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1980 Assessment of Cod in Divisions 4T and 4Vn (Jan-Apr)

by

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INTRODUCTION

The southern Gulf of St. Lawrence cod stock is migratory, spending the summer in the Magdalen shallows (Div. 4T) and the winter on the edge of the Laurentian Channel off the northeast coast of Cape Breton (Subdiv. 4Vn). Nominal catches from this stock peaked at 110,000 t in 1956, at a time when the herring biomass was substantially reduced by disease. Nominal catches then declined until 1967, after which they began to increase due to larger catches in Subdiv. 4Vn (Tables 1, 2).

Catch rates began to decline in the commercial fishery in the early 1970's as did estimated population size derived from Canadian groundfish surveys. A catch quota was first introduced for this stock in 1974 by ICNAF and since then, annual quotas have been set. Reported catches dropped to a low of 22,000 t in 1977 but have been increasing since then, coincident with the increasing biomass of this stock.

ABSTRACT

A review of the Canadian fishery on the Div. 4T-4Vn (Jan.-Apr) cod stock in the 1970s was conducted as well as an analytical assessment for this stock. The Div. 4T cod fishery has been 100% Canadian since 1977, but French catches still occur in the 4Vn (Jan.-Apr.) fishery. Otter trawls and gillnets were the main gears used in the Div. 4T fishery, and otter trawls were virtually the only gear used in the 4Vn (Jan.-Apr.) fishery. Virtually all of the catch of gillnets and long- and hand-lines was made by vessels under 50 gross registered tons. Most of the catch of Danish and Scottish seiners was made by vessels 50 - 150 GRT. The proportion of the catch attributable to different sized otter trawlers was variable, and was dependent upon regulations in force at the time.

An analysis of samples from the commercial landings indicated that the mean length and age of cod in the Subdiv. 4Vn January to April otter trawl fishery were similar to those of the May to August Div. 4T otter trawl fishery. The mean length and age of cod caught by gillnets and long- and hand-lines were greater than those caught by otter trawls and Danish and Scottish seines. In November and December of 1979 in Div. 4T, the mean length and age of cod caught by otter trawlers over 500 GRT were similar to those of smaller trawlers.

Catch per unit efforts for most segments of the fishery indicate that the stock has been increasing in abundance since 1976. Groundfish surveys also suggest that the stock has been increasing in abundance, with the abundance estimates in 1979 being the highest since the stratified random survey design began in 1970. The research surveys also indicated that the 1975 year-class was the strongest on record. The 1977 year-class also appears to be strong, but further data are necessary for confirmation.

In 1979 the majority of the catch was comprised of the 1973 and 1974 year-classes. Although the 1975 year-class is very large, it was poorly represented in the catch, and thus in the analytical assessment, the partial recruitments of age 3 and 4 cod were substantially lower than the historical average.

Variability in growth rates was investigated for this stock, with the result that growth rate appears to be inversely related with stock biomass. This result has implications for projections based upon the assumption of constant weights-at-age. Changes in weights-at-age will have to be carefully investigated for next year's assessment.

NOMINAL CATCHES

The trends since 1965 of Canadian and foreign catches from this stock are illustrated in Tables 1 and 2 and Fig. 1. The Canadian share of the catch has been increasing in the late 1970's as compared with the early 1970's. Tables 3, 4 and 5 indicate the nominal catch of cod by several gears in 4TVn (Jan-Apr) cod during the last three years. Table 6 indicates the breakdown of the catch by gear for 1971 to 1979. Otter trawls and gillnets were the two major gears, with Danish and Scottish seiners accounting for an increasing portion of the Div. 4T catch. The nominal catch for each gear type in Table 6 is broken down by vessel size in Table 7, and the relative proportion of the Canadian catch caught by different sized otter trawlers is indicated in Fig. 2. Fig. 3 illustrates the relative contribution of tonnage class 2 and 3 vessels to the total catch of Danish and Scottish seiners. Catches by tonnage class 3 vessels have comprised about 75% of the catch of all Danish and Scottish seiners since 1974.

SAMPLING OF CANADIAN LANDINGS IN THE 1970's

Table 8 indicates the level of sampling of the Canadian landings of this stock in the 1970's. The number of samples taken generally increased in 1976 and has remained at this higher level. However, although gillnets may account for at least 30% of the catch, the number of samples from the gillnet landings is less than those of otter trawl and Danish seine landings. A greater number of samples from the gillnet landings would be desirable in order to reflect more accurately removals at age from this stock.

Table 9 indicates the mean length and mean age of the cod in the landings of each gear. Cod caught by gillnets and long- and hand-lines were generally older than those caught by otter trawls and Danish and Scottish seines. In a comparison of the otter trawl landings, there was no marked difference in the mean length and mean age of cod landed in the three intervals. Cod landed in the January to April period in this stock were of similar size and age to those landed in the May-August period. Cod landed in the May-August period were slightly larger and older than those landed in the September-December period, but the difference was not pronounced.

Tables 10 and 11 indicate the mean length and age of cod caught by otter trawlers over 150 GRT in the winter 4TVn fishery since 1973. Vessels greater than 100 feet in length were excluded from Div. 4T from 1976-78, and thus no samples were available. In 1973 and 1974, the mean length and age of cod landed in Div. 4T in December were less than those

in the landings of smaller otter trawlers in the same period (Tables 9 and 10). In 1975 there were no samples from landings of otter trawlers less than 150 GRT in the September to December period. Large otter trawlers were readmitted to Div. 4T in 1979. Samples from landings in the November-December period in 1979 indicated that larger trawlers caught similar-sized and aged fish as compared with otter trawlers and longliners less than 50 GRT (Table 10.)

A comparison of the mean length and age of cod landed by otter trawlers over 150 GRT in the winter Div. 4Vn fishery (Table 11) with those of all otter trawler May-August landings in Div. 4T in the same year reveals no consistent pattern. There is no evidence that large Canadian otter trawlers in this fishery catch younger or smaller fish than smaller otter trawlers in the May-August fishery in Div. 4T.

ABUNDANCE OF COD FROM RESEARCH SURVEYS

The abundance of cod as derived from the fall groundfish cruises in Div. 4T is indicated in Table 12. The 4+, 5+, 6+ and 7+ cod are illustrated in Figure 4. The number of 4+ has increased by a factor of 2 between 1977 and 1978 and again between 1978 and 1979. This large increase in 4+ numbers is presumably accounted for by the large size of the recruiting year-classes of 1973, 1974 and 1975. The 1976 year-class also appears to be larger than those before 1973, and the 1977 year-class may equal the 1975 year-class in abundance. The abundance of the 1977 year-class at age 2 was more than twice as large as any other year-class in the research surveys. Mortalities estimated by examining fully recruited age groups indicated that fishing mortality was high through the middle 1970's but has been declining recently.

CATCH PER UNIT EFFORT

Commercial catch per unit efforts were considered for Canadian otter trawl tonnage classes 2, 3, 4 and 5 and Canadian, Danish and Scottish seiners tonnage class 2 and 3. Otter trawlers account for over 50% of the Canadian catch (Table 6, Fig. 2), and Danish and Scottish seiners account for an increasing proportion of the Div. 4T catch in the late 1970's. For otter trawlers, tonnage class 5 vessels have accounted for an increasing portion of the trawlers' catch, as has tonnage class 3 for the seiner catch. To estimate the catch per unit effort for each tonnage class, the directed catch and effort were taken for a three-month period that usually accounted for a majority of the catch. For tonnage classes

2 and 3 of both otter trawlers and Danish and Scottish seiners, this period was May, June and July. For tonnage classes 4 and 5, this was January, February and March. The catch per unit efforts for the four tonnage classes of otter trawlers are indicated in Figure 5 and Table 13 and those for Danish and Scottish seiners are shown in Figure 6 and Table 14. No effort data were available for tonnage class 2 otter trawlers in 1979, with most of these vessels based in Quebec. Figure 7 illustrates the catch per unit effort based on the stratified random survey design. These data indicate that catch per unit effort has been increasing since 1975.

Table 15 shows the correlations between the otter trawl CPUE's and research CPUE and research 4+ numbers. The trends in catch per unit effort of tonnage class 3 are the only ones that are similar to those of the research data. Table 16 indicates the same correlations for tonnage class 2 and 3 Danish and Scottish seiners. Again, only tonnage class 3 agreed with the research data, but this was only between commercial CPUE and research 4+ numbers. The catch per unit effort of tonnage class 3 trawlers and seiners appears to be the most representative in changes of abundance in the cod.

The level of foreign catch of this stock has changed markedly over time. Gray (MS 1979) indicated that the foreign catch has tended to be of smaller cod and that the amount of catch may have been under-reported. Fishing gears have also changed in the Canadian fishery. Gray (MS 1979) concluded that it was not possible to develop an average effort index that adequately reflected the fishery that could be used to adjust fishing mortalities.

REMOVALS-AT-AGE

Samples of the commercial landings of otter trawlers, seiners, gillnets and handlines were available. Removals-at-age were estimated by taking removals at age by that gear and weighting by the catch in a four-month interval when sufficient samples were available. Larger intervals were used when sampling was less intensive. Removals-at-age were calculated in this manner for 1979 and 1978, the 1978 values having been based on preliminary nominal catch data. The rest of the removals-at-age table was taken from Lett (MS 1978), except for 1976 and 1977 which were taken from Gray (MS 1979). The removals-at-age data in Table 17 formed the basis of the cohort analysis.

The same weighting of samples yielded mean weights-at-age in the commercial fishery (Table 18). The mean weights of ages 3, 4 and 5 are higher than the mean weights of all age 3, 4 and 5 in the population because these ages were only partially recruited to the commercial gear. Table 19 indicates the catch-at-age divided by the research abundance estimates, as this may be indicative of partial recruitments to the commercial fishery.

COHORT ANALYSIS

A cohort analysis was conducted by using the removals-at-age data and with the 1979 fishing mortality and selectivity pattern adjusted so that the analysis agreed with the research and commercial CPUE and the research survey data concerning the strength of the recruiting year-classes (Table 20). The abundance of each year-class at ages 1, 2 and 3 in the research cruise estimates relative to the mean for that age was averaged to provide an index of the year-class size to correlate with estimates of age 3 cod from cohort analysis. This relationship is shown in Fig. 8 and the correlation coefficient was 0.92 (r^2 = 0.85).

The accuracy of the cohort was investigated in several ways. The abundance of cod in the 1979 research survey showed a two-fold increase over that of 1978. However, there appears to be a curvilinear relationship between actual abundance and abundance derived from the research surveys, with research surveys possibly overestimating actual increases in abundance. Therefore, more weight was given to the 1976 to 1978 points in fitting final relationships. One relationship examined was the number of age 4 cod in the cohort and in the research surveys. This relationship is indicated in Fig. 9, with the correlation coefficient 0.95 including the 1979 point. Another relationship investigated was between cohort age 4+ numbers and research age 4+ numbers (Fig. 10). With 1979 included, the correlation coefficient was 0.95, and 0.97 without 1979. A final relationship involving the research data was between age 5+ cohort numbers and age 5+ research (Fig. 11). With 1979 included, the correlation coefficient was 0.91, and 0.97 without. From these relationships, it is apparent that there is good agreement between the cohort and research numbers.

A relationship between fishable biomass (numbers x partial recruitment x weight) and catch-per-unit effort of tonnage class 3 seiners and trawlers was investigated. Fishable biomass from 1967 to 1978 was calculated by applying the partial recruitments and weights-at-age from Gray (MS 1979) to numbers-at-age in the cohort. Fishable biomass for 1979 was determined by applying the weights and partial recruitments in this analysis to the 1979 numbers-at-age. The relationship between CPUE of tonnage class 3 Danish and Scottish seiners and fishable biomass is indicated in Fig. 12, and the correlation coefficient of this relationship was r = 0.90 (r^2 = 0.81). The 1979 point was very close to the

regression line. The relationship between CPUE of tonnage class 3 otter trawlers and fishable biomass is indicated in Fig. 13, with the correlation coefficient being $r = 0.80$ ($r^2 = 0.64$), with the 1979 point excluded. The 1979 point was off the regression line, with the CPUE unusually high. The 1979 CPUE was 2.7 times greater than that of 1978 (Table 13), and due to the preliminary nature of the 1979 data, must be evaluated with caution. The analyses concerning the precision of the cohort are summarized in Table 21. The regression of numbers at age 3 from the cohort on the recruitment index predicts over 150 million fish at age 3 in 1980. For projections, the 1977 year-class was set at 150 million at age 3, below the size of the 1975 year-class.

YIELD PER RECRUIT

A Thompson-Bell yield analysis was conducted on the weights and partial recruitments in Table 18. This gave a yield per recruit of 0.76 kg at $F_{0.1}$ of 0.195 and 0.82 kg at $F_{max} = 0.320$.

GROWTH

To determine if instantaneous growth rates were dependent upon population biomass, I determined instantaneous growth rates as determined by changes in weight of ages 5 to 9 and population biomass of ages 3+ from 1958 to 1978. Biomass was determined by using the weights-at-age from the September research cruises, numbers at age in the stock from 1967 through 1978 from Gray (1979) and numbers-at-age from 1958 through 1966 from Lett (1978).

Mean instantaneous growth rates of ages 5 to 9 were inversely related with population biomass ($r = -0.64$, $df = 20$, $P < 0.01$). To smooth out sampling irregularities and better illustrate trends, I examined the relationship between the three-point running averages of biomass and growth rate and found a stronger correlation ($r = -0.76$, $df = 18$, $P < 0.01$).

With population biomass implicated as having an effect on growth rate, a method to predict future growth rate changes was investigated because changes in weights-at-age can have an impact on projected total allowable catches. A multiple regression model was fitted by investigating changes in age-specific instantaneous growth rates of ages 3 to 9 that were derived by sampling the landings of otter trawlers from May through August from 1958 to 1978. Instantaneous growth rates greater than 0.45 for ages 5, 0.35 for age 6, 0.30 for ages 7 to 9, and negative rates were considered an artifact of poor sampling and were excluded from the analysis. The model fitted was:

$G = b_1W + b_2 W^2 + b_3 \ln B + b_4 \ln WXB + k$

G = age - specific instantaneous growth rate in one year

W = weights in kg for each age

B = biomass of cod in metric tonnes

K = regression constant.

This analysis yielded:

Variable	Co-efficient	S. E.	t
W	0.784	0.156	5.02
W^2	-0.094	0.023	-4.12
ln B	0.689	0.117	5.90
ln WXB	-0.810	0.107	-7.60
K	1.091		

The multiple correlation was 0.88 (R^2 = 0.77) and the regression was highly significant (F = 68.13, df = 4,98, P<0.0001).

The mean weights-at-age for Div. 4T cod in the September research cruises are shown in Table 22, and those of the May through August otter trawl fishery are shown in Table 23. The otter trawl data indicates that mean weights of fully-recruited fish have been declining the past three years and the research data indicates that mean weights of age 3 to 6 cod decreased from 1978-79.

PROJECTIONS

Projections were conducted from the 1979 numbers-at-age in the cohort analysis. The relationship between cohort age 3 numbers and the recruitment index predicted a 1979 recruitment of 100 million and a 1980 recruitment of 150 million. The 1981 recruitment was assumed to be 100 million, but this will have little bearing on the TAC due to the low partial recruitment of age 3 cod. These values were input as the estimated recruitments from 1979 to 1981.

Projections were run under the assumption that the weights-at-age and partial recruitment in 1979 will remain constant until 1981. Two projections were run, with one incorporating a 1980 TAC of 54,000 tonnes and the other an $F_{0.1}$ fishing mortality. The results of these projections are indicated in Table 24.

An example projection incorporating biomass-dependent growth.

A projection incorporating the effects of population biomass on growth rate was conducted by predicting future weights-at-age from the growth rate equation in the previous section and the 1979 weights-at-age in Table 18. For each year from 1980-85, the procedure was to calculate weights-at-age, population biomass, yield per recruit and associated $F_{0.1}$. Partial recruitments were assumed to remain constant from 1980-85. Recruitments were assumed to be 100 million in 1979, 150 million in 1980, 100 million in 1981, and 70 million from 1982-85, the geometric mean of recruitment from 1967-78. Two projections were done to illustrate the differences in TAC by assuming constant weights-at-age and biomass-dependent changes in weights-at-age.

