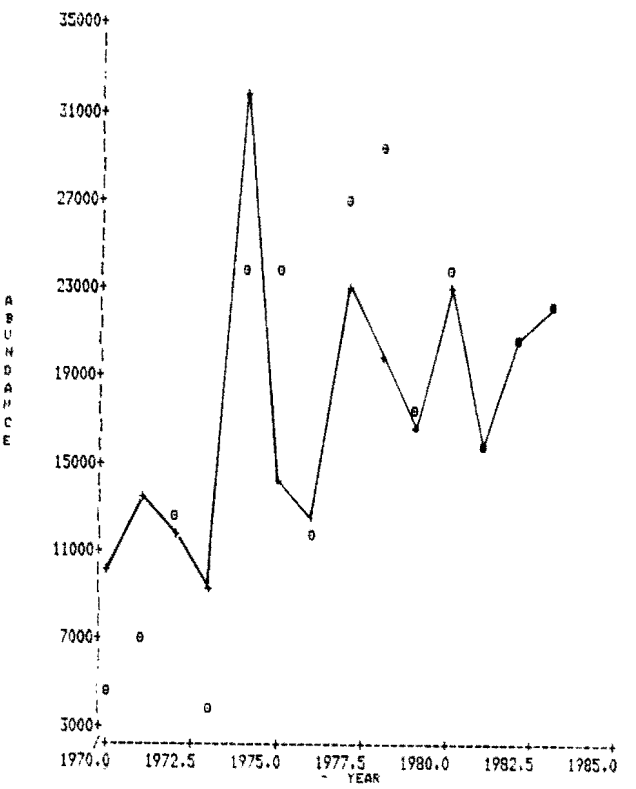
Figure 10. Age 4 tuning plots for F_{5+} of 0.65.

A. SPA numbers (000's) versus survey no. per tow.
B. Trend in observed (0) and predicted (+) abundance over time.
C. Trend in residual around ordinary least squares regression line fit over time.
D. Data used in plots: Carrier - survey no. per tow, o - observed SPA numbers (000's), + - predicated SPA numbers (000's).

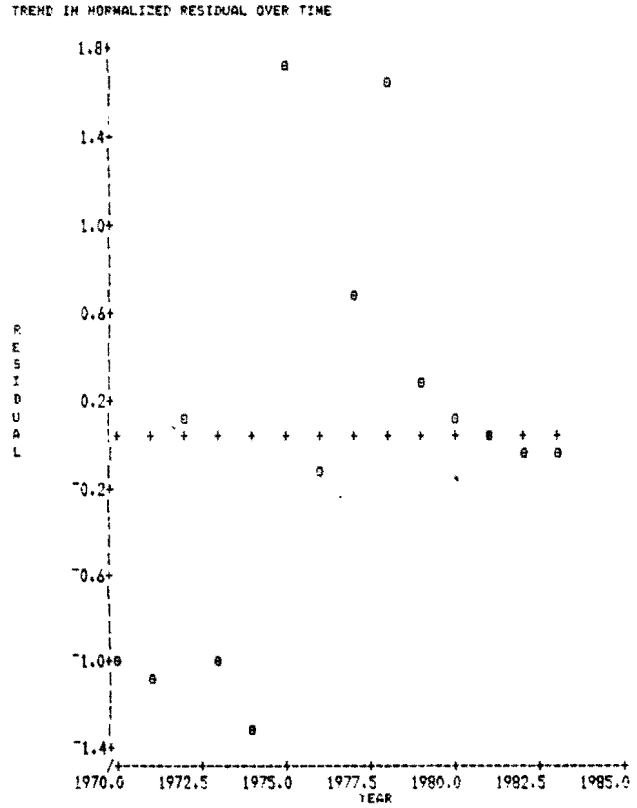
A.



B.



C.



D.

