Status of the Atlantic Cod Stock on Georges Bank, NAFO Division 5Z and Subarea 6, in 1985

by

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Abstract

Status of the Atlantic cod stock in NAFO Division 5Z and Subarea 6 is reviewed incorporating 1985 data. Total catch in 1985 was 37269 t of which Canada landed 10441 t. Catch rates, derived from Canadian OTB landings, have shown a general decline since 1977 with the exception of 1981-82 and 1985, when above average year-classes recruited to the fishery. Research survey indices of abundance indicate above average numbers at age for the 1983 and 1985 year-classes while the 1982 and 1984 year-classes are below average. Results of sequential population analysis indicate a fully recruited fishing mortality in 1985 of 0.45 and partial recruitment of 3% at age one and 80% at age two. Estimated 3+ biomass has followed a steady decline from 95000 t in 1978 to a level of 62000 t in 1985. The F0.1 yield for this stock is less than 15000 t, which is exceeded by the current USA catch, and improvement in stock status will require bilateral management by the USA and Canada.

Résumé

La population de morues de la division 5Z et de la sous-zone 6 de l'OPANO est évaluée en fonction des données recueillies en 1985. La capture totale en 1985 a été de 37 269 t dont 10 441 t ont été débarquées au Canada. Le taux de capture, calculé à partir des prises par chalut (OTB) débarquées au Canada, a subi une diminution générale depuis 1977 sauf en 1981 et 1982 et en 1985 qui ont été marqués par un recrutement de classes d'âge supérieures à la moyenne. Les indices d'abondance établis à partir des relevés de recherche sont supérieures à la moyenne pour les classes d'âge de 1983 et de 1985 mais inférieures à la moyenne pour les classes d'âge de 1982 et de 1984. Les résultats de l'analyse séquentielle de population indiquent que la mortalité par pêche pour un recrutement total a été de 0,45 en 1985 et que le recrutement partiel a été de 3 % pour l'âge d'un an et de 80 % pour l'âge de deux ans. La biomasse de la classe des3+ a subi une diminution constante, passant de 95 000 t en 1978 à 62 000 t en 1985. Le niveau $F_{0,1}$ de cette population est inférieur à 15 000 t ce qui est également inférieur aux captures américaines actuelles; pour améliorer la situation des populations de morues, les Etats-Unis et le Canada devront entreprendre une gestion bilatérale.

Introduction

The size of the cod population in NAFO Division 5Z (Figure 1) and Subarea 6 was evaluated by Brown and Heyerdahl in 1972 through the examination of research survey data and commercial catch rates. Serchuk et al (1977, 1978) conducted virtual population analysis of the catch data but considered results to be suspect because of uncertainties in the reliability of reported catch statisitics.

Catch statistics since 1977, when foreign fleets were excluded from the 200 mile economic zones of Canada and the USA, are thought to be more reliable. There have been no reported landings by foreign fleets since 1978.

The fishery has been managed independently by Canada and the USA since 1978. Canada recommended TAC's for 1978-84, while the USA has followed their Groundfish Management Plan since 1981. Canada has set Canadian TAC's for 1985 and 1986.

Hunt and Waiwood (1984), in a review of stock status, suggested a fully recruited fishing mortality of 0.4 in 1983. However, their report was not based on a formal assessment due to an inadequate time series for catch at age in the fishery.

Hunt and Waiwood (1985) used the 1978-84 catch-at-age to estimate population status and their results indicated a fully recruited fishing mortality of about 0.6 in 1984, an F of 0.65 to take 40000 t in 1985 and an F0.1 catch in 1986 of about 11000 t.

The present report considers the catch data from 1978-85 and subjects these data to sequential population analysis (SPA). Research survey data were also used to examine stock structure. Cod in Division 5Z are taken by both Canada and the USA and all data relating to USA catches, CPUE and research vessel surveys were provided by the National Marine Fisheries Service (NMFS) through Dr. Fred Serchuk at the Woods Hole, Mass., Laboratory.

Trends in Reported Landings

Annual Landings

The USA has been the main harvester of cod in Division 5Z and Subarea 6, with high foreign landings in the mid-1960 period (Table 1, Fig. 2). Catch by Canada was also high in this period and peaked at 15601 t in 1966. Total landings declined to about 20000 t in 1976 but then increased to a maximum recorded value of 57195 t in 1982.

Total landings in 1983 were 48928 t, a decline of over 8000 t from 1982, and fell by an additional 10000 t to 38676 t in 1984. This is about 68% of the 1982 level and reflects a sharp reduction in landings by Canada in both 1983 and 1984. Reported landings remained constant between 1984 and 1985

(37269 t) with a decline of 6000 t in USA landings being offset by an increase of 5000 t by Canada.

Fishery by Country and Gear

The USA cod fishery is dominated by otter trawlers (Table 2) that operate throughout Division 5Z. Catches by other gears such as gill nets, Danish seines and longlines have accounted for 10-15% of the total USA catch. A substantial "recreational" fishery also exists for this stock but there are presently no estimates of the amount caught, although it may exceed 10000 t in some years (pers. comm. Dr. Fred Serchuk).

Canadian catches of cod, since 1978, were taken on the "northeast peak" of Georges Bank (unit areas 5ZEj and 5ZEm) primarily between April and November. Landings have been dominated by otter trawlers, except for 1984 (Table 3, Fig. 3). This gear took 70% of the total catch in 1982, was 57% in 1983 and only 13% (745 t) in 1984. Catches of longliners were about 5000 t between 1981 and 1984. Catches in 1985 indicate an increase to 7600 t by otter trawlers and a decrease to 2800 t by longliners. A trend for the smaller TC 2 and 3 vessels to take an increasing proportion of the total catch has also been noted in recent years.

The Fishery in 1986

Preliminary Canadian 1986 quota reports indicate a catch of 5812 t by otter trawl and 1004 t by longline at the end of August for a total of 6816 t. Catches by small TC 2 and 3 otter trawlers account for 5065 t or about 74% of the total. No estimates of the USA catch are available at the present time.

A total of 18 samples were collected by Port Technicians, 15 from otter trawl catches and 2 from longliners. Ageing for these samples has been completed and indicates a catch composition of 0.1, 9.1, 54.0, 13.7, 23.1% for ages 1,2,3,4,5+, respectively. Fish between 45-65 cm accounted for the bulk of the total catch of 1878 thousand fish with a dominant 1983 year-class.

Anecdotal information from Port Technicians indicated catch rates for the TC 2 and 3 vessels, based on commercial catch samples, of about 10.6 t per three day trip. This compares to an average of 25 t for similar observations in the 1985 fishery.