Table 25 illustrates the results for the fixed parameter projection. A TAC in 1980 of 54,000 mt results in a fully-recruited fishing mortality of 0.21. A projection incorporating biomass-dependent growth was also run, under the assumption of a TAC of 54,000 tonnes in 1980 and a fishing mortality of $F_{0.1}$ from 1981-85. Age 3 cod were assumed to be a constant weight of 0.35 kg. The parameters used for each annual projection are indicated in Table 26. The results of the biomass-dependent weights-at-age projection are shown in Table 27. A TAC in 1980 of 54,000 tonnes results in a fully-recruited fishing mortality of 0.25. The catch biomasses at the $F_{0.1}$ fishing mortality range between 10,000 - 30,000 tonnes less in the biomass-dependent growth projection than in the fixed parameter projection. The weights-at-age in the commercial fishery in 1980 will have to be carefully investigated for next year's assessment in order to provide updated advice for 1981.

DISCUSSION

The comparison of the fixed parameter and biomass-dependent growth projections to 1985 are for illustrative purposes only and are not intended, in either case, to be representative of the actual conditions experienced in the future. The empirical statistical relationship between growth rate and population biomass has not been validated, and it has not been established that weight-at-age 3 is constant as assumed in the projection. It seems reasonable that partial recruitment to the fishery is likely to vary with

growth rate rather than remain constant as assumed. The illustration simply indicates that biomass-dependent growth could result in even short-term projections using a fixed parameter model being in error by 10 to 20%. However, in relation to 1981, errors in assessment of the current status of the stock are probably of a similar magnitude, and the difference between the results of the two projections in the short term may not be meaningful. It would be useful to investigate management strategies other than fishing at $F_{0.1}$ in relation to maximizing long-term catches from a stock when growth rate is dependent upon stock biomass.

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LITERATURE CITED

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Table 1. 4TVn (winter) Cod: Nominal Catch (t) all gears, all countries.

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
4T															
Canada	45453	37227	32918	37467	40624	42616	40644	39987	24833	19121	24570	15935	19536	25441	42593
Total	46471	38248	34245	37910	40905	43410	40669	42096	25756	28579	28853	17600	19536	25441	42593
% Canada	97.81	97.33	96.12	98.83	99.31	98.17	99.94	94.99	96.42	66.91	85.16	90.54	100	100	100
4VN (Winter)															
Canada	10888	10438	2866	6214	5449	4732	6916	7130	8790	9882	6878	11744	2428	3996	6463
Total	16556	16603	7069	8641	6914	21049	15706	23195	23852	18676	12378	15179	2683	12439	8609
% Canada	65.76	62.87	40.54	71.91	78.81	22.48	44.03	30.74	36.85	52.91	55.57	77.37	90.50	72.24	75.07
4T + 4VN (winter)															
Canada	56341	47665	35784	43681	46073	47348	47560	47117	33623	29003	31448	27679	21964	34427	49056
Total	63027	54851	41314	46551	47819	64459	56375	65291	49608	47255	41231	32779	22219	37880	51202
% Canada	89.39	86.90	86.61	93.83	96.35	73.45	84.36	72.16	67.78	61.38	76.27	84.44	98.85	90.88	95.81
TAC										63000	50000	30000	15000	38000	46000

Table 2a. Nominal Cod Catch (t) by countries in Div. 4T

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Canada	45453	37227	32918	37467	40624	42616	40644	39987	24833	19121	24570	15935	19536	25441	42593
Denmark								672	212	86					
France	912	1009	481	302	259	520	2	495	265	1664	2170	1459			
Norway										686					
Portugal	67					148		366	446	7022	805	206			
Spain	39	12	811	141	22	126	23	576			1308				
U.S.A.			35												
Total	46471	38248	34245	37910	40905	43410	40669	42096	25756	28579	28853	17600	19536	25441	42593

Table 2b: Nominal Cod Catch (t) by countries in Div. 4VN (Jan - Apr.)

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Canada	10888	10438	2866	6214	5449	4732	6916	7150	8790	9882	6878	11744	2428	8986	6463
France	1260	5726	1398	226	120	2450	624	7606	8647	4567	5368	1407	255	3453	2146
Norway	-	128	-	-	-	-	-	-	-	15	-	-	-		
Portugal	1325	138	85	25	307	2526	126	2579	2555	1752	-	170	-		
Spain	2923	2173	2470	2176	1038	11540	8040	5724	3860	2227	2132	1858	-		
FRG	-	-	-	-	-	1	-	-	-	233	-	-	-		
USA	-	-	-	-	-	-	-	75	-	-	-	-	-		
UK	160	-	223	-	-	-	-	82	-	-	-	-	-		
USSR	-	-	9	-	-	-	-	-	-	-	-	-	-		
Poland	-	-	-	-	-	-	-	1	-	-	-	-	-		
Other	-	-	18	-	-	-	-	-	-	-	-	-	-		
TOTAL	16556	16603	7069	8641	6914	21049	15706	25195	23852	18676	12378	15179	2683	12439	8609

Table 3a .1977 Nominal catches (t) for Canadian cod fishery in 4T by month and gear

Catch	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total Catch
Fixed gill net	-	-	-	5	443	1116	1608	1508	875	265	111	-	5931
Handlines	-	-	-	-	37	199	303	224	154	97	95	5	1114
Misc	-	-	-	-	112	185	168	139	105	133	70	-	912
Side O.T.	-	-	-	148	1450	949	989	905	471	1086	1294	52	7344
Stern O.T.	-	-	11	20	332	18	35	32	57	133	188	8	834
OTB unspec.	-	-	-	-	22	1	5	5	9	48	19	-	109
Longlines	-	-	-	-	-	11	78	25	15	17	41	17	204
Purse Seine	-	-	-	-	-	1	1	-	-	-	-	-	2
Danish Seine	-	-	-	-	311	273	311	418	371	318	694	7	2703
Scot. Seine	-	-	-	-	41	32	83	35	47	13	82	14	347
Midwater	-	-	-	-	-	-	1	2	-	-	-	-	3
Pair Seine	-	-	-	-	-	-	2	-	-	-	-	-	2
Uncovered pound nets	-	-	-	-	2	10	12	-	-	-	-	-	24
Covered pots & fyke nets	-	-	-	-	-	-	-	-	-	4	-	-	4
Dredges	-	-	-	-	-	-	-	3	-	-	-	-	3
Total Can	-	-	11	173	2750	2795	3596	3296	2104	2114	2594	103	19536

Table 3b. 1977 Nominal catches (t) for Canadian Cod fishery in 4VN from January - April by gear

Catch	Jan	Feb	Mar	Apr	Total
Side O.T.	402	399	23	51	875
Stern O.T.	417	443	675	7	1542
Longline	-	-	-	3	3
Danish Seine	-	-	-	6	6
Midwater	-	-	2	-	2
Total Can.	819	842	700	67	2428

Table 4.a. 1978 Nominal catch (t) for Canadian fishery in Div. 4T by month and gear.

CATCH	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
Fixed gillnets	-	-	-	4	722	1635	2569	2183	1112	607	97	-	8929
Handlines	-	-	-	-	20	332	273	135	207	232	139	4	1342
Longlines	-	-	-	17	16	7	20	26	23	10	22	-	141
Traps	-	-	-	-	5	5	3	6	-	-	1	-	20
Miscellaneous	-	-	-	-	14	39	89	67	98	104	31	-	442
Otter Trawl (unspec.)	-	-	-	2	43	-	3	26	-	1	29	-	104
Otter trawl (side)	95	-	-	561	3290	983	1214	754	635	1073	159	-	8764
Otter trawl (stern)	68	-	1	59	461	53	90	40	57	239	60	-	1128
Midwater	-	-	-	28	68	-	-	-	-	-	-	-	96
Purse seine	-	-	-	-	3	-	-	-	-	-	-	-	3
Pair seine	-	-	-	-	-	6	-	-	-	-	-	-	6
Danish seine	-	-	-	53	1070	556	469	607	361	322	314	174	3926
Scottish seine	-	-	-	70	332	17	79	3	2	21	16	-	540
TOTAL	163	-	1	794	6044	3633	4809	3847	2495	2609	868	178	25441

Table 4.b. Nominal catch (t) for Canadian cod fishery in Subdiv. 4Vn (January - April) by month-gear in 1978.

CATCH	J	F	M	A	TOTAL
Fixed gillnets	-	-	-	-	-
Handlines	4	-	-	10	14
Longlines					
Traps	-	-	-	-	-
Miscellaneous	-	-	-	-	-
Otter trawl (unspec.)	-	-	-	-	-
Otter trawl (side)	3203	1133	27	27	4390
Otter trawl (stern)	1403	2736	4	18	4161
Midwater	82	337	-	-	419
Purse seine	-	-	-	-	-
Pair seine	-	-	-	-	-
Danish seine	-	-	-	2	2
Scottish seine	-	-	-	-	-
TOTAL	4692	4206	31	57	8986
FRANCE					
Otter trawl (side)	-	62	32	-	94
Otter trawl (stern)	646	1053	1660	-	3359
TOTAL	646	1115	1692	-	3453

Table 5.a. 1979 Nominal catch (t) for Canadian fishery in Div. 4T by month and gear.

CATCH	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL
Fixed gillnets	-	-	-	2	173	358	1069	632	252	392	79	-	2957
Drift gillnets	-	-	-	-	13	67	11	4	1	-	1	-	97
Handlines	-	-	-	-	57	143	194	166	97	164	97	16	934
Longlines	7	-	-	1	5	26	9	10	22	46	111	14	251
Traps	-	-	-	-	48	32	18	8	5	-	-	-	111
Miscellaneous	-	-	-	93	282	170	106	175	231	196	37	-	1290
Otter trawls (unspec.)	-	-	-	-	-	-	-	-	-	-	-	-	-
Otter trawls (side)	-	-	-	487	1676	445	235	129	107	650	2266	1346	7341
Otter trawl (stern)	43	10	-	179	377	41	78	60	59	109	1537	2581	5074
Midwater trawl	-	-	-	-	22	-	-	-	-	-	-	-	22
Purse seine	-	-	-	-	-	-	-	-	-	-	-	-	-
Pair seine	-	-	-	64	280	23	3	-	-	5	5	-	380
Danish seine	6	-	-	573	1436	906	407	390	251	421	1992	470	6852
Scottish seine	-	-	-	52	334	153	109	73	13	86	205	119	1144
Quebec (no breakdown by gear and month)	-	-	-	-	-	-	-	-	-	-	-	-	16140
TOTAL													42593

Table 5.b. 1979 Nominal catch (t) for Canadian cod fishery (M and N) in Div. 4Vn (January - April) by month and gear.

CATCH	J	F	M	A	TOTAL
Fixed gillnets	-	-	-	-	-
Handlines	-	-	-	-	-
Longlines	44	3	-	246	293
Traps	-	-	-	-	-
Miscellaneous	-	-	-	-	-
Otter trawls (unspec.)	-	-	-	-	-
Otter trawls (side)	810	406	419	31	1666
Otter trawls (stern)	141	2644	1165	199	4149
Midwater trawl	213	-	-	-	213
Purse seine	-	-	-	-	-
Pair seine	-	-	-	-	-
Danish seine	12	-	-	130	142
Scottish seine	-	-	-	-	-
TOTAL	1220	3053	1584	606	6463
FRANCE					
Otter trawl (side)	-	96	213	-	309
Otter trawl (stern)	-	1405	407	25	1837
TOTAL	-	1501	620	25	2146
GRAND TOTAL	1220	4554	2204	631	8609

Table 6a. Nominal catch (mt) by all countries of cod in Div. 4T by gear type. Percentage of total catch for that year is in parenthesis.

	Otter Trawls	Seines	Gillnets	Longlines & Handlines	Misc.	Total
1971	20027 (49)	2237 (5)	9675 (24)	6738 (17)	1992 (5)	40669
1972	26712 (63)	2058 (5)	7863 (19)	3007 (7)	2456 (6)	42096
1973	12023 (47)	2066 (8)	8128 (31)	2511 (10)	1028 (4)	25756
1974	18077 (63)	1731 (6)	6070 (21)	2098 (8)	603 (2)	28579
1975	16033 (55)	1970 (7)	6327 (22)	3665 (13)	858 (3)	28853
1976	10014 (57)	1340 (8)	4449 (25)	1215 (7)	582 (3)	17600
1977	8290 (42)	3054 (15)	5931 (30)	1318 (7)	943 (5)	19536
1978	10092 (40)	4475 (17)	8929 (35)	1483 (6)	462 (2)	25441
1979 [1]	12437 (47)	8376 (32)	3054 (12)	1185 (4)	1401 (5)	26453

1 Maritime and Newfoundland data only.

Table 6b. Nominal catch (mt) by all countries of cod in Subdiv. 4Vn (Jan-Apr) by gear type. Percentage of total catch for that year is in parenthesis.

	Otter Trawls	Seines	Gillnets	Longlines & Handlines	Misc.	Total
1971	15440 (98)	22 (0)	-	244 (2)	-	15706
1972	23050 (100)	57 (0)	-	88 (0)	-	23195
1973	23775 (98)	40 (0)	1 (0)	36 (0)	-	23852
1974	18593 (100)	10 (0)	-	73 (0)	-	18676
1975	12374 (100)	2 (0)	-	2 (0)	-	12378
1976	15156 (100)	14 (0)	-	9 (0)	-	15179
1977	2674 (100)	6 (0)	-	3 (0)	-	2683
1978	12423 (100)	2 (0)	-	14 (0)	-	12439
1979 [1]	8174 (95)	142 (2)	-	293 (3)	-	8609

1 Maritime, Newfoundland and French data.

Table 7a. Nominal catch (mt) by all countries of cod in Division 4T by vessel size by gear. Percentage of gear total catch for each size class is in parenthesis

1971 tonnage class (tons)	otter trawls	seiners	gillnetters	long & hand lines	miscellaneous
0-49.9	6922 (34)	1824 (82)	9301 (96)	6655 (99)	1992 (100)
50-149.9	6129 (31)	413 (18)	374 (4)	83 (1)	
150-499.9	5423 (27)				
500-999.9	1528 (8)				
1000-1999.9	25 (0)				
Total	20027	2237	9675	6738	1992
1972					
0-49.9	5676 (21)	1341 (65)	7658 (97)	2982 (99)	1667 (68)
50-149.9	6769 (26)	717 (35)	205 (3)	25 (1)	
150-499.9	8067 (30)				
500-999.9	4891 (18)				115 (5)
1000-1999.9	1276 (5)				2 (0)
≥ 2000	33 (0)				
NK					672 (27)
Total	26712	2058	7863	3007	2456
1973					
0-49.9	4175 (35)	1006 (49)	7918 (97)	2494 (99)	813 (79)
50-149.9	3270 (27)	1060 (51)	210 (3)	17 (1)	3 (0)
150-499.9	3209 (26)				
500-999.9	763 (6)				
1000-1999.9	539 (5)				
≥ 2000	67 (1)				
NK					212 (21)
Total	12023	2066	8128	2511	1028
1974					
0-49.9	2562 (14)	499 (29)	5942 (98)	1409 (67)	517 (86)
50-149.9	2090 (12)	1232 (71)	128 (2)	3 (0)	
150-499.9	3579 (20)			686 (33)	
500-999.9	1263 (7)				
1000-1999.9	5319 (29)				
≥ 2000	3264 (18)				
NK					86 (14)
Total	18077	1731	6070	2098	603
1975					
0-49.9	4242 (27)	340 (17)	6240 (99)	3660 (100)	858 (100)
50-149.9	3893 (24)	1630 (83)	87 (1)	5 (0)	
150-499.9	1981 (12)				
500-999.9	2666 (17)				
1000-1999.9	2960 (18)				
≥ 2000	291 (2)				
Total	16033	1970	6327	3665	858
1976					
0-49.9	2513 (25)	202 (15)	4449 (100)	1215 (100)	582 (100)
50-149.9	1506 (15)	1138 (85)			
150-499.9	2404 (24)				
500-999.9	3327 (33)				
1000-1999.9	203 (2)				
≥ 2000	61 (1)				
Total	10014	1340	4449	1215	582
1977					
0-49.9	3835 (46)	537 (18)	5929 (100)	1317 (100)	943 (100)
50-149.9	3935 (47)	2517 (82)	2 (0)	1 (0)	
150-499.9	375 (5)				
500-999.9	145 (2)				
Total	8280	3054	5931	1318	943
1978					
0-49.9	4347 (43)	1188 (27)	8929 (100)	1466 (99)	453 (98)
50-149.9	4951 (49)	3284 (73)		17 (1)	9 (2)
150-499.9	743 (7)	3 (0)			
500-999.9	70 (1)				
Total	10111	4475	8929	1483	462
1979					
0-49.9	936 (9)	2393 (29)	3040 (100)	1173 (99)	1216 (87)
50-149.9	4336 (43)	5983 (71)	14	12 (1)	186 (13)
150-499.9	2503 (25)				
500-999.9	2283 (23)				
Total	10058	8376	3054	1185	1402

Maritimes

Table 7b. Nominal catch (mt) by all countries of cod in Subdivision 4Vn (Jan-Apr) by vessel size by gear. Percentage of gear total catch for each size class is in parentheses.