SUMMARY OF DATA FROM PLOT

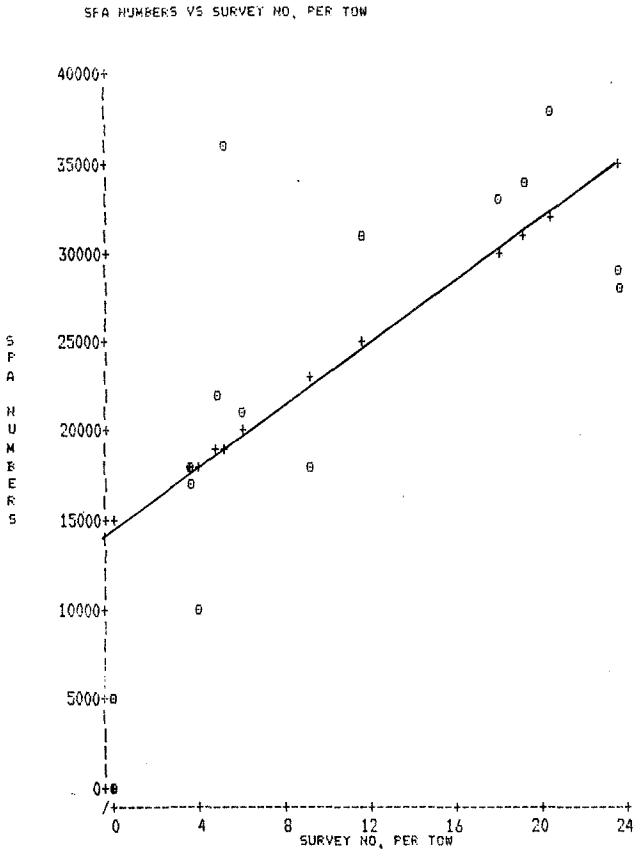
CARRIER VARIABLE; SURVEY
RESPONSE VARIABLE(S); POPULATION NOS - 0;OBSERVED, +;PREDICTED

INDEX	CARRIER	0	+	RANK
1970	1.148	4.531E3	1.041E4	1973
1971	3.933	7.127E3	1.340E4	1970
1972	2.732	1.298E4	1.211E4	1972
1973	0.479	3.750E3	9.685E3	1976
1974	21.00	3.395E4	3.202E4	1971
1975	4.383	2.408E4	1.389E4	1975
1976	3.394	1.210E4	1.282E4	1981
1977	13.077	2.716E4	2.325E4	1979
1978	9.544	2.925E4	1.945E4	1978
1979	6.605	1.774E4	1.628E4	1982
1980	13.179	2.389E4	2.336E4	1983
1981	5.86	1.581E4	1.548E4	1977
1982	10.492	2.033E4	2.047E4	1980
1983	11.837	2.185E4	2.192E4	1974

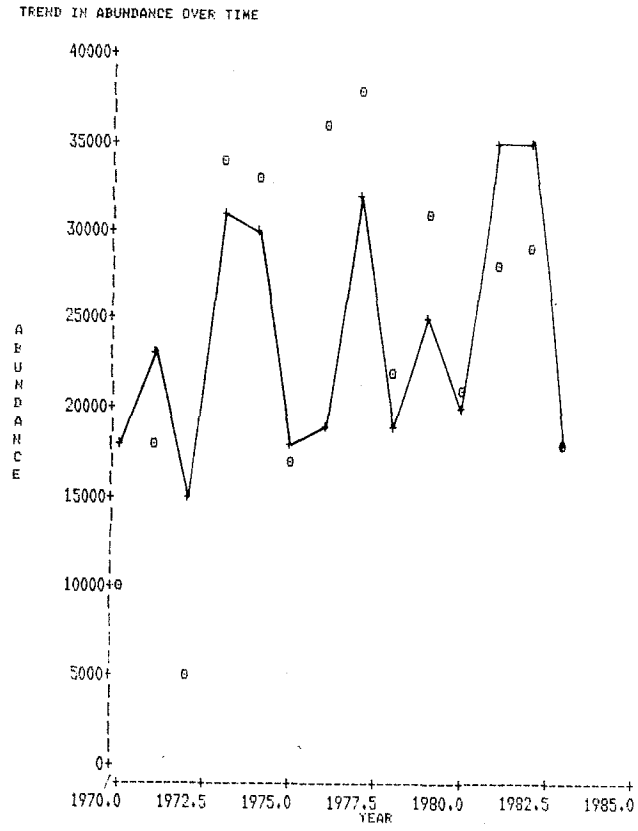
Figure 11. Age 3 tuning plots for F_{5+} of 0.65.

A. SPA numbers (000's) versus survey no. per tow.
B. Trend in observed (o) and predicted (+) abundance over time.
C. Trend in residual around ordinary least squares regression line fit over time.
D. Data used in plots: Carrier - survey no. per tow, o - observed SPA numbers (000's), + - predicated SPA numbers (000's).