Personal observation of one trip lasting three days in July showed variable catch rates between vessels. The observed vessel landed about 3000 kg of cod and 2500 kg of haddock with catch rates of 0.091 t/hr cod and 0.071 t/hr haddock based on 36.5 hours fishing. Catch rates for other vessels fishing in close proximity were higher. Vessels tended to be closely aggregated and able to selectively fish for either cod or haddock by varying depth. Very few discards of small fish were noted and close to 100% of the catch was landed. The captain of the vessel also noted that

under-reporting of landings was common within the fleet and could amount to 25% of the reported landings. No direct evidence of this practice is available but it could be a significant factor influencing analysis.

Age Composition of the Commercial Catch

Sampling Intensity

Sampling coverage of the Canadian fishery averaged about one sample per 1000 t landed, since 1980, and is biased towards otter trawl catches with fair coverage in 1978, 1984 and 1985 but poor coverage in 1979, 80 and 83. Only 7 samples, all from longline gear, were taken in 1984 from a total catch of less than 6000 t. From 400-1000 cod are aged each year.

USA sampling has increased substantially since 1980, when 70 samples were collected, and is now at a level of over 150 samples per year. Sufficient samples are collected to estimate catch at age by gear, quarter and market category for USA landings.

Age Composition

Estimated removals at age prior to 1978 given by Serchuk et al(1977) are probably under-estimated and are not considered reliable because of suspected under-reporting of catches by foreign fleets.

Catch composition of USA landings for 1978-85 was provided by the Dr. F. Shercuk, NMFS, Woods Hole, Mass. and also included an estimate of total removals at age derived by prorating the USA numbers with the Canadian catch. Only the US catch at age was used in this study.

Canadian samples were used to obtain statistics by age according to the method described by Gavaris and Gavaris (1983). The bias introduced by applying otter trawl length frequencies to partition longline catches, in years lacking samples for this gear, may be significant. A summary of catches and samples used to estimate removals at age is given in Table 4 and percent age composition in Table 5.

Different values for a and b, in the length weight relationship, were used by Canada and the USA. Canadian values, derived from commercial sampling data, were a=0.0000163 and b=2.9048 for round weight in kilograms and length in centimeters. These compare to values of a=0.000008104 and b=3.0521 for USA survey data (Serchuk et al, 1982). Comparison of calculated weight at length using the two values for a and b indicate that, in the central part of the commercial length range, the USA parameters estimate a higher round weight at length (Hunt and Waiwood, 1985).

Mean weight and length-at-age for Canadian and USA commercial catches are given in Tables 7 and 8, with the "+" group set to 115 cm and 15.0 kg. Means for the total catch were derived by weighting individual values with the catch in numbers for each country.

Age groups 2-5 account for most of the yield but a difference in the age composition between Canada and USA is apparent (Fig 4). USA catches show a higher proportion at age 2 in some years and in 1982-84 this age group accounted for more than twice the percentage taken by Canada at age two. The 1984 catch at age is influenced by the small otter trawl catch.

An exchange of ageing material and discussion between USA and Canadian age readers was completed in 1986 at a workshop in Woods Hole. Canadian samples were prepared following the method described by Strong et al (1985) and consisted of thin cross sections mounted on clear acrylic. USA samples were burned to enhance zones and then broken to obtain a cross section and cleared with alcohol at the time they were examined. Joint ageing of over 100 otoliths indicated a good level of overall agreement (> 85%) between readers with no apparent bias. The differing preparation techniques were not considered a factor which might influence interpretation. Some enhancement of zones after burning was noted and Canadian readers have adopted this method for preparation of cod otoliths. Comparison of the length distribution and percent age composition for Canadian landings (Fig 5) suggests historical consistency in ageing.

Age-specific spatial distribution may be a factor influencing availability with higher potential catches of younger fish in the western part of the area. A further contributing factor to the apparent difference in age composition may be the proportion of longline catches in the Canadian fishery. This gear is selective for larger and older fish and between 1981 and 1984 accounted for a substantial proportion of the total Canadian catch. It was therefore concluded that the best estimate of total catch at age would be derived by summing the catch at age for each country. Total removals by age group, in thousands, for Canada and the USA are given in Table 6.

Stock Abundance Trends

Research Surveys

Random, depth-stratified bottom trawl surveys have been conducted by the USA in the autumn since 1963 and a spring was survey added in 1968. A summer survey was conducted from 1977 to 1981. Surveys in Subdivision 5Ze were completed by Canada in March, 1984,86. Mean catch per tow in numbers by age group for each of the USA surveys is given in Table 9 and the mean catch per tow in numbers and weight in Table 10, Fig. 6. No adjustment for different gears or vessels used during the time series has been made. The spring survey used the larger "Yankee 41" trawl from 1973-81 and considerable differences in catch per tow could be anticipated. Total net opening of the "41" trawl is about 1.7 times the opening of the "Yankee 36".

The spring survey has shown a steady decline in 0+ numbers since 1981 and was at the lowest observed level in 1984 but increased in the 1985 survey. The autumn survey has also shown a steady decline since 1981 but has leveled off in the 1985 survey. Serchuk (pers. comm.) notes that catches of all species were anomolously low in the 1982 autumn survey

which may indicate a change in availability and this may also be a factor in the 1983 survey.

Stratified mean catch per tow within US strata in recent years were calculated using Canadian computer software (STRAP) and tow by tow data provided by the USA and are summarized in Figure 7. Years for which the USA and Canadian results, derived from different analysis programs, did not agree were excluded (1978, 1981). Distribution of catch by age group did not indicate apparent segregation by age and younger age groups were taken on both sides of the international boundary. However, this survey is made after the peak fishing season and may not be representative of distribution and availability to the commercial fishery.

Commercial Catch Rates

Catch and effort statistics by month, for the Canadian fishery, were derived from Table 5 of the NAFO/ICNAF Statistical Bulletins for 1967-83. Data for 1984-85 were obtained from the Canadian Department of Fisheries and Oceans. Due to previous observations regarding systematic bias caused by truncation of this type of data (Gavaris and Sinclair, 1985), all observations where either the catch was less than 10 t or the effort was less than 10 hours were excluded from analysis. A multiplicative model (Gavaris, 1980) was used.

Examination of the residuals from the preliminary unweighted analysis resulted in the exclusion of three observations: OTB2-4, April 1967; OTB2-2 December 1968; OTB2-2, October 1982. There did not appear to be any annual trends in either month or gear residuals but these residuals showed that observations with lower catch and effort were more variable. Therefore a weighted analysis was applied. An iterative procedure described by Judge et al (1980) was used to estimate the weights based on the partitioning of residuals along a logarithmic (catch x effort) scale. The analysis of variance from the weighted regression (Table 11) indicates that months do not account for much of the systematic variation. The coefficients for gears follow an intuitive pattern with larger vessels associated with greater fishing power.