Tonnage class (tons)	otter trawls	seiners	gillnetters	long & hand lines	total
1971					
0-49.9		2 (9)		244 (100)	246
50-149.9	135 (1)	20 (91)			155
150-499.9	3060 (52)				3060
500-999.9	2599 (17)				2599
1000-1999.9	4541 (29)				4541
≥ 2000	105 (1)				105
Total	15440	22		244	15706
1972					
0-49.9				74 (84)	74
50-149.9	69 (0)	57 (100)		14 (16)	140
150-499.9	6404 (28)				6404
500-999.9	3824 (17)				3824
1000-1999.9	11474 (50)				11474
≥ 2000	1279 (5)				1279
Total	23050	57		88	23195
1973					
0-49.9				33 (92)	33
50-149.9	8 (0)	40 (100)		3 (8)	51
150-499.9	5611 (23)				5611
500-999.9	5654 (24)				5654
1000-1999.9	11816 (50)		1 (100)		11817
≥ 2000	686 (3)				686
Total	23775	40	1	36	23852
1974					
0-49.9				44 (60)	44
50-149.9	3 (0)	10 (100)		14 (19)	27
150-499.9	4254 (23)			15 (21)	4269
500-999.9	7832 (42)				7832
1000-1999.9	4776 (26)				4776
≥ 2000	1728 (9)				1728
Total	18593	10		73	18676
1975					
0-49.9				2 (100)	2
50-149.9	4 (0)	2 (100)			6
150-499.9	3004 (24)				3004
500-999.9	5019 (41)				5019
1000-1999.9	4050 (33)				4050
≥ 2000	297 (2)				297
Total	12374	2		2	12378
1976					
0-49.9	3 (0)	1 (7)		9 (100)	13
50-149.9	31 (0)	13 (93)			44
150-499.9	5344 (35)				5344
500-999.9	7846 (52)				7846
1000-1999.9	1777 (12)				1777
≥ 2000	155 (1)				155
Total	15156	14		9	15179
1977					
0-49.9	2 (0)	6 (100)		3 (100)	11
50-149.9	2 (0)				2
150-499.9	1071 (40)				1071
500-999.9	1599 (60)				1599
Total	2674	6		3	2683
1978					
0-49.9				14 (100)	14
50-149.9	99 (1)	2 (100)			101
150-499.9	4497 (50)				4497
500-999.9	5271				5271
1000-1999.9	2556				2556
Total	12423	2		14	12439
1979					
0-49.9		54 (38)		293 (100)	347
50-149.9	81 (2)	77 (54)			158
150-499.9	1300 (27)	11 (8)			1311
500-999.9	3409 (71)				3409
Total	4790	142		293	5225

Table 8. Extent of Canadian sampling of commercial landings of cod in Division 4T and Subdivision 4Vn (Jan-Apr) 1971-79.

	Jan-April trawl			May-August trawl			September-December trawl			Seine			Line			Gillnet		
Year	No. of samples	Number measured	No. aged	No. of samples	Number measured	No. aged	No. of samples	Number measured	No. aged	No. of samples	Number measured	No. aged	No. of samples	Number measured	No. aged	No. of samples	Number measured	No. aged
1971	6	1780	280	4	785	133	1	200	38	8	1898	254	1	142	38	2	179	58
1972	7	2360	334	7	1574	255	4	887	137	5	1248	160	1	200	0	2	400	90
1973	7	2161	320	4	801	151	5	1107	177	3	600	107	3	577	80	10	1841	516
1974	15	4849	711	3	700	117	4	894	126	3	600	109	0	0	0	8	1552	316
1975	13	4191	697	10	1855	361	5	1659	233	3	538	88	2	400	85	7	1313	254
1976	18	6166	884	12	2929	523	1	78	23	22	4468	755	11	2188	440	7	1212	270
1977	4	1163	203	11	2217	377	6	1205	202	35	7076	1219	15	2871	592	6	1227	256
1978	12	3855	497	12	2212	407	2	431	66	24	4809	843	6	1200	183	3	580	101
1979	12	3866	457	9	1799	307	13	3435	496	21	4231	697	12	2400	455	4	736	159

Table 9. Mean length (cm) and age (years) of cod in the Canadian landings from the 4TVn (January-April) fishery in the 1970's

	TRAWL						SEINE		LINE		GILLNET	
	January-April		May-August		September-December		May-December		May-December		May-December	
Year	Mean Length	Mean Age	Mean Length	Mean Age	Mean Length	Mean Age	Mean Length	Mean Age	Mean Length	Mean Age	Mean Length	Mean Age
1971	53.9	6.4	52.2	6.0	50.8	5.5	49.7	5.4	63.4	6.2	79.2	8.8
1972	52.4	5.7	44.9	5.2	50.1	5.5	49.4	5.4	58.1	-	85.7	9.5
1973	47.4	5.6	52.3	6.5	46.8	4.4	48.1	5.0	68.4	8.5	80.1	9.0
1974	54.4	6.5	49.1	5.6	48.6	4.3	46.1	4.3	-	-	72.8	8.8
1975	46.8	5.2	53.6	6.2	49.8	4.8	46.3	4.5	62.4	6.8	71.7	8.8
1976	50.3	5.7	49.2	5.1	47.3	4.3	49.1	5.0	53.0	5.3	67.2	7.5
1977	51.4	5.7	53.0	5.7	49.0	4.8	48.6	4.8	51.5	5.0	68.1	7.7
1978	51.9	5.5	45.4	4.9	51.8	5.2	46.8	4.8	52.8	5.6	52.4	5.4
1979	51.1	5.6	51.0	5.6	51.0	5.2	51.0	5.6	54.7	5.9	61.1	6.8

Table 10. Mean length (cm) and age (yr) of cod caught by otter trawlers over 150 tons in the winter Div. 4T fishery.

Period	Vessel Type	Vessel Size (tons)	No. of Samples	No. Measured	No. Aged	Mean Length	Mean Age
Dec. 1973	Side OT	151 - 500	1	300	46	42.7	3.8
Dec. 1974	Stern OT	151 - 500	1	194	27	44.6	3.4
Dec. 1975	Side OT	151 - 500	3	984	121	46.8	4.3
Dec. 1975	Stern OT	> 500	2	675	112	52.3	5.3
Nov. 1979	Side OT	151 - 500	2	576	108	58.4	5.8
Nov. 1979	Stern OT	> 500	1	301	26	48.1	4.8
*Nov. 1979	Stern OT	0 - 50	1	223	30	50.8	5.2
*Nov. 1979	Longliner	0 - 25	1	200	29	47.8	5.3
Dec. 1979	Stern OT	> 500	4	1021	170	51.1	5.3

* Added for comparison.

Table 11. Mean length (cm) and age (yr) of cod caught by otter trawlers over 150 tons in the winter Subdiv. 4Vn (Jan-Apr) fishery.

Period	Vessel Type	Vessel Size (tons)	No. of Samples	No. Measured	No. Aged	Mean Length	Mean Age
1973	Side OT	151 - 500	4	1214	178	47.6	5.7
1974	Side OT	151 - 500	5	1570	245	52.0	6.2
1974	Stern OT	> 500	5	1645	227	56.7	6.8
1975	Side OT	151 - 500	3	1140	152	39.6	4.0
1975	Stern OT	> 500	10	3051	545	54.1	6.3
1976	Side OT	151 - 500	6	1701	234	49.1	5.6
1976	Stern OT	> 500	11	3832	555	50.8	5.7
*1976 (Dec.)	Stern OT	> 500	3	785	152	52.4	4.8
1977	Side OT	151 - 500	1	309	53	54.7	5.4
1977	Stern OT	> 500	3	854	150	51.8	5.9
*1977 (Dec.)	Stern OT	> 500	5	1152	201	50.6	4.7
1978	Side OT	151 - 500	7	2408	296	53.0	5.7
1978	Stern OT	151 - 500	1	300	44	48.6	5.3
1978	Stern OT	> 500	4	1147	157	50.9	5.3
1979	Side OT	151 - 500	5	1532	200	52.4	5.9
1979	Stern OT	151 - 500	3	967	124	52.4	5.7
1979	Stern OT	> 500	4	1367	133	50.3	5.5

* Added for comparison.

Table 12. 4TVn (Winter) Cod: Fall Research Cruise Population Estimates

Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
0	-	-	-	43	-	-	-	21	-	277
1	42	118	1478	146	160	806	5998	1089	2365	336
2	6687	1148	4193	9511	4671	10983	14844	20481	9707	43877
3	15069	12508	9196	18806	20431	8263	64245	29976	43924	44532
4	14551	15132	24553	8727	14375	12506	16128	25203	47326	94433
5	17996	14336	10173	13741	5517	10501	10833	10088	26747	57621
6	16184	11229	8455	6597	6621	3677	4554	5325	8140	23493
7	4849	6979	5756	4607	2934	2636	1206	3000	4593	6135
8	2078	1727	3335	3527	2171	1768	894	1289	1569	2517
9	1793	354	643	2234	2011	819	502	969	627	1257
10	358	381	469	611	855	598	475	614	784	336
11	584	219	406	145	339	712	417	492	910	370
12	467	127	128	462	198	168	124	400	110	616*
13+	944	331	158	228	435	91	147	481	300	-
UK	213	91	-	122	19	-	62	103	-	-
Total	82017	64682	68943	69506	60737	53529	120428	99531	147102	275800
4+	59804	50815	54076	40879	35456	33476	35280	47681	91106	186778
5+	45253	35683	29523	32152	21081	20970	19152	22658	43780	92345
6+	27257	21347	19350	18411	15564	10469	8319	12570	17033	34724
7+	11073	10118	10895	11814	8943	6792	3765	7245	8893	11231
$Z_{4+/5+}$	.52	.54	.52	.66	.53	.56	.44	.09	-.01	
$Z_{5+/6+}$	.75	.61	.47	.73	.70	.92	.42	.29	.23	
$Z_{6+/7+}$	.99	.67	.49	.72	.83	1.02	.14	.35	.42	

* Data for age 12+

Table 13. 4TVn (Jan-Apr) cod: catch per unit effort (t/hr), Canadian otter trawlers.

	Directed Trips (May-July)						Directed Trips (Jan-Mar)					
	TC2			TC3			TC4			TC5		
	C	E	C/E	C	E	C/E	C	E	C/E	C	E	C/E
1967	3991	24871	0.16	1654	7436	0.22	2918	3322	0.88	388	371	1.05
1968	2528	17607	0.14	1603	7001	0.23	4835	4525	1.07	160	133	1.20
1969	3477	15968	0.22	1824	7200	0.25	6019	6060	0.99	1743	1289	1.35
1970	4511	19601	0.23	2491	9618	0.26	5888	5995	0.98	2517	1991	1.26
1971	3733	20418	0.18	3312	12786	0.26	4130	5695	0.73	2321	2495	0.93
1972	3392	17786	0.19	4433	15748	0.28	4902	5225	0.94	3689	3582	1.03
1973	1919	15392	0.12	1570	9164	0.17	2924	3991	0.73	2678	2918	0.92
1974	915	10902	0.08	371	4211	0.09	3664	5444	0.67	3967	5355	0.75
1975	1634	13595	0.12	1981	9924	0.20	2370	3108	0.76	3519	4456	0.79
1976	1072	9828	0.11	707	4631	0.15	5919	6752	0.88	6395	6914	0.92
1977	1773	13723	0.13	1396	7428	0.19	940	1692	0.56	1332	2277	0.59
1978	1938	14451	0.13	2747	11009	0.25	4458	3219	1.38	4084	2010	2.03
1979	-	-	-	1512	2228	0.68	1168	1820	0.64	3151	2906	1.08

Table 14. 4TVn (Jan-Apr) Cod, catch per unit effort, Canadian Danish seiners.

Directed trips (May, June, July)

	TC2 (t/hr)			TC3 (t/hr)		
	C	E	C/E	C	E	C/E
1967	1290	6505	0.20	20	56	0.36
1968	486	2701	0.18	-	-	-
1969	55	127	0.43	63	191	0.33
1970	343	1615	0.21	93	259	0.36
1971	505	4286	0.12	90	221	0.41
1972	292	1232	0.24	153	476	0.32
1973	135	474	0.28	165	481	0.34
1974	-	-	-	-	-	-
1975	-	-	-	-	-	-
1976	-	-	-	268	1507	0.18
1977	20	226	0.29	561	2488	0.23
1978	405	1422	0.28	1580	4442	0.36
1979	402	1530	0.26	2409	4954	0.49

Table 15.a. Correlations between OTB CPUEs and research cruise numbers of age 4+ cod 1979-79.

	RES 4+	TC2[1]	TC3	TC4	TC5
RES 4+	1.00	0.38	0.94**	0.03	0.37
TC 2[1]		1.00	0.85	0.26	0.24
TC 3			1.00	-0.09	0.22
TC 4				1.00	0.92**
TC 5					1.00

[1] Comparison 1970-78

** P<0.01

Table 15.b. Correlations between OTB CPUEs and research CPUE

	RESEARCH	TC2	TC3	TC4	TC5
Research	1.00	-0.17	0.73*	0.15	0.42
TC 2		1.00	0.85	0.26	0.24
TC 3			1.00	-0.09	0.22
TC 4				1.00	0.91**
TC 5					1.00

* P <0.05

Table 16a. Correlations between Danish and Scottish seiner CPUEs and research cruise numbers of age 4+ cod 1970-79.

	Res 4+	TC2	TC3
Res 4+	1.00	0.38	0.73*
TC2		1.00	0.41
TC3			1.00

* P< 0.05

Table 16b. Correlations between Danish and Scottish seiner CPUEs and research CPUE.

	Research	TC2	TC3
Research	1.00	0.28	0.31
TC2		1.00	0.41
TC3			1.00

Table 17. Catch at age 4TVn (winter) cod.

AGE	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
3	75	1	16	255	100	464	1498	700	310	327	26	2	1541	378	1229	2379	335	633	370	118
4	3967	3304	1720	2123	970	5504	7055	7068	8140	4936	3395	2476	14294	4396	3170	9902	3744	3065	9779	2497
5	8983	13921	10887	4352	6728	6148	10689	5503	8086	12530	14972	7313	11326	11878	3862	6096	8820	3721	9743	14070
6	12515	9475	1889	16021	5863	9292	4505	4586	4674	3571	11925	8941	7193	5982	9851	2350	6710	3039	4804	9894
7	7144	8313	7870	14742	12038	4481	3423	3040	2916	2516	4194	6127	8479	4492	3631	3173	1454	1660	2519	3147
8	1736	2661	4290	6390	9261	8524	1841	1735	1276	2136	1905	2567	5128	3455	2188	1250	1136	429	1021	1611
9	795	777	1480	3180	3760	5534	2262	407	753	917	1444	1237	1370	2204	2081	1033	420	306	216	809
10	1812	506	589	984	1133	1845	1890	1021	434	785	727	554	719	740	1186	738	216	233	258	322
11	388	741	153	392	347	1004	867	901	899	212	569	156	452	380	300	571	126	126	103	213
12	279	385	178	137	149	423	357	383	698	283	360	432	127	130	178	113	134	55	165	61
13	76	188	37	102	103	150	242	171	259	292	239	42	92	63	74	47	41	64	36	50
14	93	174	26	37	88	52	76	82	139	55	139	103	34	35	26	40	16	12	5	9
15	51	33	36	50	24	124	42	23	65	21	30	144	72	14	4	5	8	4	7	15

Table 18. Mean weights-at-age of 4TVn (Jan-Apr) cod derived from commercial sampling and partial recruitments used for cohort analysis.