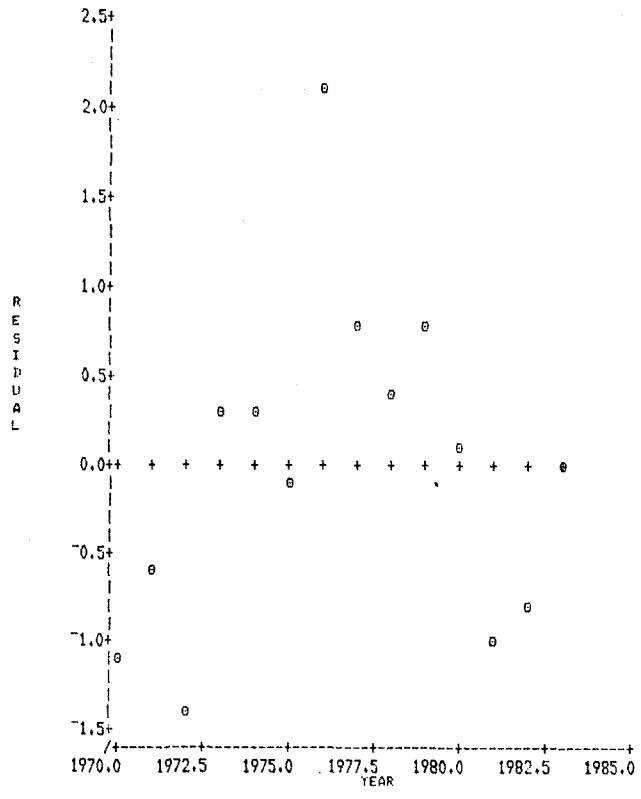
A.



B.



C.



D. SUMMARY OF DATA FROM PLOT

CARRIER VARIABLE: SURVEY
RESPONSE VARIABLE(S): POPULATION NOS - 0:OBSERVED, +:PREDICTED

INDEX	CARRIER	0	+	RANK
1970	3.921	1.024E4	1.834E4	1972
1971	9.263	1.839E4	2.284E4	1975
1972	0.195	4.669E3	1.519E4	1983
1973	19.053	3.367E4	3.110E4	1970
1974	17.942	3.256E4	3.016E4	1978
1975	3.466	1.688E4	1.795E4	1976
1976	5.272	3.573E4	1.947E4	1980
1977	20.246	3.841E4	3.211E4	1971
1978	4.66	2.240E4	1.896E4	1979
1979	11.528	3.061E4	2.475E4	1974
1980	6.028	2.071E4	2.011E4	1973
1981	23.78	2.759E4	3.509E4	1977
1982	23.442	2.903E4	3.480E4	1982
1983	3.717	1.812E4	1.816E4	1981

Figure 12. Age 2 tuning plots for F_{5+} of 0.65

A. SPA numbers (000's) versus survey no. per tow.
B. Trend in observed (0) and predicted (+) abundance over time.
C. Trend in residual around ordinary least squares regression line fit over time.
D. Data used in plots: Carrier - survey no. per tow, o - observed SPA numbers (000's), + - predicated SPA numbers (000's).