The results of the analysis are shown in Table 11 in both the ln and re-transformed linear scale. Trends in the linear scale (Figures 8 and 9) indicate fairly low levels in the mid-1970's with an abrupt increase in 1977 probably due to the recruitment of the 1975 year-class. This is followed by a general decline, although catch rates increased somewhat in 1981-82 and 1985, probably due to recruitment of the 1980 and 1983 year-classes, respectively.

USA catch rates were provided by Serchuk and are reproduced in Table 12, Fig. 10. Landings by TC 2, 3 and 4 otter trawlers for all trips and >50% cod trips are given. Catch rates in all categories show a general decline between 1978 and 1983 and, without exception, the catch rates in 1984 were the lowest since 1978. Catch rates for trips landing cod showed an increase in 1985, but trips landing >50% cod were down from 1984.

Survey Index of Recruitment

Indices of recruitment were obtained from the autumn survey catch per tow at ages 0, 1 and 2 for the 1962-84 year-classes. The catch per tow at age was normalized to the mean of the 1962-85 catch per tow and the average at ages 0+1 and 1+2 selected as an survey index of relative abundance. The calculated indices are given in Table 13. The 1+2 index is probably influenced by the effect of fishing mortality on age two fish. The 1966, 1971 and 1975 are dominant, with the 1980 year-class above average, 1981 and 1982 below average, and the 1983 year-class the highest since the 1975 year-class. The 1984 year-class appears to be below average while the 1985 year-class catch at age 0 suggests above average abundance.

Comparison of catch per tow in successive years for the same year-class indicates poor correlation for the spring surveys but a higher level for the autumn surveys. It also appears that the 0-group catch in the autumn survey is indicative of year-class size. Catch of 0-group fish in the spring survey appears to be inconsistent and may sample only results of occasional early spawning (December) rather than the main spawning in March. Correlation coefficients for ages 0 to 3, for the 1975-84 year-classes, are shown in Table 14.

Total Mortality Estimates

Calculated values of total mortality (Z) and derived estimates of F based on USA spring and autumn survey catch per tow are given in Table 15. The ratio of numbers at 4+ to numbers at 5+ from spring surveys and the ratio of numbers at 3+ to numbers at 4+ from autumn survey in the same five time intervals were used to estimate mortality. Both surveys show an increase between 1977-80 and 1981-83 and the autumn survey is the higher of the two estimates. The 1981-83 spring survey indicates a Z of 0.74 and the autumn survey 0.98. However, availability in the 1982 autumn survey may overestimate Z in the last time period and, as noted above, the spring survey results have not been adjusted for a change in gear. Using the limited time series for 1982-84 in spring surveys avoids the change in gear used and estimates a Z of 0.73 and an F of 0.53. The 1981-85 autumn surveys indicate a Z of 0.89 and 0.69 fishing mortality over the last four years of the fishery.

Sequential Population Analysis (SPA)

Estimates of total mortality (Z) derived from USA autumn survey results indicated a fishing mortality of above 0.5 for recent years. Full recruitment at age three was assumed based on the historical pattern in the F matrix and the relationship between SPA and survey numbers. Trial runs of SPA with the 1978-85 catch at age and terminal fishing mortality (Ft) between 0.4 - 0.6 were made to estimate population numbers and fishing mortality. Results of SPA were regressed on the corresponding index from the

autumn research survey, the weighted 3+ F on directed effort, and exploitable biomass on CPUE.

SPA age 4+ numbers and survey age 3+ numbers, lagged by one year, were well correlated (R = 0.79-0.82) and indicated an Ft between 0.4 and 0.5, based on minimization of sum of squares for residuals. SPA age 3+ numbers and survey age 2+ numbers were not correlated, probably due to some negative Z values within cohorts in the survey catch per tow data. SPA age 2+ numbers and survey age 1+ numbers (lagged) for 1978-84 were also well correlated (R = 0.73-0.81) and the relationship was optimized at an Ft of 0.6, although little discrimination between input Ft values was evident for intercept, r-squared or residual parameters. SPA age 3 and RV age 2 numbers showed significant correlation (R > 0.8) with Ft between 0.4 and 0.6 and the relation was optimized at an Ft 0.6, based on maximization of r-squared values.

Canadian trawlable biomass, assuming full recruitment at age three, was calculated with partial F's for the Canadian OTB catch. Derived values of biomass were regressed on the Canadian OTB CPUE but the relationship was found to have a negative slope and unsuitable for calibration of SPA.

Mean 3+ fishing mortalities, weighted by population numbers, were regressed on standardized effort derived from the Canadian OTB CPUE. Best correlation and minimization of residuals occurred with an Ft between 0.4 and 0.5 (R >0.8).

Results of regression analysis suggest that the fully recruited fishing mortality in 1985 is above 0.4 and may exceed 0.5, although the relationships between mean 3+ F and effort were inconsistent with those derived from population numbers. Further resolution of Ft did not seem warranted and a value of 0.45 was selected for fully recruited fishing mortality in 1985. A summary of regression analysis is given in Table 16 and in Figures 11-15.

Regesssion of SPA age 2 on RV age 1 (lagged) indicated good correlation (R > 0.9) and residuals for the last three years were minimized with a fishing mortality of 0.358 at age two in 1985. This implies a partial recruitment of 0.796 at age two in 1985 which compares to values ranging from 0.3 to 0.7 derived from the F matrix in 1978-84. The high 1985 value is derived from the apparent average size of the 1983 year-class and the substantial catch at age two in 1985.

The relationship between SPA numbers at age 1 and USA autumn survey number at age 0, lagged by one year, did not indicate significant correlation. This may be the result of low catchability of age 0 fish by the survey. The regression of SPA age 1 on RV age 1, without lag, indicated good correlation (R >0.9) and residuals for the last three years were minimized at a fishing mortality of 0.012 on age one, with an implied PR of 0.027 in 1985. Regression of beginning of year numbers from the SPA on RV numbers in the autumn of the same year (no lag) was justified on the basis of low fishing mortality on age one fish.

A summary of the results of regression analysis used to estimate partial recruitment in 1985 is given in Table 17 and Figures 16 and 17.

Final SPA Run

Population number, biomass and fishing mortality were calculated from SPA using a fully recruited F in 1985 of 0.45 and a partial recruitment vector of 0.027, 0.796, and 1 for ages 1, 2 and 3+ in 1985. Results are given in Table 18.

Fishing mortality (3+) increased from a mean of 0.384 to a high of 0.513 in 1982 and averaged to 0.487 for 1982-85. Cumulative fishing mortality was above 2.0 for most age groups by 1981.