Age	Weight (Kg)	Partial Recruitment
3	.47	0.005
4	.65	0.07
5	1.00	0.80
6	1.41	1.00
7	2.28	1.00
8	3.18	1.00
9	3.93	1.00
10	5.97	1.00
11	5.82	1.00
12	6.00	1.00
13	4.82	1.00
14	6.82	1.00
15	12.92	1.00

Table 19. Catch at age divided by research abundance estimates.

Age	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
3	0.002	0.000	0.168	0.020	0.060	0.288	0.005	0.021	0.008	0.003
4	0.233	0.164	0.582	0.504	0.221	0.792	0.232	0.122	0.207	0.026
5	0.832	0.510	1.113	0.864	0.700	0.581	0.814	0.369	0.364	0.244
6	0.737	0.796	0.851	0.907	1.488	0.639	1.473	0.571	0.590	0.421
7	0.865	0.878	1.473	0.975	1.238	1.204	1.206	0.553	0.548	0.513
8	0.917	1.486	1.538	0.980	1.008	0.707	1.271	0.333	0.651	0.640
9	0.805	3.494	2.131	0.987	1.035	1.261	0.837	0.316	0.345	0.644
10	2.031	1.454	1.533	1.211	1.387	1.234	0.455	0.379	0.329	0.988
11	0.974	0.712	1.113	2.621	0.885	0.802	0.302	0.256	0.113	0.576

Table 20a. Cohort analysis with M = 0.20 and partial recruitment as in Table 18.

POPULATION NUMBERS

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
3	134533	45918	59793	41328	60372	52212	61421	105673	93601	57374	51639	77112	30456	47878	61910	56004
4	116677	110078	37593	48940	33606	49338	42328	48932	85885	76354	46678	42255	63132	23541	38857	49575
5	70558	91938	87135	29222	38148	26636	35414	28271	33666	62951	58047	35145	32355	38754	15296	28945
6	47648	49640	62676	61489	19987	25145	16245	19323	18167	20247	40202	33978	22157	16242	20982	9029
7	20430	27687	32069	49605	35847	11059	12179	9224	11671	10645	13346	22125	19728	11632	7885	8265
8	6164	10263	15146	19134	27274	18456	5000	6874	4801	6917	6439	7132	12570	8480	5459	3170
9	3218	3476	5995	8519	9884	13951	7398	2428	4058	2776	3730	3548	3516	5652	3817	2490
10	4737	1915	2143	3569	4097	4690	6414	4010	1619	2641	1443	1747	1786	1639	2633	1242
11	1566	2239	1110	1221	2032	2329	2171	3542	2359	933	1452	524	929	811	673	1082
12	908	931	1162	770	645	1349	999	993	2084	1118	572	674	288	352	320	279
13	2323	491	414	791	507	393	722	495	466	1075	659	143	161	121	171	101
14	619	1833	232	306	555	322	186	372	250	147	616	324	79	49	42	73
15	1434	422	1343	166	217	375	216	84	230	79	71	378	172	34	8	11
	410815	346830	306811	265061	233171	206257	190694	230221	258860	243258	224895	225084	187329	155184	158052	160266

	1976	1977	1978	1979
3	104257	132686	180082	96502
4	43699	85056	108061	147104
5	31629	32390	66864	79624
6	18183	17915	23152	45928
7	5266	8815	11918	14608
8	3896	2996	5715	7478
9	1464	2161	2064	3755
10	1104	819	1493	1495
11	349	708	460	989
12	370	172	466	283
13	126	181	91	232
14	40	66	91	42
15	23	19	43	70
	210406	283984	400500	398111

Table 20b. Fishing mortalities derived from cohort analysis.

FISHING MORTALITY

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
3	0.001	0.000	0.000	0.007	0.002	0.010	0.027	0.007	0.004	0.006	0.001	0.000	0.058	0.009	0.022	0.048	0.004	0.005	0.002	0.001
4	0.038	0.034	0.052	0.049	0.032	0.132	0.204	0.174	0.111	0.074	0.084	0.067	0.288	0.231	0.094	0.249	0.099	0.041	0.105	0.019
5	0.152	0.183	0.149	0.180	0.217	0.294	0.406	0.242	0.308	0.248	0.336	0.261	0.489	0.414	0.327	0.265	0.368	0.136	0.176	0.216
6	0.343	0.237	0.034	0.340	0.392	0.525	0.366	0.304	0.335	0.217	0.397	0.344	0.444	0.523	0.732	0.339	0.524	0.208	0.260	0.270
7	0.489	0.403	0.316	0.398	0.464	0.594	0.372	0.453	0.323	0.303	0.427	0.365	0.644	0.556	0.711	0.552	0.364	0.233	0.266	0.270
8	0.373	0.338	0.375	0.461	0.470	0.714	0.522	0.327	0.348	0.417	0.396	0.507	0.599	0.598	0.585	0.572	0.389	0.172	0.220	0.270
9	0.319	0.284	0.319	0.532	0.545	0.577	0.412	0.205	0.229	0.454	0.558	0.487	0.563	0.564	0.923	0.613	0.381	0.170	0.123	0.270
10	0.550	0.345	0.362	0.363	0.365	0.570	0.394	0.330	0.351	0.398	0.813	0.431	0.589	0.691	0.689	1.069	0.244	0.377	0.212	0.270
11	0.320	0.455	0.165	0.438	0.209	0.647	0.582	0.330	0.547	0.289	0.567	0.399	0.771	0.729	0.679	0.875	0.509	0.219	0.285	0.270
12	0.415	0.610	0.185	0.219	0.295	0.425	0.503	0.556	0.462	0.328	1.188	1.232	0.669	0.525	0.952	0.593	0.512	0.437	0.497	0.270
13	0.037	0.550	0.104	0.154	0.254	0.547	0.463	0.481	0.952	0.357	0.512	0.393	0.998	0.860	0.653	0.720	0.444	0.494	0.576	0.270
14	0.182	0.111	0.132	0.144	0.193	0.197	0.599	0.279	0.951	0.532	0.287	0.433	0.647	1.588	1.161	0.938	0.576	0.223	0.063	0.270
15	0.040	0.090	0.030	0.400	0.130	0.450	0.240	0.358	0.370	0.344	0.621	0.538	0.612	0.602	0.767	0.710	0.472	0.270	0.195	0.270

Table 21. Results of cohort analysis.

Year	Fishable Biomass (t)	Recruitment Index
1967	171112	
1968	174772	
1969	188524	
1970	207320	
1971	198512	0.761
1972	192489	0.275
1973	152387	0.639
1974	125070	1.184
1975	103255	0.381
1976	104024	2.031
1977	122741	1.399
1978	182156	3.297
1979	225909	1.723
1980		2.683

CORRELATIONS

	With 1979	Without 1979
Age 3 in cohort and recruitment index	--	0.92
Age 4 cohort and age 4 research	0.95	0.94
Age 4+ cohort and age 4+ research	0.95	0.97
Age 5+ cohort and age 5+ research	0.91	0.97
Fishable biomass and TC 3 seiner	0.90	--
Fishable biomass and TC 3 trawler	0.69	0.80

Table 22. Mean weight-at-age (kg) for cod caught in otter trawls during September cruises of the research vessels *M.V. Harengus* and *E.E. Prince*. Number of otoliths read for each age is in parentheses.

Age	1959	1960	1961	1962[a]	1963	1964	1965	1966	1967	1968
2	0.14 (19)	0.17 (38)	0.15 (36)	-	0.19 (136)	0.19 (68)	0.22 (35)	0.17 (69)	0.20 (51)	0.19 (61)
3	0.36 (33)	0.34 (117)	0.30 (45)	-	0.37 (72)	0.39 (160)	0.40 (86)	0.37 (89)	0.44 (128)	0.42 (126)
4	0.65 (49)	0.66 (136)	0.55 (102)	0.67	0.60 (83)	0.57 (95)	0.68 *89)	0.78 (86)	0.70 (117)	0.81 (185)
5	1.24 (84)	1.10 (73)	0.89 (102)	0.95	0.91 (57)	0.90 (130)	1.18 (34)	1.28 (75)	1.45 (90)	1.36 (138)
6	1.61 (80)	1.73 (72)	1.35 (58)	1.24	1.08 (145)	1.19 (76)	1.23 (59)	1.59 (38)	1.89 (89)	1.91 (89)
7	2.00 (64)	2.00 (19)	2.07 (36)	1.73	1.46 (138)	1.35 (143)	1.67 (27)	1.91 (41)	2.40 (39)	2.62 (86)
8	2.81 (40)	2.76 (15)	2.76 (24)	2.34	2.01 (40)	1.96 (95)	2.02 (58)	2.27 (16)	2.48 (22)	3.64 (37)
9	3.49 (80)	3.69 (6)	3.63 (12)	3.06	2.83 (25)	2.58 (33)	2.54 (52)	2.45 (43)	2.90 (13)	2.56 (29)
10	3.74 (29)	3.18 (7)	5.23 (4)	4.29	5.02 (14)	4.38 (25)	2.92 (17)	3.41 (30)	4.22 (20)	2.94 (9)
11	5.17 (21)	3.68 (6)	6.89 (7)	6.64	3.03 (5)	6.91 (9)	5.05 (5)	4.86 (22)	4.72 (16)	3.96 (16)
12	5.75 (15)	4.20 (3)	7.23 (5)	5.18	8.42 (4)	9.30 (3)	- (0)	6.71 (22)	6.34 (11)	5.31 (18)
13	10.01 (7)	4.37 (2)	7.77 (5)	9.11	9.35 (2)	- (0)	8.59 (4)	8.07 (11)	8.25 (2)	6.27 (6)
14	7.98 (3)	13.37 (1)	8.98 (3)	14.34	6.14 (1)	4.63 (2)	- (0)	10.31 (4)	10.57 (4)	9.53 (8)
15	- (0)	6.14 (1)	15.50 (1)	15.65	- (0)	- (0)	9.70 (1)	- (0)	11.60 (3)	10.78 (2)

Age	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
2	0.18 (42)	0.18 (94)	0.13 (34)	0.15 (83)	0.17 (149)	0.21 (102)	0.09 (171)	0.16 (128)	0.13 (234)	0.17 (110)	0.11 (203)
3	0.43 (77)	0.42 (197)	0.42 (226)	0.39 (134)	0.33 (222)	0.46 (286)	0.29 (177)	0.27 (390)	0.33 (343)	0.33 (406)	0.25 (256)
4	0.84 (89)	0.78 (186)	0.75 (202)	0.73 (335)	0.75 (144)	0.74 (225)	0.74 (244)	0.72 (245)	0.66 (366)	0.71 (429)	0.59 (437)
5	1.41 (106)	1.20 (237)	1.16 (202)	1.22 (171)	1.20 (227)	1.18 (112)	1.20 (218)	1.31 (178)	1.40 (214)	1.21 (281)	0.97 (401)
6	2.03 (29)	1.77 (275)	1.43 (177)	1.56 (174)	1.56 (123)	1.69 (147)	1.79 (88)	1.92 (97)	1.90 (132)	2.14 (100)	1.48 (301)
7	2.77 (32)	2.55 (104)	1.96 (149)	1.95 (140)	1.93 (103)	2.15 (66)	2.36 (67)	2.50 (36)	2.71 (79)	2.60 (62)	2.17 (114)
8	3.71 (25)	3.3.5 (48)	3.01 (50)	2.73 (100)	2.38 (88)	2.33 (49)	2.85 (47)	3.15 (28)	4.42 (42)	3.54 (23)	2.77 (57)
9	4.83 (8)	4.12 (43)	4.24 (14)	3.98 (23)	2.83 (63)	2.49 (46)	3.29 (22)	3.16 (13)	4.03 (29)	5.39 (7)	3.64 (32)
10	2.94 (12)	4.15 (9)	5.66 (16)	5.01 (18)	5.00 (18)	3.64 (20)	4.25 (15)	4.18 (15)	5.54 (22)	7.18 (12)	6.86 (11)
11	9.70 (1)	3.76 (14)	5.57 (8)	6.69 (18)	3.74 (5)	5.20 (8)	4.67 (18)	5.52 (14)	5.04 (18)	6.54 (6)	7.37 (11)
12	5.43 (12)	4.16 (11)	3.92 (5)	7.68 (8)	7.94 (9)	5.99 (6)	5.69 (5)	4.93 (5)	5.49 (16)	7.60 (3)	6.41 (9)
13	7.68 (5)	4.42 (12)	3.53 (1)	5.55 (3)	3.61 (2)	10.44 (6)	10.61 (3)	6.91 (2)	6.28 (12)	- (0)	11.40 (3)
14	9.68 (3)	7.26 (9)	4.85 (5)	9.80 (2)	3.14 (4)	- (0)	11.81 (1)	4.89 (1)	- (0)	7.55 (4)	5.65 (3)
15	10.74 (2)	7.15 (2)	6.35 (7)	6.13 (2)	4.89 (1)	4.31 (1)	13.92 (1)	3.39 (1)	14.94 (3)	10.65 (2)	13.85 (2)

[a] 1962 data are derived from landings of commercial otter trawlers as otoliths were not collected in the September research cruise.

Table 23. Mean weight-at-age (kg) for cod derived from samples of commercial landings of otter trawlers in the May through August period of each year.

Age	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
3	-	1.09	0.78	-	-	-	0.44	0.85	0.41	-	0.35	-	-	-	.28	0.44	0.32	0.44	0.36	0.34	0.27	0.47
4	0.99	0.85	0.84	0.84	0.67	0.60	0.63	0.77	0.64	0.86	0.62	0.83	0.74	0.75	.47	0.69	0.61	0.82	0.71	0.76	0.60	0.65
5	1.42	1.24	1.11	1.03	0.95	0.84	0.81	0.88	1.17	1.35	1.09	1.28	0.99	1.13	.90	1.01	1.01	1.15	1.12	1.21	0.86	0.98
6	1.88	1.66	1.65	1.41	1.24	1.08	1.05	1.06	1.20	1.56	1.51	1.69	1.38	1.34	1.36	1.29	1.46	1.78	1.77	1.73	1.49	1.37
7	2.54	2.12	2.20	1.93	1.73	1.35	1.34	1.41	1.49	2.42	2.14	2.50	2.11	1.94	1.49	1.73	1.65	2.19	2.26	2.25	2.19	1.89
8	3.16	2.87	2.88	2.68	2.34	2.00	1.78	1.73	1.95	1.49	2.75	3.52	3.78	3.07	2.17	2.10	2.75	2.39	2.97	3.13	2.59	2.40
9	3.83	3.66	4.18	4.51	3.06	3.17	2.53	2.41	2.44	2.74	2.80	3.14	2.07	3.69	4.14	2.58	3.05	2.72	3.68	3.66	3.87	3.37
10	4.75	3.84	3.76	4.33	4.29	4.97	4.56	3.39	3.48	5.22	3.79	3.36	2.79	3.58	4.36	4.64	2.92	3.80	3.33	2.78	4.24	6.74
11	5.25	5.05	5.77	5.37	6.64	5.25	7.54	5.69	5.54	3.62	3.89	4.96	5.72	8.90	5.83	5.05	2.58	4.23	4.01	3.56	4.77	2.91
12	8.74	7.01	5.93	5.66	5.18	9.12	7.20	7.44	6.61	6.81	4.69	5.55	3.51	11.95	4.34	9.57	7.20	6.27	4.73	5.21	5.99	4.74
13	6.87	11.95	8.49	8.67	9.11	5.66	11.84	10.74	8.85	-	7.46	7.51	7.23	-	5.78	4.08	-	8.64	4.29	8.71	3.47	5.15
14	7.04	13.10	5.73	8.82	14.34	12.65	8.43	16.71	11.46	-	7.72	3.14	9.85	9.49	5.73	7.11	-	4.45	13.10	-	-	-
15	-	8.61	9.85	10.00	15.65	17.55	12.36	11.39	7.83	-	10.63	14.34	-	8.02	3.45	-	-	-	5.73	-	8.02	-

Table 24. Fixed parameter projections.

$F_{0.1}$ = 0.195 with yield of 0.76 kg/recruit

F_{max} = 0.320 with yield of 0.82 kg/recruit

Year	Pop Numbers $x10^{-3}$	Pop Biomass t	Catch Numbers $x10^{-3}$	Catch Biomass t	Fully-recruited F
		TAC TAKEN IN 1980			
1980	449233	454081	34974	54000	0.210
1981	436286	507171	34038	60338	0.195
		$F_{0.1}$ IN 1980			
1980	449233	454081	32643	50420	0.195
1981	438379	511716	34372	61067	0.195

Table 25. Fixed parameter projections.