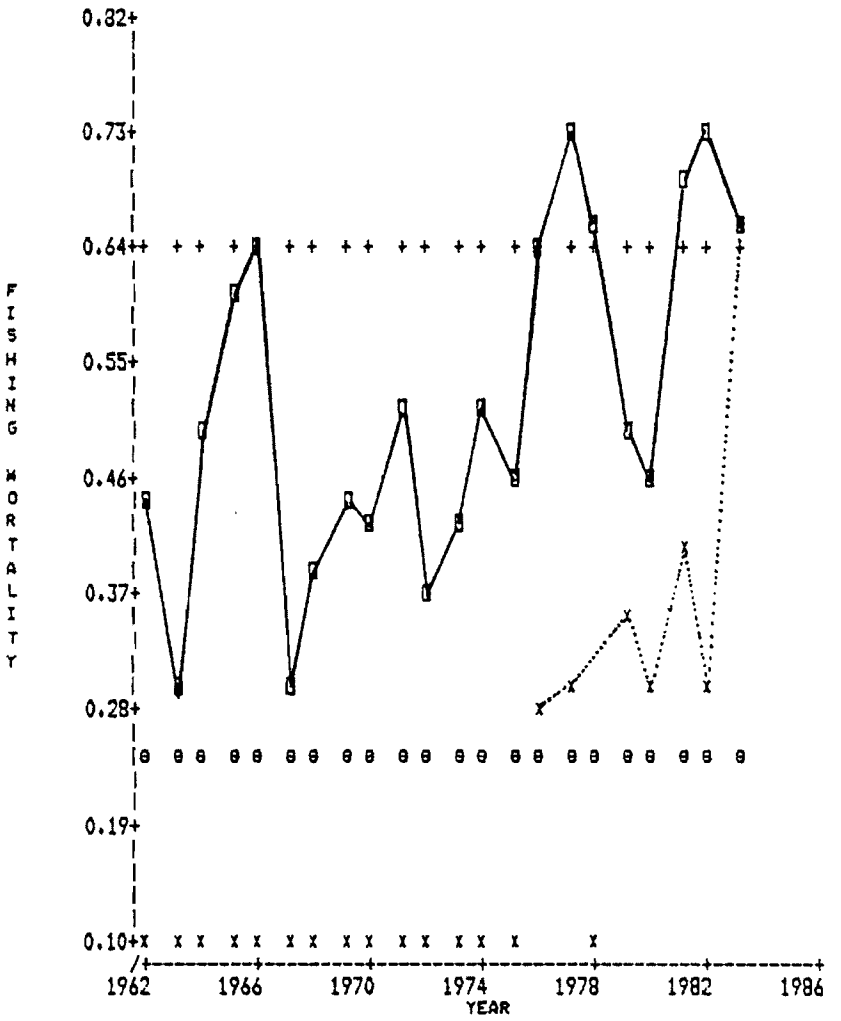


Figure 13. Trend in SPA-generated (F 5+ of 0.65 in 1983) F_{7-10} during 1962-83.

+ - F_{MAX}

⊖ - $F_{0.1}$

x - CAFSAC determined F

□ - weighted (on population numbers) fishing mortality for ages 7 to 10.

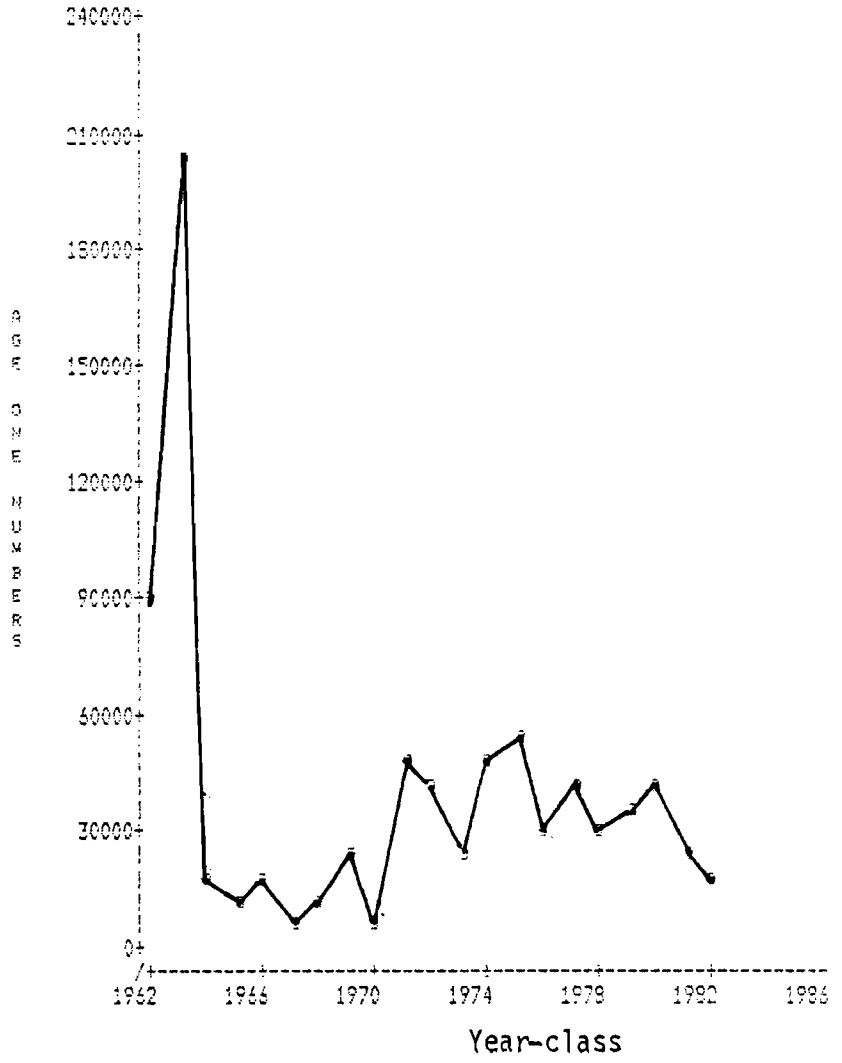


Figure 14. Trend in 4X haddock recruitment (age one numbers) during 1962-83, based on cohort analysis presented in Table 17.