Estimated 1+ population numbers ranged from 70-90 million for 1978-82 but fell to about 65 million in 1983 and 1984, reflecting the small size of the 1982 year-class at age 1 and 2. Numbers at age 3+ were 20 million in 1985, the lowest in the series, but the size of the 1982 year-class is a dominant factor. Similar results are apparent in the estimate of population biomass and the 3+ biomass was below 80000 t in 1984. This is primarily the effect of high catches of the 1980 year-class at ages 2, 3 and 4 as well as low recruitment of the 1982 year-class. Trends in recruitment at age 1 and estimated 3+ biomass are given in Figures 18 and 19.

Management Considerations

Fishing mortality on this stock has exceeded both the F0.1 and the Fmax levels in recent years. However, unilateral imposition of reduced Canadian quotas by Canada based on an F0.1 management strategy may not result in national benefit. The current USA catch exceeds the estimated F0.1 catch and without a bilateral management strategy by the USA and Canada it is unlikely that reductions in Canadian catches would result in stock rebuilding.

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Table 1. Nominal catches (t, round) of Atlantic cod from Georges Bank and southward (NAFO Division 5Z and Subarea 6), 1960-85.

Year	USA (a)	Canada	USSR	Other (b)	Total
1960	10834	19	-	-	10853
1961	14453	223	55	-	14731
1962	15637	2404	5302	143	23486
1963	14139	7832	5217	1	27189
1964	12325	7108	5428	304	25165
1965	11410	10598	14415	1910	38333
1966	11990	15601	16830	8713	53134
1967	13157	8232	511	14852	36752
1968	15279	9127	1459	17271	43136
1969	16782	5997	646	14514	37939
1970	14899	2583	364	7806	25652
1971	16178	2979	1270	7752	28179
1972	13406	2545	1878	7230	25059
1973	16202	3220	2977	6524	28923
1974	18377	1374	476	7104	27331
1975	16017	1847	2403	4741	25008
1976	14906	2328	933	1759	19926
1977	21138	6173	54	2	27367
1978	26579	8904	-	-	35483
1979	32645	6011	-	-	38656
1980	40053	8094	-	-	48147
1981	33849	8508	-	-	42357
1982	39333	17862	-	-	57195
1983	36756	12172	-	-	48928
1984	32915	5761	-	-	38676
1985 (c)	26828	10441	-	-	37269

a. includes catches from all gear components
b. Primarily Spain
c. Preliminary

Table 2. Distribution of USA commercial landings (t, round) of Atlantic cod from Georges Bank (5Ze), by gear type, 1965-1984. Data only reflect landings which could be identified by gear type. (from Serchuk et al, 1982 and pers. comm.)

Landings (t, live)

Year	Otter Trawl	Line Trawl	Handline	Gillnet	Other Gear	Total
1965	10251	582	505	0	9	11347
1966	10206	787	757	0	19	11769
1967	10915	894	704	0	9	12522
1968	12084	936	524	0	-	13544
1969	13194	1371	387	0	-	14952
1970	11270	1676	404	0	-	13350
1971	12436	2334	230	0	2	15002
1972	10179	2071	217	0	10	12477
1973	12431	2185	206	3	21	14846
1974	14078	2548	11	3	9	16649
1975	12069	2435	84	0	4	14592
1976	12257	1519	153	4	5	13938
1977	18529	912	83	30	22	19576
1978	20862	1569	1180	81	59	23751
1979	26562	2707	860	620	159	30908
1980	32479	1102	-	4491	273	38345
1981	27694	120	584	3515	197	32110
1982	33371	385	624	2935	210	37525
1983	30981	831	441	1812	81	34146
1984	26161	366	753	2573	197	32913
1985	21444	436	284	2482	163	24809

Table 3. Nominal ~~landings~~ of cod by gear and month for Canada in NAFO Division 5Ze, 1978-85. (Ot - otter trawl; LL - longline; misc - miscellaneous)

		Month												
Year	Gear	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
78	Ot	167	763	241	26	305	1943	1139	22	220	1733	1625	-	8184
	LL	-	-	-	-	11	193	295	128	74	19	-	-	720
	Misc	-	-	-	1	-	-	1	-	-	-	-	-	2
	Total	167	763	241	27	316	2136	1435	150	294	1752	1625	-	8906
79	Ot	72	301	179	78	74	1635	667	675	661	294	28	7	4671
	LL	-	-	-	5	20	528	333	305	136	11	-	-	1338
	Misc	-	-	1	-	1	-	-	-	-	-	-	-	2
	Total	72	301	180	83	95	2163	1000	980	797	305	28	7	6011
80	Ot	23	86	4	53	110	1374	1594	786	637	617	69	100	5453
	LL	-	-	-	-	208	950	596	496	337	47	-	-	2634
	Misc	-	-	1	2	1	2	1	-	-	-	-	-	7
	Total	23	86	5	55	319	2326	2191	1282	974	664	69	100	8094
81	Ot	2	204	55	8	38	540	1005	743	1024	36	230	98	3983
	LL	-	-	1	2	537	1476	1043	837	286	281	56	5	4524
	Misc	-	-	-	1	-	-	-	-	-	-	-	-	1
	Total	2	204	56	11	575	2016	2048	1580	1310	317	286	103	8508
82	Ot	89	74	-	-	12	882	4283	2112	1509	2361	932	119	12372
	LL	-	11	26	195	773	1036	1386	1083	634	307	34	4	5489
	Misc	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	89	85	26	195	785	1918	5669	3195	2143	2668	966	123	17862
83	Ot	179	80	9	6	35	2215	1094	2115	957	173	75	11	6949
	LL	-	-	171	147	439	1441	699	576	1304	309	89	-	5175
	Misc	-	-	-	-	-	6	34	3	5	1	-	-	49
	Total	179	80	180	153	474	3662	1827	2694	2266	483	164	11	12173
84	Ot	5	3	13	1	39	272	93	239	61	19	-	-	745
	LL	-	-	167	152	111	1192	1210	1183	605	286	49	-	4955
	Misc	-	-	-	-	-	52	9	-	-	-	-	-	61
	Total	5	3	180	153	150	1516	1312	1422	666	305	49	-	5761
85	Ot	-	2	-	-	165	1172	2561	2431	692	435	4	80	7546
	LL	-	29	54	181	151	414	230	542	647	501	29	29	2807
	Misc	-	1	2	14	15	20	9	19	4	2	1	1	88
	Total	-	32	56	195	331	1606	2800	2992	1343	938	34	110	10441
86	Ot	}												5812
	LL	}	from Canadian quota reports to 10.09.86											1004
	Misc	}												-
	Total	}												6816

Table 4. Samples collected from the Canadian commercial cod fishery in NAFO Division 5Z during 1978-85 were used to obtain statistics by age. Length frequencies were applied to the weight indicated. The braces represent the manner in which statistics were pooled. The number in brackets shows the number of age interpretations available for the age length key which was applied at that stage.