$F_{0.1}$ = 0.195 with yield per recruit of 0.76 kg.

F_{max} = 0.320 with yield per recruit of 0.82 kg.

Recruitments: 100 million 1979, 1981
150 million 1980
70 million 1982-85

Year	Pop Numbers $x10^{-3}$	Pop Biomass t	Catch Numbers $x10^{-3}$	Catch Biomass t	Fully-recruited F
1980	449233	454081	34974	54000	0.2102
1981	436286	507171	34038	60338	0.1950
1982	396478	548738	37528	72259	0.1950
1983	360755	568978	36410	78879	0.1950
1984	332445	572044	32441	79964	0.1950
1985	312840	569185	29282	79503	0.1950

Table 26. Inputs to annual projections incorporating changes in weights-at-age due to biomass-dependent growth

	Weights-at-age (kg)					
	1980	1981	1982	1983	1984	1985
3	0.35	0.35	0.35	0.35	0.35	0.35
4	0.77	0.67	0.67	0.67	0.67	0.68
5	0.93	1.03	0.93	0.94	0.94	0.95
6	1.25	1.18	1.28	1.18	1.19	1.21
7	1.68	1.51	1.42	1.53	1.44	1.46
8	2.70	1.98	1.78	1.69	1.81	1.73
9	3.67	3.16	2.32	2.09	2.00	2.16
10	4.16	4.00	3.62	2.73	2.47	2.38
11	3.34	4.21	4.16	3.98	3.22	2.95
12	3.49	3.78	4.21	4.21	4.18	3.73
13	3.31	3.90	4.07	4.21	4.24	4.27
14	4.18	3.76	4.12	4.18	4.24	4.28
15	2.40	4.21	4.05	4.20	4.24	4.28
$F_{0.1}$	0.231	0.222	0.221	0.224	0.231	0.237
Yield Per Recruit (kg)	0.63	0.59	0.56	0.53	0.52	0.53
F_{max}	0.411	0.444	0.483	0.586	0.775	0.906
Yield Per Recruit (kg)	0.67	0.64	0.60	0.59	0.58	0.59

Table 27. Projections incorporating recruitments of Table 25 and annual weights-at-age of Table 26.

AGE	POPULATION NUMBERS ($x10^{-3}$)					
	1980	1981	1982	1983	1984	1985
3	150000	100000	70000	70000	70000	70000
4	81766	122650	81783	57247	57245	57243
5	118184	65739	98876	65917	46118	46097
6	52526	78614	45100	67672	44862	31237
7	28705	33171	51601	29515	43977	28980
8	9130	18128	21773	33769	19181	28408
9	4674	5766	11899	14249	21945	12390
10	2347	2952	3785	7787	9260	14176
11	934	1482	1938	2477	5060	5982
12	618	590	973	1268	1610	3269
13	177	390	387	637	824	1040
14	145	112	256	253	414	532
15	26	92	74	168	164	267
	449233	429686	388445	350957	320661	299621

AGE	POPULATION BIOMASS (t)					
	1980	1981	1982	1983	1984	1985
3	52500.00	35000.00	24500.00	24500.00	24500.00	24500.00
4	63134.29	81750.22	54408.41	38159.21	38399.16	38697.39
5	109662.95	67814.38	92445.75	61676.59	43477.45	43970.82
6	65920.51	92553.37	57544.46	80134.54	53491.10	37750.90
7	48329.94	49980.19	73429.37	45125.27	63411.33	42360.51
8	24634.81	35905.25	38685.63	56987.67	34840.47	49218.36
9	17140.63	18219.78	27644.25	29757.72	43842.43	26824.43
10	9772.12	11836.38	13700.13	21277.45	22879.27	33756.92
11	3123.75	6235.03	8058.24	9862.00	16283.06	17616.99
12	2159.06	2231.58	4091.83	5334.16	6734.28	12193.43
13	585.72	1520.78	1574.40	2683.59	3494.71	4441.11
14	606.44	420.10	1053.94	1059.51	1756.20	2277.83
15	63.18	385.53	297.93	703.09	696.65	1144.49
	397633.40	403852.59	397434.33	377260.81	353806.11	334753.18

... CONTINUED

Table 27. Projections incorporating recruitments of Table 25 and annual weights-at-age of Table 26.

... continued (page 2 of 2)

AGE	CATCH NUMBERS ($x10^{-3}$)					
	1980	1981	1982	1983	1984	1985
3	170	101	70	71	73	75
4	1291	1715	1138	807	832	854
5	19546	9724	14565	9831	7074	7239
6	10609	14238	8135	12355	8419	5998
7	5798	6008	9308	5388	8253	5564
8	1844	3283	3927	6165	3599	5454
9	944	1044	2146	2601	4118	2379
10	474	535	683	1422	1738	2722
11	189	268	350	452	950	1148
12	125	107	175	232	302	628
13	36	71	70	116	155	200
14	29	20	46	46	78	102
15	5	17	13	31	31	51
	41060	37129	40627	39517	35622	32414

AGE	CATCH BIOMASS (t)					
	1980	1981	1982	1983	1984	1985
3	60	35	25	25	26	26
4	997	1143	757	538	558	577
5	18137	10031	13618	9198	6669	6905
6	13314	16762	10380	14630	10038	7248
7	9761	9052	13245	8238	11900	8133
8	4976	6503	6978	10404	6538	9450
9	3462	3300	4986	5433	8228	5150
10	1974	2144	2471	3885	4294	6481
11	631	1129	1454	1800	3056	3382
12	436	404	738	974	1264	2341
13	118	275	284	490	656	853
14	122	76	190	193	330	437
15	13	70	54	128	131	220
	54000	50924	55179	55938	53687	51205

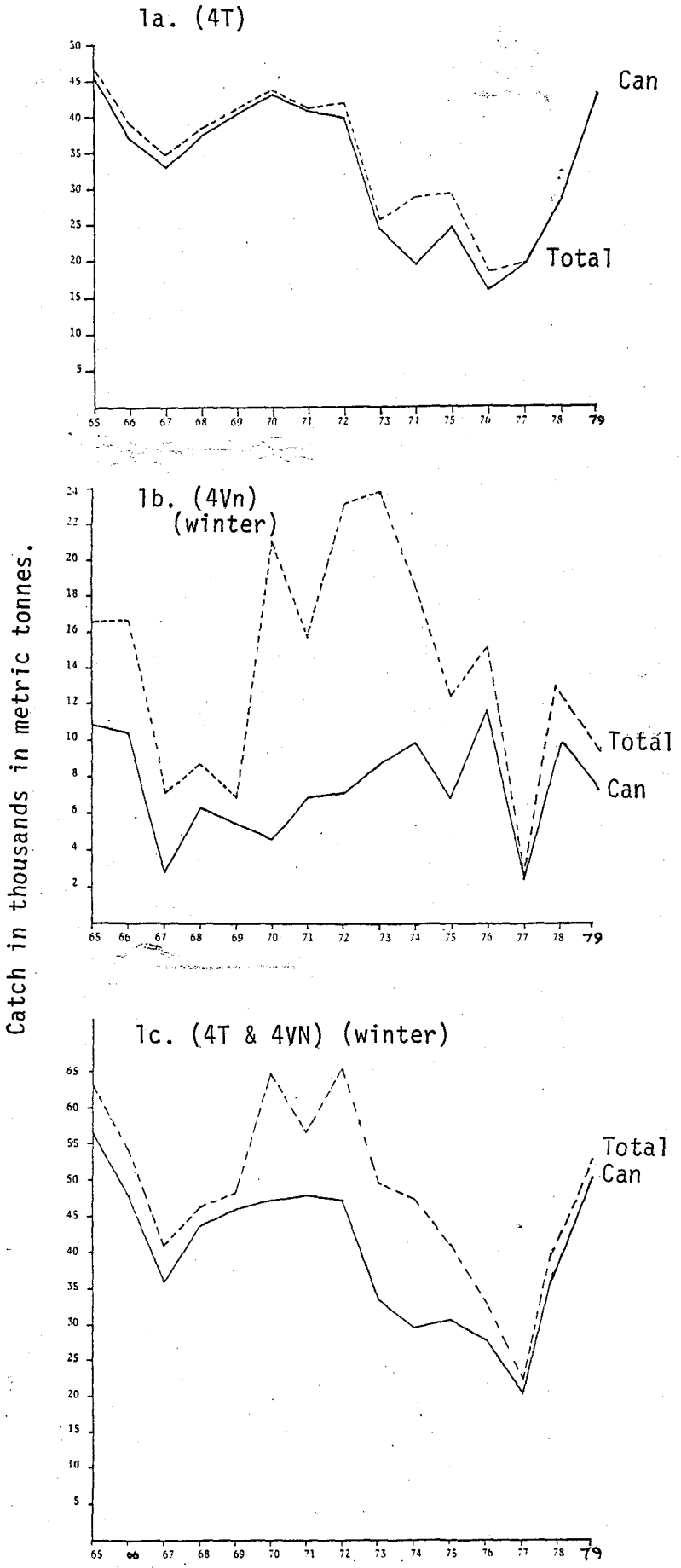

Figure 1. Cod catch 1965-1978.

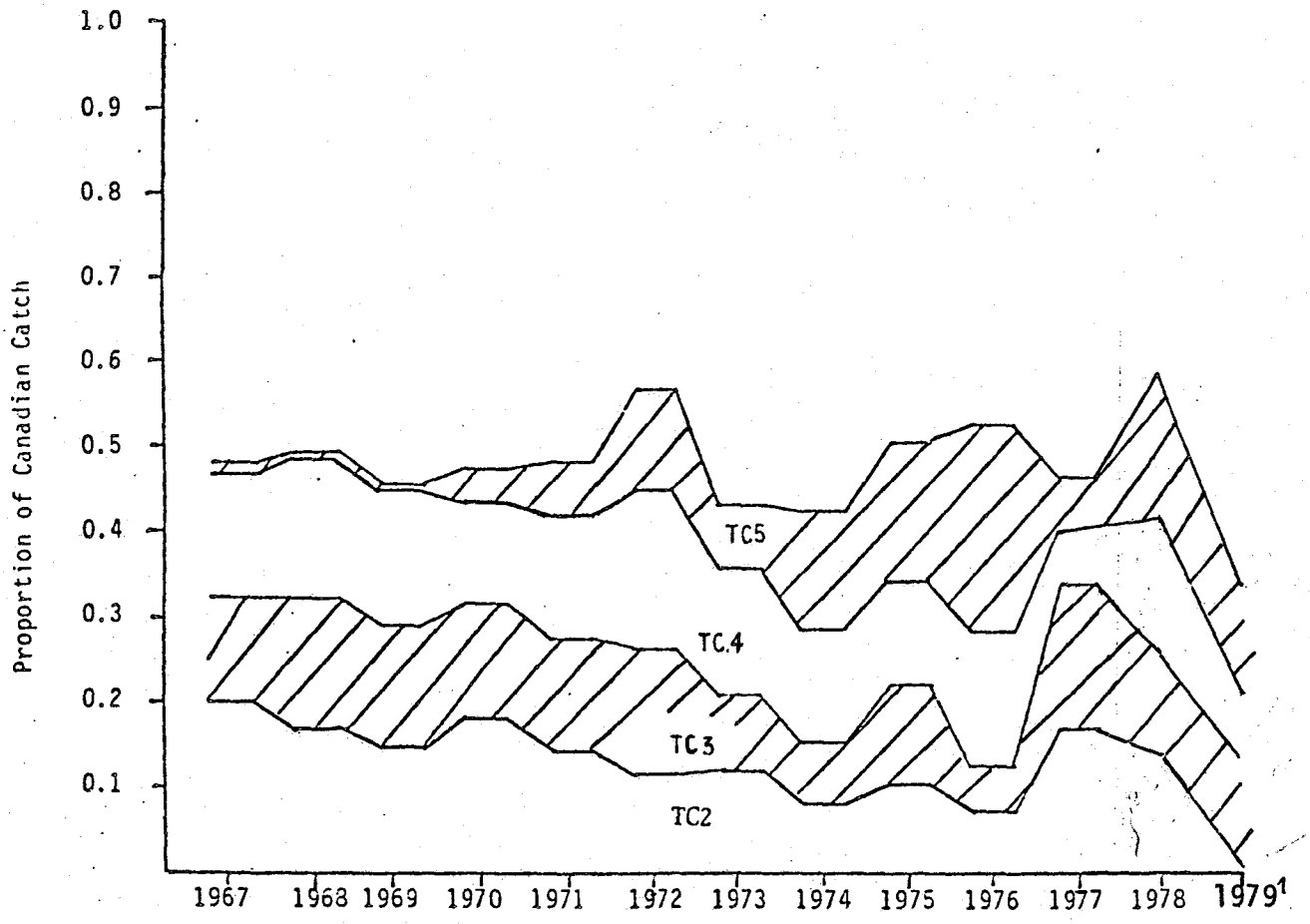

Figure 2. 4TVN (winter) Cod porportion of catch caught by OTB tonnage classes 2,3,4 and 5.

[1] Canada - Maritimes only.

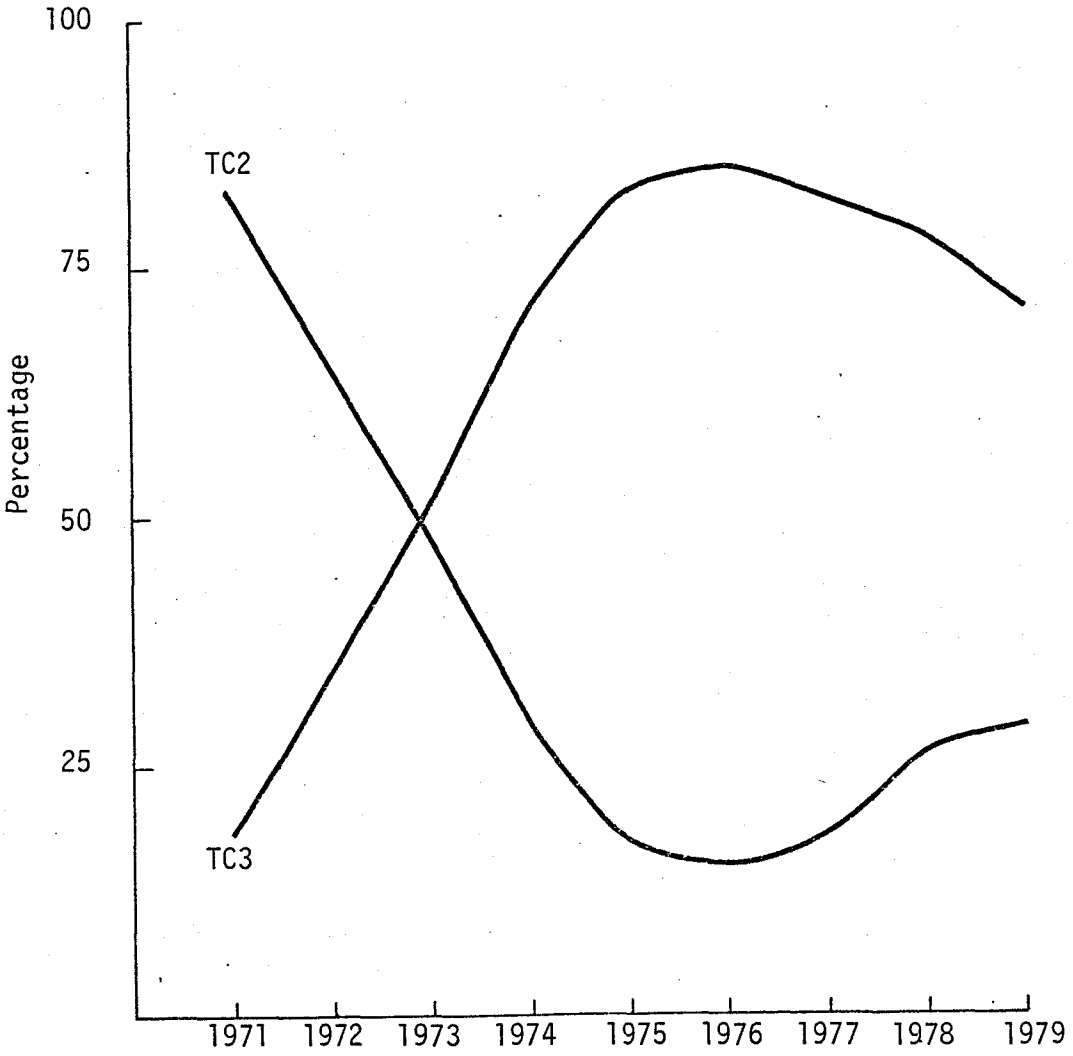

Figure 3. Relative contributions of tonnage classes 2 and 3 of the total catch of Danish and Scottish seiners.

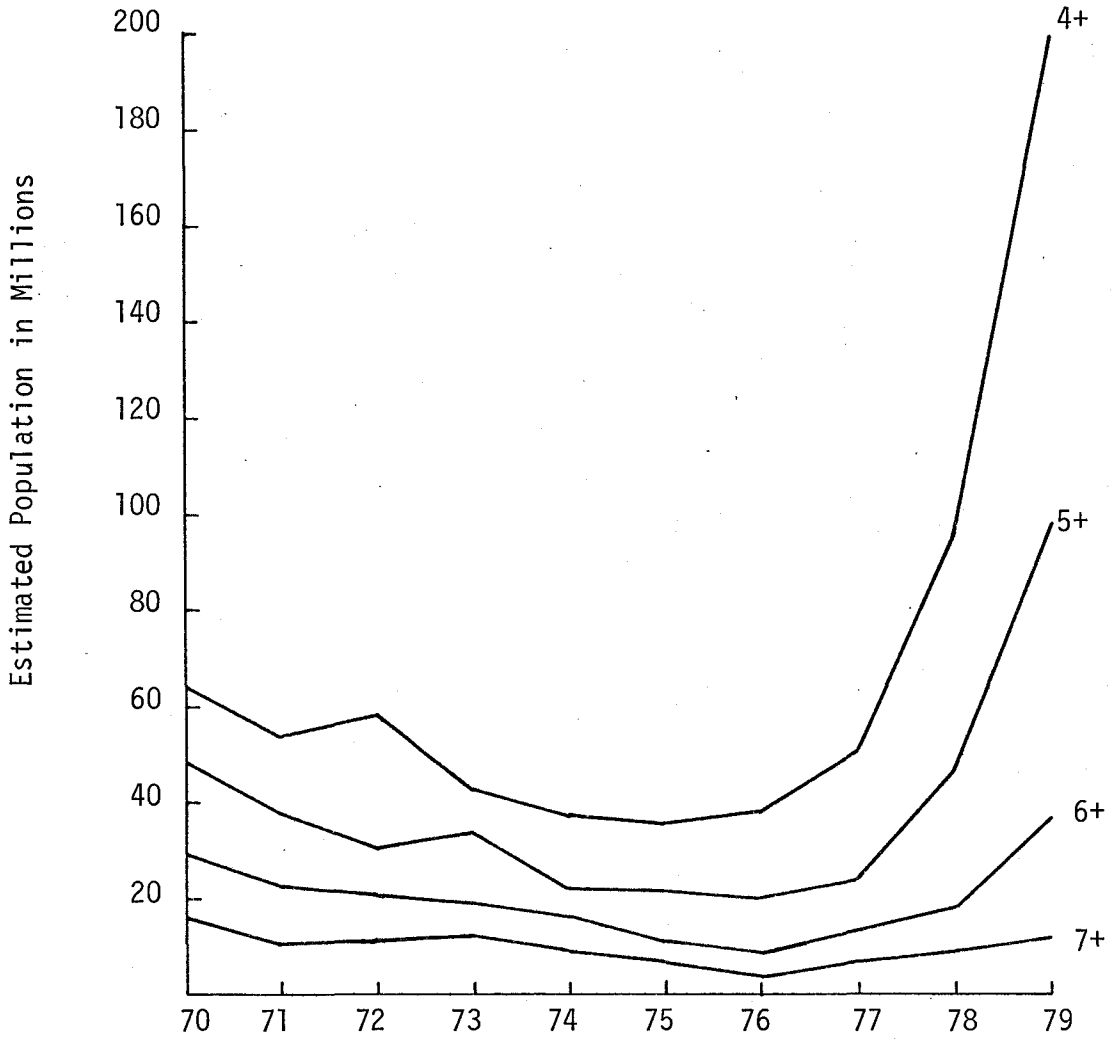

Figure 4. Abundance of age 4+, 5+, 6+ and 7+ Cod in Division 4T from the fall research surveys.

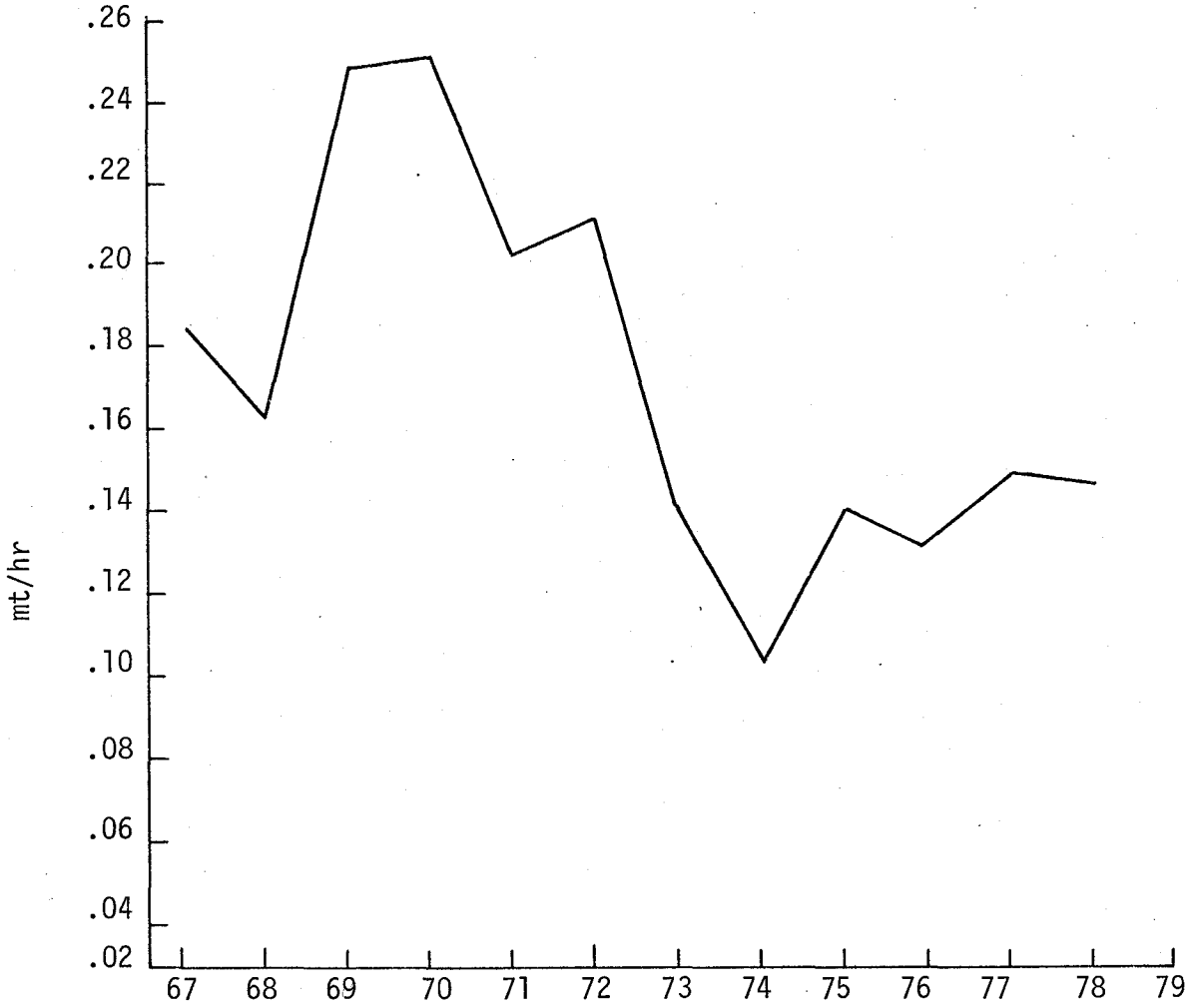

Figure 5a. Cod CPUE to OTB TC2 in 4TVn (winter). Directed catch, May, June, and July.