a. 1978

Gear	Month	Number measured	Weight (t)			
OT	Jan.	-	167			
	Feb.	1470	763	930		
	Mar.	618	241		1171(387)	
	Apr.	-	26			
	May	512	305	331		
	June	1397	1943		2274(340)	
	July	2300	1139			
	Aug.		22			
	Sept.		220	1381(338)		
	Oct.	1371	1733			
	Nov.	359	1625	3358(351)		8184
	Dec.	-	-			
LL						720
Misc.						2
						8906

b. 1979

Gear	Month	Number measured	Weight (t)			
OT	Jan.	-	72			
	Feb.	-	301			
	Mar.	-	179			
	Apr.	-	78			
	May	-	74			
	June	979	1635	2339		
	July	839	667			
	Aug.	1232	675			
	Sept.	611	661			
	Oct.	-	294			
	Nov.	-	28			
	Dec.	-	7	990	4671(671)	
LL					1338	
Misc.					2	6011

Table 4. (Cont'd.)

c. 1980

Gear	Month	Number measured	Weight (t)				
OT	Jan.	-	23				
	Feb.	-	86				
	Mar.	-	4				
	Apr.	-	53				
	May	-	110				
	June	603	1374	1650			
	July	1036	1594				
	Aug.	-	786	2380			
	Sept.	241	637		4667(343)		
	Oct.	570	617				
	Nov.	-	69				
	Dec.	334	100	786(193)		5453	
LL						2634	
Misc.						7	8094

d. 1981

Gear	Month	Number measured	Weight (t)				
OT	Jan.	-	2				
	Feb.	-	204				
	Mar.	242	55	261			
	Apr.	-	8				
	May	-	38				
	June	1261	540	586	847(354)		
	July	543	1005				
	Aug.	954	743				
	Sept.	-	1024	2772(315)			
	Oct.	-	36				
	Nov.	518	230				
	Dec.	-	98	364(122)			
LL	Mar.	-	1				
	Apr.	-	2				
	May	-	537				
	June	183	1476	2016			
	July	205	1043				
	Aug.	241	837				
	Sept.	-	286				
	Oct.	-	281				
	Nov.	-	56				
	Dec.	-	5	1465	4524(106)		
Misc.					1		8508

Table 4. (Cont'd.)

e. 1982

Gear	Month	Number measured	Weight (t)			
OT	Jan.	-	89			
	Feb.	-	74			
	May	-	12			
	June	243	882	1057		
	July	577	4283			
	Aug.	785	2112			
	Sept.	1159	1509		8961(485)	
	Oct.	876	2361			
	Nov.	554	932			
	Dec.		119	1051	3412(270)	
LL	Feb.	-	11			
	Mar.	-	26			
	Apr.	-	195			
	May	218	773	1005		
	June	293	1036			
	July	-	1386			
	Aug.	-	1083			
	Sept.	-	634			
	Oct.	-	307			
	Nov.	-	34			
	Dec.	-	4	4484	5489(103)	17862

f. 1983

Gear	Month	Number measured	Weight (t)			
OT	Jan.	179	179			
	Feb.	-	80			
	Mar.	-	9	268(47)		
	Apr.	-	6			
	May	-	35			
	June	745	2215	2256		
	July	725	1094			
	Aug.	1681	2115			
	Sept.	317	957			
	Oct.		173			
	Nov.		75			
	Dec.		11	1216		
LL	Mar.	-	171			
	Apr.	-	147			
	May	-	439			
	June	175	1441			
	July	-	699			
	Aug.	-	576			
	Sept.	-	1304			
	Oct.	-	309			
	Nov.	-	89	5175	11856(557)	
Misc.					49	12173

Table 4. (Cont'd.)

g. 1984

Gear	Month	Number measured	Weight (t)			
OT			745			
LL	Mar.	-	167			
	Apr.	-	152			
	May	-	111			
	June	227	1192	1622		
	July	-	1210			
	Aug.	596	1183		4015	
	Sept.	461	605			
	Oct.	605	286			
	Nov.	-	49	335		5761
Misc.					61	

h. 1985

Gear	Month	Number measured	Weight (t)			
OT	Feb.	-	2			
	June	1920	1336	1338(308)		
	July	2332	2563			
	Aug.	826	2432			
	Sept.	1037	691			
	Oct.		435			
	Nov.		5			
	Dec.		80	1211	6206(406)	
LL	Feb.	-	29			
	Mar.	-	54			
	Apr.	240	181	264		
	May	233	151			
	June	298	414		829(182)	
	July	116	230			
	Aug.	379	540			
	Sept.	263	647			
	Oct.	-	501			
	Nov.	-	29			
	Dec.	-	29	1206	1976(166)	
Misc.					92	10441

Table 5. Age composition (percent by number) derived from biological samples of Atlantic cod from Georges Bank (5Ze) taken by Canadian vessels, 1975-85

Age	1978	1979	1980	1981	1982	1983	1984	1985
1	0.06	0.00	0.03	0.09	0.12	0.45	0.00	0.09
2	1.99	24.64	27.12	9.31	36.71	10.53	1.95	51.57
3	66.40	23.85	40.19	34.14	25.00	39.87	9.10	21.48
4	20.60	35.25	7.74	25.35	16.24	25.67	29.46	8.97
5	6.14	12.29	16.45	6.25	12.15	8.54	30.48	11.93
6	2.24	2.41	5.31	17.19	2.69	6.07	14.03	3.44
7	1.68	0.83	1.31	3.77	4.19	2.47	7.71	1.08
8	0.01	0.02	0.02	0.10	0.02	0.11	0.19	0.02
9	0.30	0.09	0.73	0.90	0.43	1.83	2.13	0.24
10+	0.18	0.09	0.54	0.67	0.80	0.91	3.06	0.24
#samples	29	13	10	17	17	15	7	18
#aged	1364	591	536	491	956	601	412	1064

Table 6. Removals at age (000's) by Canada and the USA for 1978-85

	Age Group										
	1	2	3	4	5	6	7	8	9	10+	Total
1978 Cdn	2	65	2162	671	200	73	55	12	10	6	3256
USA	-	331	5731	1636	625	53	288	35	28	8	8735
Total	2	396	7893	2307	825	126	343	47	38	14	11991
1979 Cdn	-	499	483	714	249	49	17	10	2	2	2025
USA	34	1618	572	4107	910	403	59	244	-	45	7992
Total	34	2117	1055	4821	1159	452	76	254	2	47	10017
1980 Cdn	1	704	1043	201	427	138	34	14	19	14	2595
USA	88	3002	4707	286	1888	951	413	76	153	-	11564
Total	89	3706	5750	487	2315	1089	447	90	172	14	14159
1981 Cdn	2	195	715	531	131	360	79	48	19	14	2094
USA	25	3060	3613	1960	101	1026	330	72	109	46	10342
Total	27	3255	4328	2491	232	1386	409	120	128	60	12436
1982 Cdn	7	2047	1394	906	678	150	234	91	24	45	5576
USA	325	7855	2466	1682	1258	117	452	116	50	57	14378
Total	332	9902	3860	2588	1936	267	686	207	74	92	19954
1983 Cdn	15	345	1306	841	280	199	81	118	60	30	3275
USA	81	3542	5557	1244	854	722	85	218	88	62	12453
Total	96	3887	6863	2085	1434	921	166	336	148	92	15728
1984 Cdn	-	21	98	317	328	151	83	22	23	33	1076
USA	81	1281	3305	2961	500	393	386	25	153	39	9167
Total	81	1302	3403	3278	828	544	469	47	176	115	10243
1985 Cdn	4	2144	893	373	496	143	45	39	10	10	4157
USA	130	4280	1539	985	1388	273	173	165	12	86	9031
Total	134	6424	2432	1358	1884	416	218	204	22	96	13188

Table 7. Mean length-at-age of cod derived from Canadian and USA samples 1978-85. Total weighted by catch in numbers for each country.

Year	Age group 1	2	3	4	5	6	7	8	9	10+ [a]
1978 Cdn	36.4	44.3	53.9	57.9	63.6	74.6	76.0	89.9	86.0	115.0
USA	-	50.2	61.5	69.8	73.7	79.3	89.3	91.3	107.1	115.0
Total	36.4	49.2	59.4	66.3	71.3	76.6	87.2	90.9	101.5	115.0
1979	50.7	53.3	69.1	75.3	80.4	95.9	104.4	99.6	115.0	115.0
	44.7	52.9	61.0	73.9	77.5	88.2	95.3	99.4	-	115.0
	44.7	53.0	64.7	74.1	78.1	89.0	97.3	99.4	115.0	115.0
1980	24.7	33.0	40.1	44.6	51.9	57.0	58.4	71.1	70.2	115.0
	43.9	52.6	61.6	72.4	81.9	86.3	92.9	92.2	91.2	115.0
	43.7	48.9	57.7	60.9	76.4	82.6	90.3	88.9	88.9	115.0
1981	42.2	49.2	58.8	67.8	77.4	85.7	94.5	96.0	97.4	115.0
	44.6	52.3	60.4	68.5	78.4	88.7	93.1	98.2	112.8	115.0
	44.4	52.1	60.1	68.4	77.8	87.9	93.4	97.3	110.5	115.0
1982	36.8	49.8	57.1	69.8	78.6	84.9	95.0	95.8	107.2	115.0
	42.3	51.4	64.4	70.8	79.9	84.1	96.5	99.2	105.5	115.0
	42.2	51.1	61.8	70.4	79.4	84.5	96.0	97.7	106.1	115.0
1983	42.6	50.4	58.4	67.1	77.8	84.8	93.0	99.3	104.4	115.0
	46.3	52.7	61.5	68.1	75.9	84.5	90.7	99.1	101.5	115.0
	45.7	52.5	60.9	67.7	76.4	84.6	91.8	99.2	102.7	115.0
1984	-	50.2	60.4	70.2	76.9	83.5	92.2	99.7	101.4	115.0
	47.2	54.1	61.5	69.8	79.3	86.5	94.8	97.5	102.5	115.0
	47.2	54.0	61.5	69.8	78.3	85.7	94.3	98.5	102.4	115.0
1985	38.7	49.3	55.3	67.9	74.8	83.2	90.1	95.6	98.8	115.0
	45.1	51.8	58.6	72.4	79.0	84.5	91.4	99.4	104.7	115.0
	44.9	51.0	57.4	71.2	77.9	84.1	91.1	98.7	102.0	115.0

a) A length of 115 cm was assumed for age 10+

Table 8. Mean weight-at-age for cod derived from Canadian and USA samples. Total weighted by catch in numbers for each country.

Year		Age group 1	2	3	4	5	6	7	8	9	10+[a]
1978	Cdn	0.656	1.206	2.121	2.644	3.540	5.682	6.140	9.268	8.399	15.000
	USA	-	1.298	2.470	3.692	4.473	5.199	7.522	7.924	12.794	15.000
	Total	0.656	1.283	2.374	3.387	4.247	5.479	7.300	8.267	11.637	15.000
1979		-	1.483	1.723	3.691	4.730	5.986	9.586	12.058	10.412	15.000
		0.889	1.522	2.464	4.301	4.974	7.309	9.127	10.264	-	15.000
		0.889	1.513	2.125	4.211	4.922	7.166	9.230	10.335	10.412	15.000
1980		0.387	.908	1.635	2.184	3.447	4.519	4.815	8.339	8.162	15.000
		0.839	1.490	2.478	3.992	5.792	6.703	8.489	8.648	8.046	15.000
		0.834	1.379	2.325	3.246	5.359	6.426	8.210	8.600	8.059	15.000
1981		0.864	1.368	2.312	3.467	5.113	6.816	9.108	9.575	10.485	15.000
		0.885	1.501	2.360	3.389	5.209	7.339	8.397	9.988	14.884	15.000
		0.883	1.493	2.352	3.406	5.155	7.203	8.534	9.823	14.231	15.000
1982		0.592	1.410	2.128	3.814	5.335	6.656	9.158	9.574	12.941	15.000
		0.767	1.395	2.852	3.845	5.449	6.457	9.473	10.297	12.434	15.000
		0.763	1.398	2.591	3.834	5.409	6.569	9.366	9.979	12.598	15.000
1983		0.885	1.466	2.265	3.371	5.210	6.641	8.593	10.428	11.999	15.000
		0.993	1.497	2.456	3.434	4.703	6.407	7.955	10.280	11.091	15.000
		0.976	1.494	2.420	3.409	4.828	6.458	8.266	10.332	11.459	15.000
1984		-	1.438	2.477	3.841	4.977	6.310	8.541	10.486	11.034	15.000
		1.053	1.638	2.450	3.597	5.308	6.751	8.960	9.710	11.361	15.000
		1.053	1.635	2.451	3.621	5.177	6.629	8.886	10.073	11.318	15.000
1985		0.680	1.391	1.950	3.571	4.742	6.399	8.074	9.664	10.584	15.000
		0.914	1.424	2.157	3.989	5.201	6.398	8.075	10.355	12.107	15.000
		0.907	1.413	2.081	3.874	5.080	6.398	8.075	10.223	11.415	15.000

a) a weight of 15.0 kg was assumed for 10+

Table 9. Stratified mean catch per tow at age (numbers) of Atlantic cod in USA offshore spring, summer and autumn bottom trawl surveys on Georges Bank a, 1963-1985.b (pers. comm., Dr. F. Serchuk, NMFS, Woods Hole, USA)