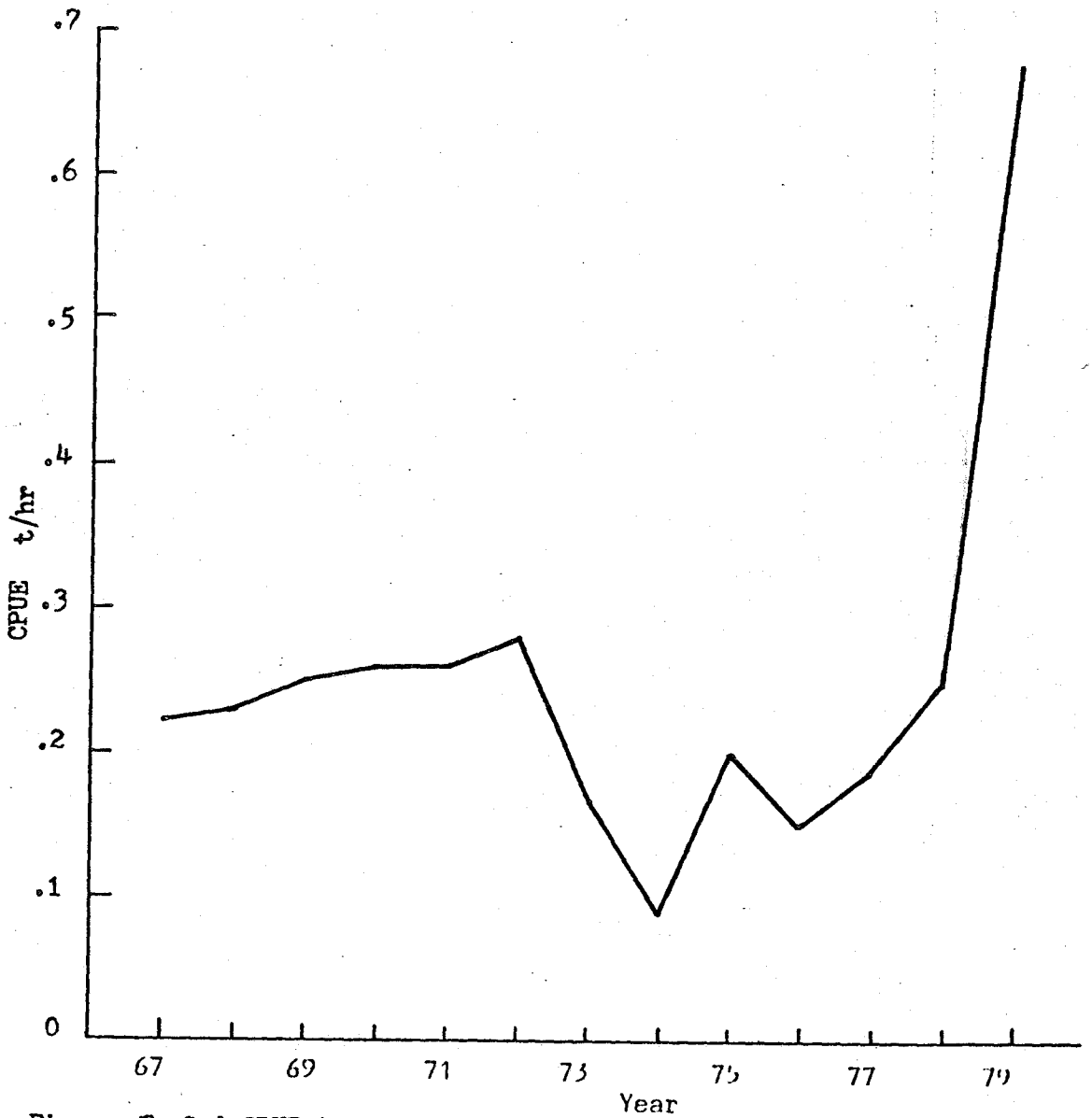

Figure 5b Cod CPUE to OTB TC3 in 4TVn(winter) Directed catch May, June July

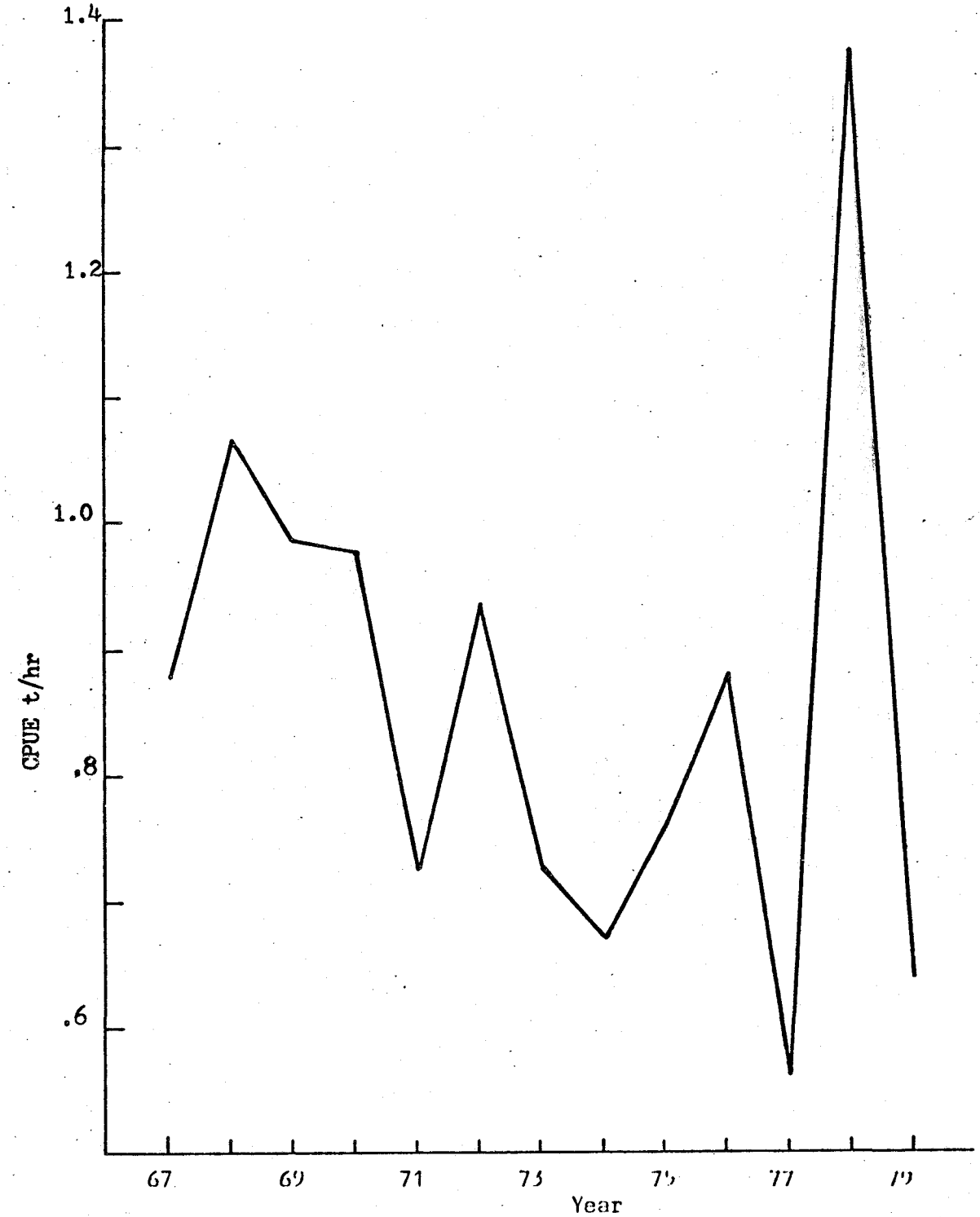

Figure 5c Cod CPUE to OTB TC4 in 4TVn (winter) Directed catch Jan.,Feb., March

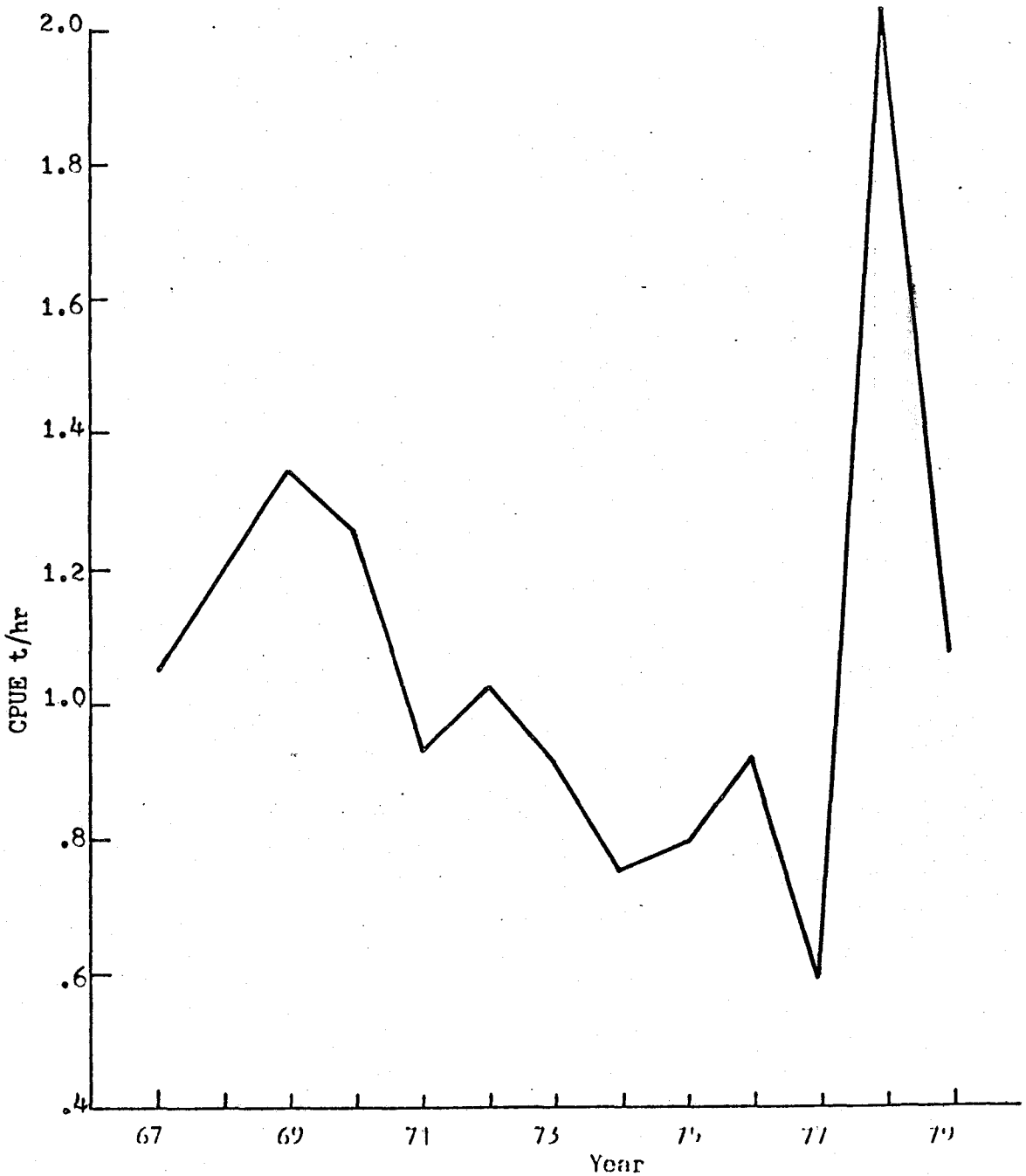

Figure 5d Cod CPUE to OTB TC5 in 4TVn (winter) Directed catch Jan.,Feb., March

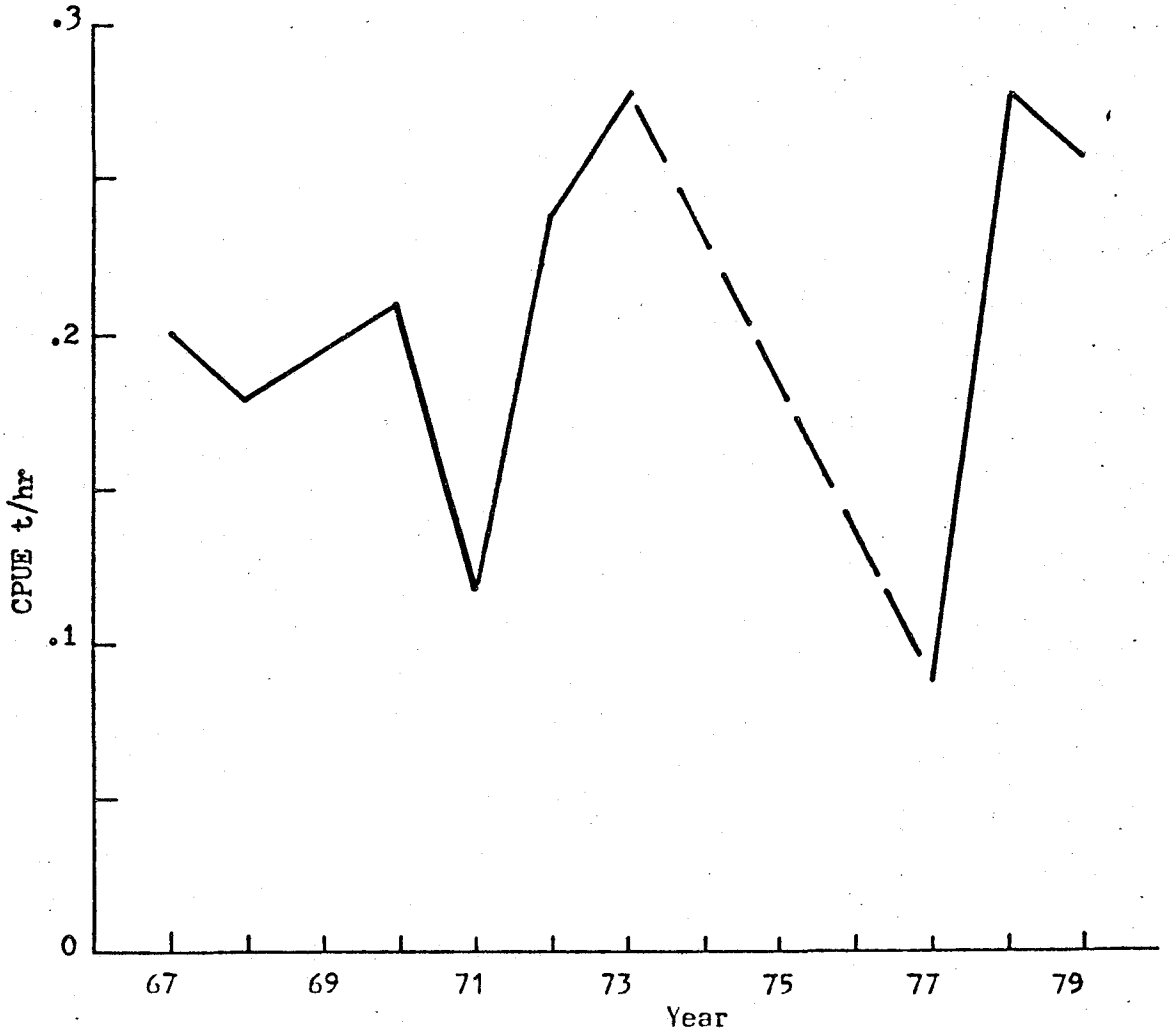

Figure 6a Cod CPUE to Seiners TC2 in 4TVn (winter) Directed catch, May,June, July.

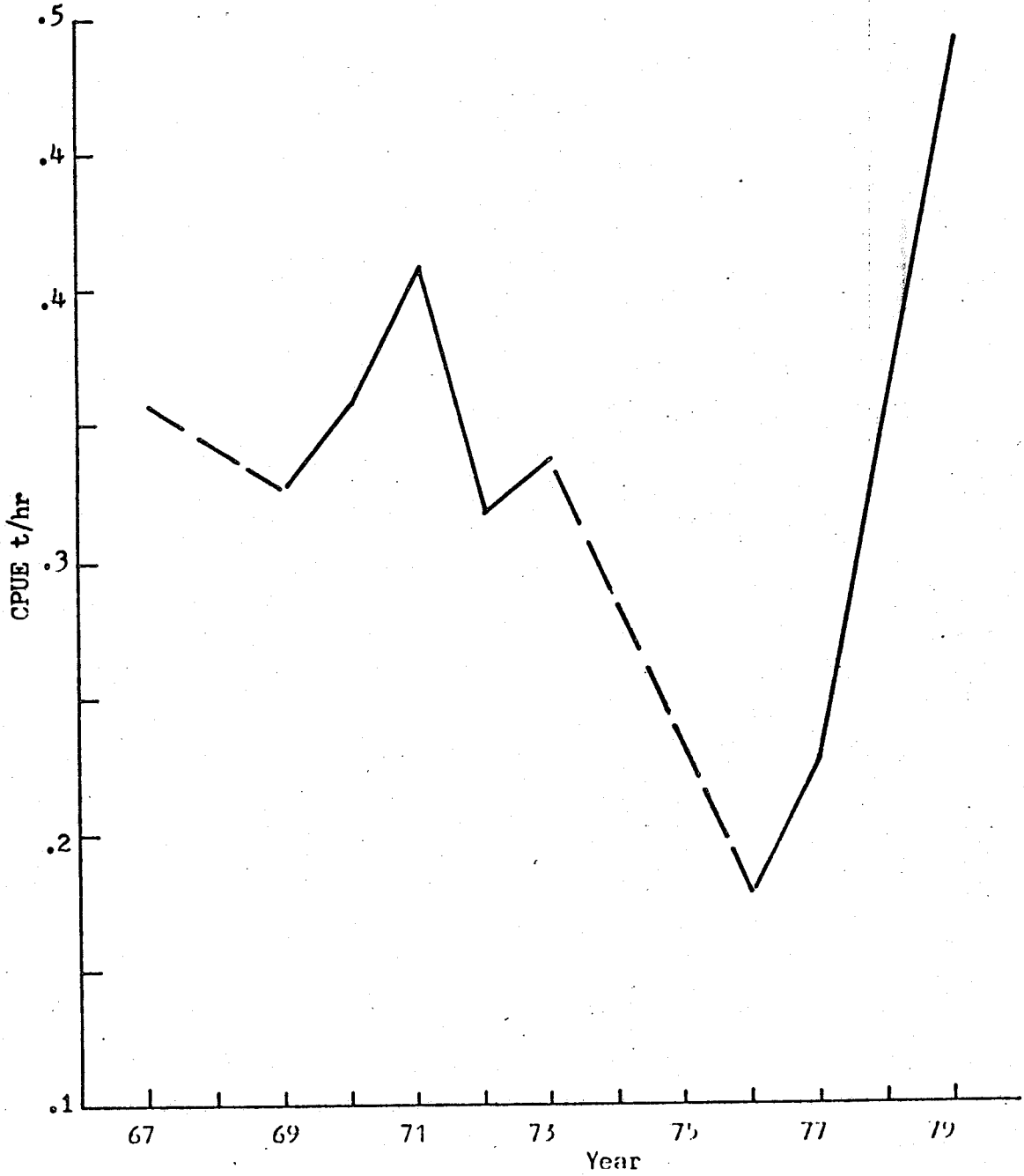

Figure 6b Cod CPUE to Danish seine TC3 in 4TVn (winter) Directed catch May, June, July.

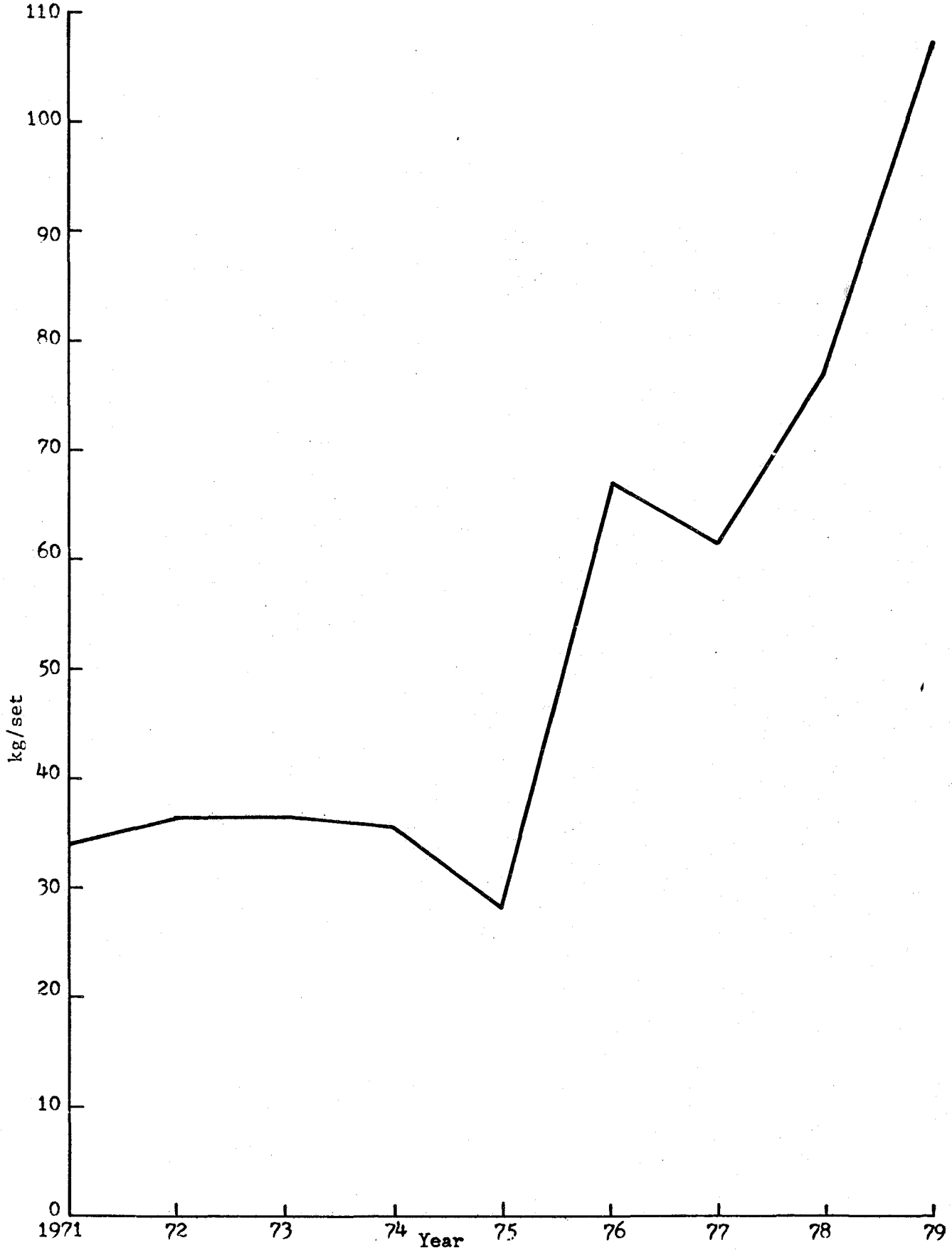

Figure 7 Mean weight per tow (kg) of 4TVn (Jan-Apr) cod in research surveys.