	Age											Totals				
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+
Spring c																	
1968	.329	.087	1.035	.529	.426	.247	.158	.090	.053	.036	.037	3.027	2.698	2.611	1.576	1.047	.621
1969	.000	.079	.350	1.141	.569	.289	.209	.138	.082	.046	.072	2.975	2.975	2.896	2.546	1.485	.836
1970	.000	.244	.522	.308	.830	.104	.420	.176	.039	.087	.053	2.783	2.785	2.539	2.017	1.709	.879
1971	.000	.133	.525	.322	.143	.375	.091	.225	.195	.051	.112	2.172	2.172	2.039	1.514	1.192	1.049
1972	.036	1.860	1.175	1.695	.327	.076	.208	.078	.141	.074	.000	5.748	5.712	3.852	2.677	.984	.657
1973e	.036	.334	7.464	1.403	1.628	.273	.201	.227	.032	.130	.249	11.977	11.941	11.607	4.143	2.740	1.112
1974	.000	.286	2.921	3.828	.488	1.284	.282	.065	.165	.022	.112	9.453	9.453	9.167	6.246	2.418	1.930
1975	.000	.041	.242	1.389	1.982	.167	.440	.083	.060	.069	.025	4.418	4.418	4.377	4.135	2.826	.844
1976	.071	.834	1.232	.685	.443	1.008	.105	.168	.023	.000	.035	4.524	4.453	3.619	2.387	1.782	1.339
1977	.000	.018	2.261	.692	.335	.179	.466	.033	.042	.000	.013	4.039	4.039	4.021	1.760	1.068	.733
1978	2.123	.241	.128	3.545	.621	.499	.092	.457	.033	.091	.070	7.892	5.769	5.528	5.408	1.863	1.242
1979	.070	.279	.871	.191	1.226	.347	.150	.056	.093	.008	.014	3.305	3.254	2.956	2.084	1.897	.668
1980	.067	.025	1.452	1.723	.134	.950	.383	.123	.020	.019	.071	4.967	4.890	4.865	3.413	1.690	1.556
1981	.244	1.869	1.555	2.255	1.353	.081	.706	.218	.117	.000	.069	8.467	8.223	6.354	4.799	2.544	1.191
1982f	.120	.396	2.755	1.141	1.051	.843	.013	.242	.052	.013	.028	6.654	6.534	6.138	5.088	2.242	1.191
1983	.052	.211	1.261	1.954	.491	.447	.276	.035	.123	.000	.007	4.937	4.885	4.674	2.720	1.459	.968
1984	.000	.258	.296	.511	.744	.286	.272	.143	.000	.100	.005	2.615	2.615	2.357	2.061	1.550	.806
1985	.244	.098	2.633	.757	1.058	1.328	.270	.203	.172	.025	.158	6.938	6.694	6.596	3.963	3.206	2.148
1986	(.092)	(.698)										5.048	(4.948)	(4.258)			
Summer d																	
1977	.131	.195	5.121	1.111	.660	.164	.326	.051	.081	.000	.026	7.866	7.735	7.540	2.419	1.388	.648
1978	.755	.350	.266	1.542	.369	.149	.057	.109	.000	.028	.000	3.625	2.870	2.520	2.254	.712	.343
1979	.236	1.459	1.767	.375	.943	.234	.050	.053	.115	.000	.031	5.261	5.025	3.566	1.799	1.426	.483
1980	2.646	.640	4.135	2.371	.864	.415	.092	.000	.031	.000	.000	10.394	7.748	7.108	2.973	.602	.538
1981	.024	3.347	1.657	1.224	.568	.035	.098	.048	.000	.000	.000	7.001	6.977	3.630	1.973	.749	.181
Autumn																	
1963	.012	.461	.499	.590	.575	.227	.209	.112	.066	.009	.044	2.804	2.792	2.331	1.832	1.242	.667
1964	.006	.410	.448	.377	.345	.093	.087	.040	.032	.109	.053	1.910	1.904	1.494	1.046	.669	.324
1965	.111	.833	.640	.453	.310	.107	.115	.072	.052	.015	.015	2.723	2.612	1.779	1.139	.686	.376
1966	.657	1.085	.641	.330	.169	.064	.061	.040	.025	.001	.011	3.084	2.427	1.342	.701	.371	.202
1967	.046	4.869	.855	.335	.260	.085	.085	.035	.033	.008	.045	6.656	6.610	1.741	.886	.551	.291
1968	.045	.201	1.033	.502	.174	.047	.043	.017	.015	.005	.031	2.113	2.068	1.867	.834	.332	.158
1969	.000	.220	.399	.401	.212	.060	.039	.012	.015	.014	.038	1.410	1.410	1.190	.791	.390	.178
1970	.265	1.082	.867	.336	.445	.098	.000	.021	.035	.035	.063	3.247	2.982	1.900	1.033	.697	.252
1971	.256	.386	.405	.250	.193	.305	.117	.027	.057	.000	.048	2.044	1.788	1.402	.997	.747	.554
1972	.607	4.771	.830	1.135	.256	.156	.366	.070	.131	.014	.053	8.389	7.788	3.011	2.181	1.046	.790
1973	.130	1.121	3.891	.758	1.290	.135	.145	.112	.040	.089	.161	7.872	7.742	6.621	2.730	1.972	.682
1974	.296	.262	.419	.975	.105	.073	.066	.000	.044	.000	.000	2.240	1.944	1.682	1.263	.288	.183
1975	1.524	.637	.270	.400	1.000	.072	.100	.000	.000	.000	.024	4.107	2.583	1.946	1.676	1.276	.196
1976	.000	3.941	1.328	.489	.178	.474	.035	.073	.025	.034	.013	6.690	6.690	2.749	1.421	.932	.754
1977	.123	.192	2.778	.570	.204	.141	.321	.006	.022	.000	.063	4.420	4.297	4.105	1.327	.757	.553
1978	.321	1.505	.207	3.392	.782	.272	.134	.279	.041	.024	.011	6.968	6.647	5.142	4.935	1.543	.761
1979	.096	1.314	1.393	.182	1.309	.240	.146	.029	.093	.006	.018	4.826	4.730	3.416	2.023	1.841	.532
1980	.227	.664	.458	.628	.062	.204	.043	.054	.020	.000	.000	2.360	2.133	1.469	1.011	.383	.321
1981	.212	2.860	1.826	1.265	.478	.044	.470	.046	.052	.015	.067	7.335	7.123	4.263	2.437	1.172	.694
1982	.205	.561	1.342	.141	.044	.062	.000	.010	.000	.000	.014	2.379	2.174	1.613	.271	.130	.086
1983	.661	.415	.655	.510	.035	.030	.002	.000	.000	.000	.015	2.331	1.670	1.255	.600	.090	.055
1984	.119	1.600	.065	.568	.558	.011	.040	.025	.004	.025	.028	3.043	2.924	1.324	1.259	.691	.133
1985	1.004	.220	.803	.103	.115	.101	.000	.000	.004	.000	.000	2.430	1.346	1.126	.323	.220	.105

a. Spring and autumn: strata 13-25; summer: strata 13, 16, 19-25

b. Catch per tow at age for 1963-69 obtained by applying 1970-81 age-length keys to stratified mean catch per tow at length distributions from each survey.