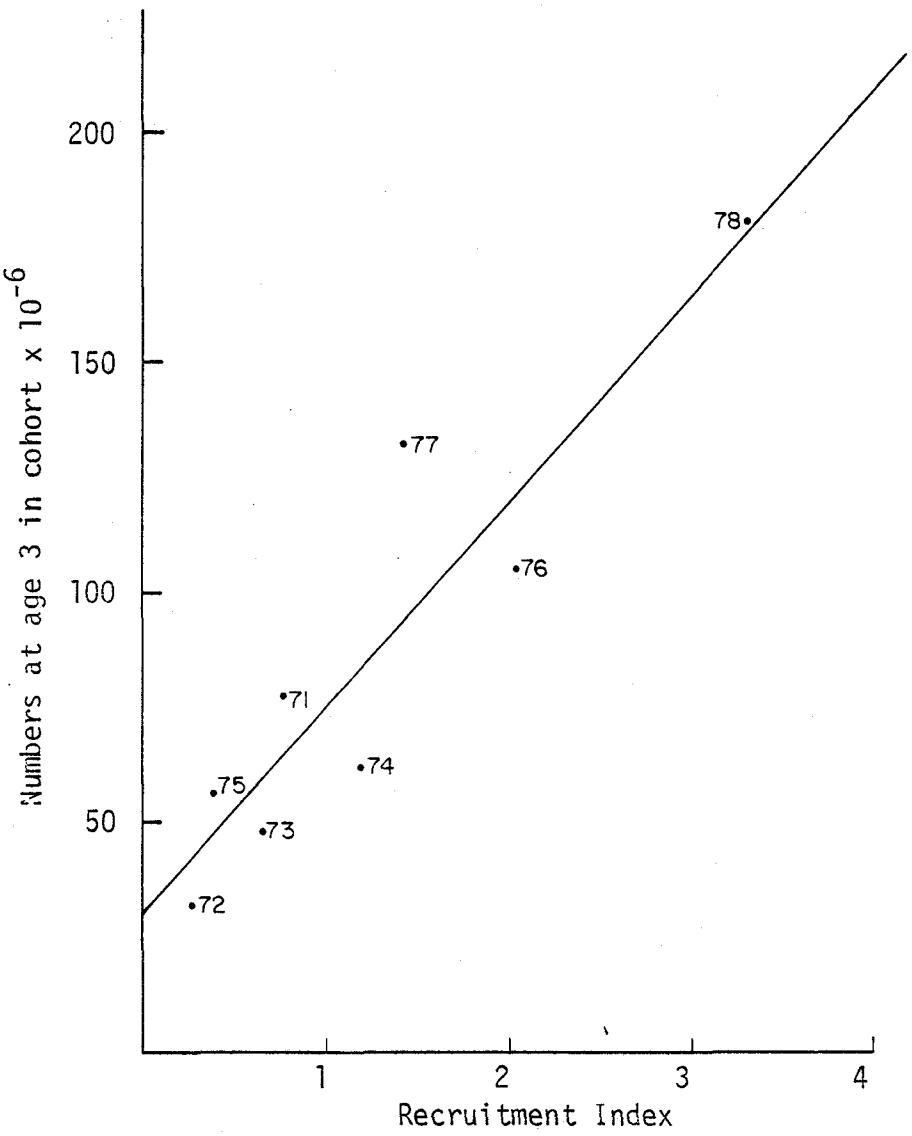

Fig. 8. Relationship between recruitment index and numbers at age 3 in cohort.

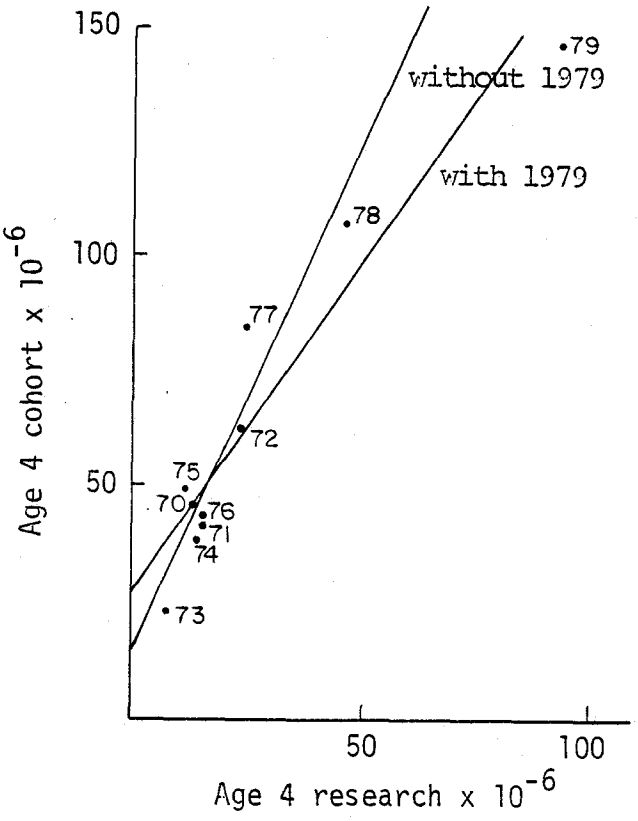

Fig. 9. Relationship between numbers of age 4 cod in cohort and in research surveys.

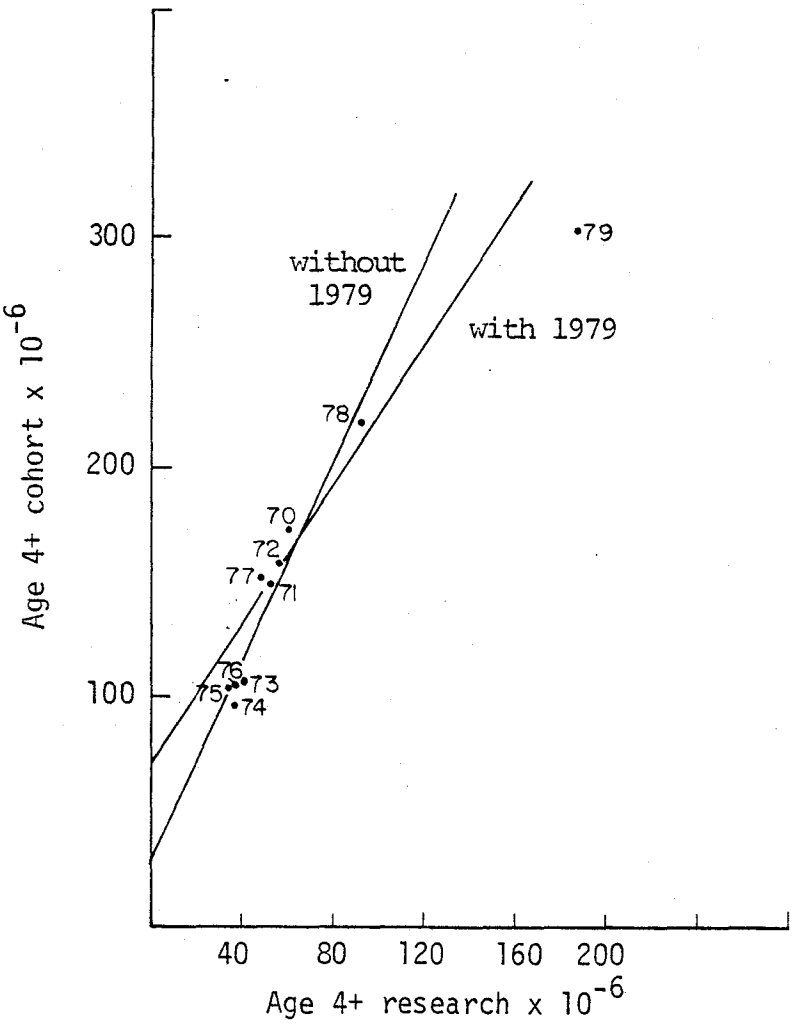

Figure 10. Relationship between numbers of age 4+ cod in cohort and in research surveys.

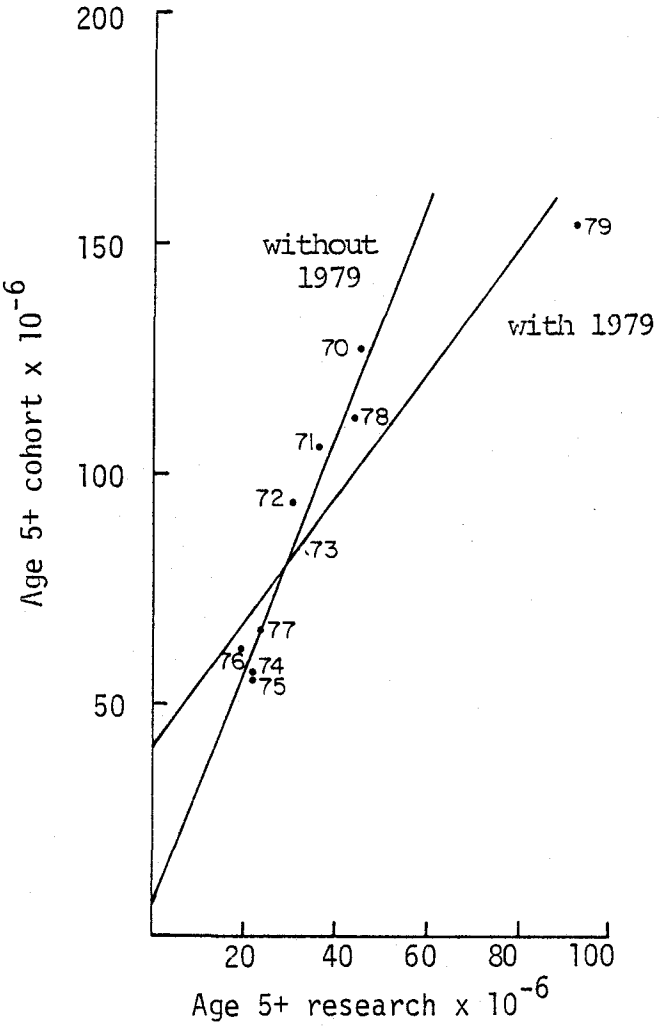

Fig. 11. Relationship between numbers of age 5+ cod in cohort and in research surveys.

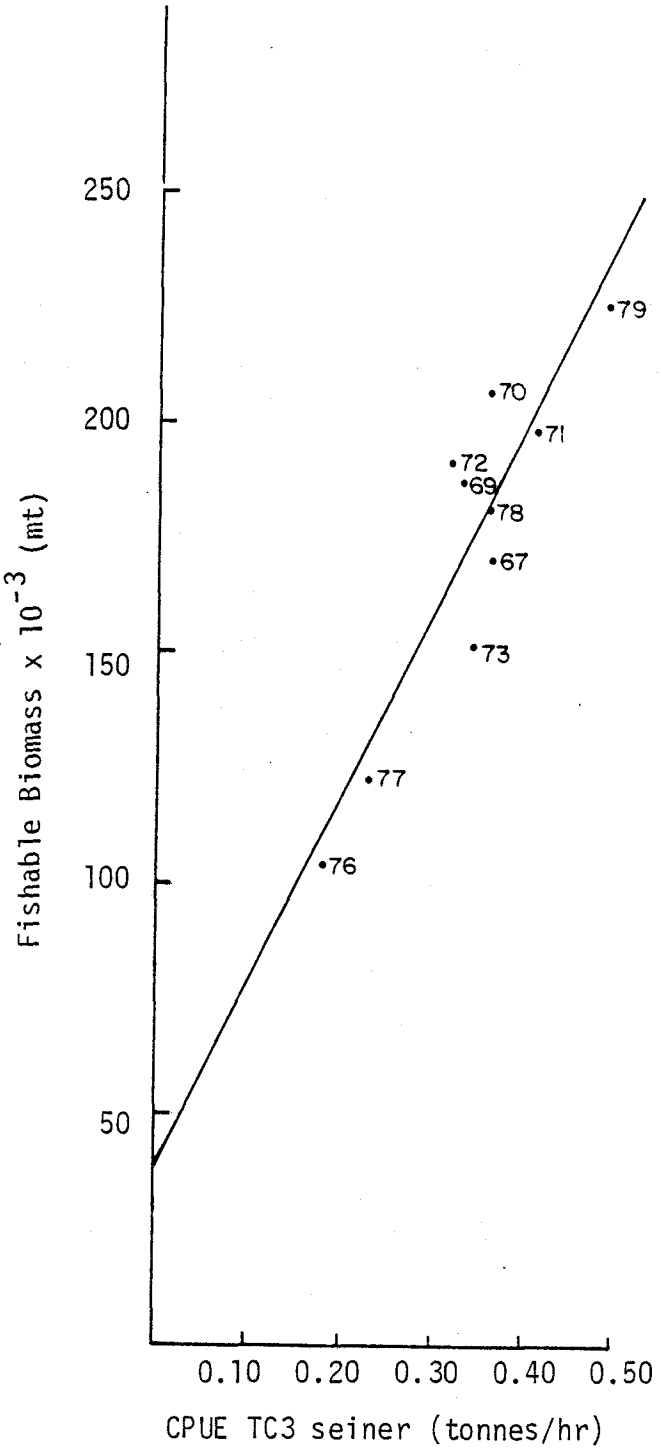

Fig. 12. Fishable biomass from cohort versus CPUE TC3 Danish and Scottish seiners.

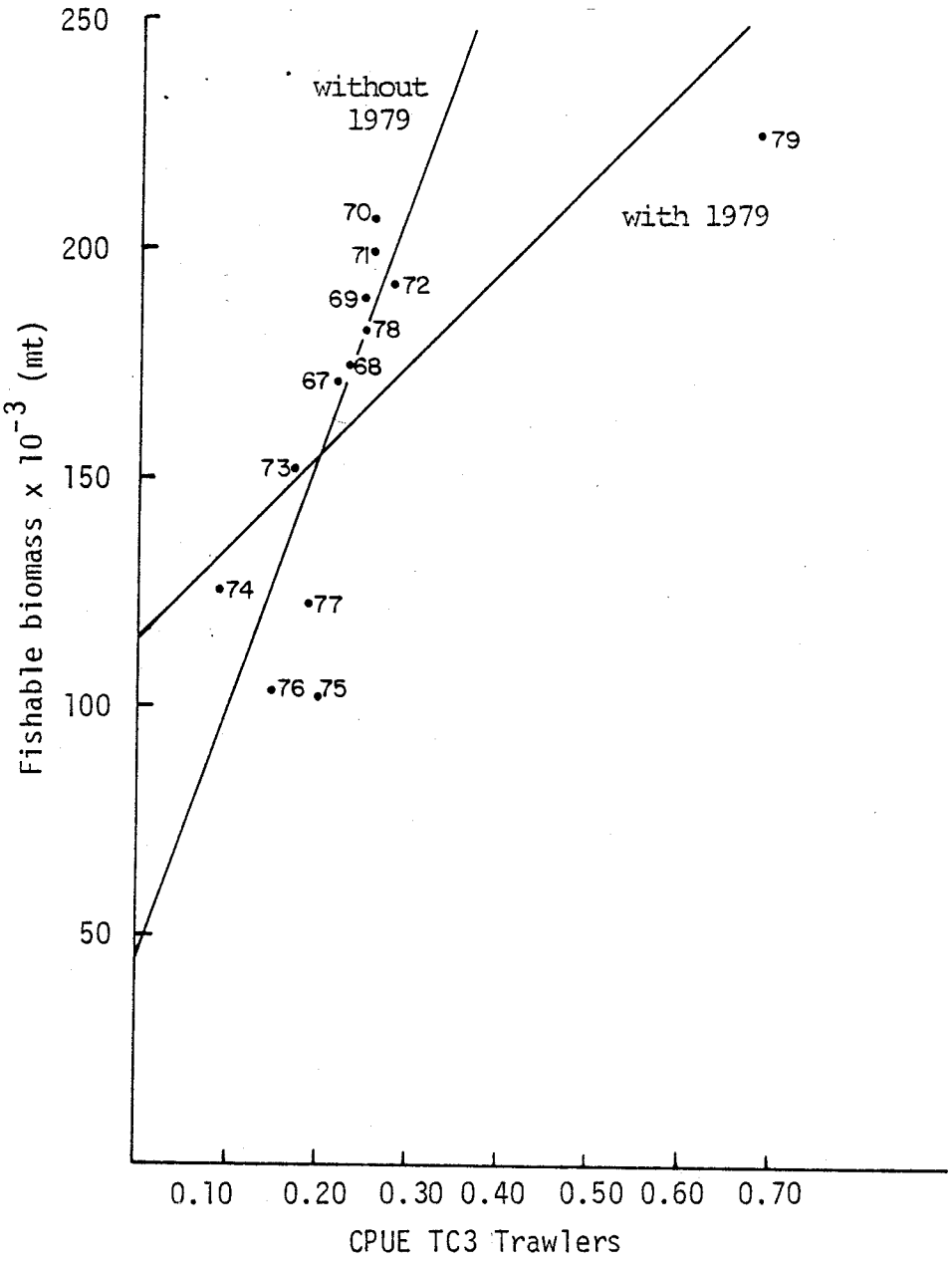

Fig. 13. Fishable biomass from cohort versus CPUE TC3 otter trawlers.