c. Spring surveys during 1973-81 were accomplished with a "Yankee 41" trawl. In all other years, spring surveys were accomplished with a "Yankee 36" trawl. No adjustments have been made for these gear differences.

d. Summer survey in 1978 only sampled strata 13, 16, 19-28, 23-25. Summer survey in 1981 sampled strata 13, 16, 19-21, 23 and 25.

e. Excludes unusually high catch of 1894 cod (2558 kg) at Station 238 (Strata tow 28-4)
f. Excludes unusually high catch of 1032 cod (4896 kg) at Station 323 (Strata tow 16-7)

Table 10. Stratified mean catch per tow in numbers and weight (kg) for Atlantic cod from USA offshore spring, summer and autumn bottom trawl surveys (Strata 13-25) 1963-86.

Year	Spring a Nos	Spring a Wgt (kg)	Summer b Nos	Summer b Wgt (kg)	Autumn Nos	Autumn Wgt (kg)
1963	-	-	-	-	2.80	11.0
1964	-	-	-	-	1.91	7.1
1965	-	-	-	-	2.72	7.2
1966	-	-	-	-	3.09	5.0
1967	-	-	-	-	6.66	8.3
1968	3.03	7.8	-	-	2.12	5.3
1969	2.97	11.0	-	-	1.41	4.9
1970	2.78	9.7	-	-	3.25	7.8
1971	2.17	8.8	-	-	2.04	6.1
1972	5.74	11.7	-	-	8.39	14.2
1973	11.98e	24.5e	-	-	7.87	19.1
1974	9.45	22.5	-	-	2.24	5.1
1975	4.42	16.1	-	-	4.11	8.7
1976	4.52	11.5	-	-	6.68	10.9
1977	4.04	9.5	7.87	17.6	4.42	11.5
1978 c	7.89	19.3	3.62	10.7	6.97	21.5
1979	3.30	10.4	5.25	12.3	4.82	15.2
1980 d	4.96	15.3	10.39	15.0	2.36	6.2
1981	8.47	24.0	7.00	10.2	7.33	17.5
1982	6.65e	14.2e	-	-	2.38	4.3
1983	4.94	14.8	-	-	2.33	4.0
1984	2.61	9.5	-	-	3.04	6.3
1984 Cdn	5.83	24.4	-	-	-	-
1985	6.94	21.5			2.43	3.5
1986	5.04	16.7				

a. Spring surveys, 1973-80, were accomplished with "41 Yankee" trawl and with "36 Yankee" trawl in other years. No adjustment in catch per tow has been made for these gear differences.
b. Summer surveys only include Strata 13, 16, 19-25
c. Summer survey in 1978 only sampled Strata 13, 16, 19-20, 23-25
d. Summer survey in 1981 only sampled Strata 13, 16, 19-21, 23, 25
e. Excludes one unusually high catch of cod.
Cdn. Preliminary results of Canadian survey in March 1984, Strata 16-22 using a "Western IIA" bottom trawl.

Table 11. Catch rate index for cod in NAFO Division 5Z, standardized to Can-M OTB2-5 and June. The standardized effort index was calculated using the mean catch rate and catch.

Year	CPUE	Catch	Effort	Ln CPUE	Gear	ln power	Month	ln power
67	0.492	36752	74769	-0.78510	OTB1-4	.000	Nov	-0.736
68	0.547	43136	78844	-0.67690	OTB2-2	.093	Sep	-0.533
69	0.469	37939	80928	-0.83250	OTB2-4	.152	Oct	-0.506
70	0.335	25652	76463	-1.16430	OTB2-3	.260	Aug	-0.481
71	0.322	28179	87513	-1.20690	OTB2-5	.410	Dec	-0.433
72	0.351	25059	71356	-1.11390			May	-0.394
73	0.377	28923	76721	-1.04760			Feb	-0.378
74	0.282	27331	96963	-1.29850			Jul	-0.363
75	0.393	25008	63700	-0.09983			Jun	-0.341
76	0.288	19926	69292	-1.31450			Apr	-0.023
77	0.882	27367	31020	-0.19640			Jan	-0.000
78	0.870	35483	40768	-0.21350			Mar	0.243
79	0.709	38656	54520	-0.41810				
80	0.557	48147	86443	-0.65900				
81	0.734	42357	57736	-0.38100				
82	0.796	57195	71891	-0.30370				
83	0.498	48928	98293	-0.77220				
84	0.452	37676	85553	-0.85720				
85	0.635	37269	58687	-0.52630				

Regression of Multiplicative model

Multiple r-squared 0.498

Analysis of Variance

Source	DF	Sum Squares	Mean Squares	f-value
Intercept	1	2.875 E2	2.875 E2	
Regression	33	4.426 E1	1.341 E0	8.431
Gear	4	5.572 E0	1.893 E0	11.901
Month	11	2.668 E0	5.152 E-1	3.239
Year	18	2.788 E1	1.549 E0	9.737
Residuals	281	4.470 E1	1.591 E-1	
Total	315	3.764 E2		

Table 12. USA commercial landings and landings per day fished for otter trawl trips catching cod from Georges Bank (5Ze), 1965-85. (from unpublished data provided by Dr. F. Serchuk, NMFS, Woods Hole, Mass.)

	All Trips		50% Trips	
Year	Landings	t/day Fished	Landings	t/day Fished
1965	10039 t	0.74 *	1190	4.79 *
1966	9871	0.73	1368	4.74
1967	10248	0.76	2371	4.22
1968	12085	1.05	3123	3.97
1969	13194	1.26	4160	3.72
1970	11270	1.18	3598	3.96
1971	12430	1.22	4512	3.84
1972	10180	1.07	4168	3.53
1973	12431	1.45	6304	5.01
1974	14073	1.49	7865	4.39
1975	12065	1.33	6052	4.29
1976	12251	1.55	6488	4.32
1977	18523	1.78	9996	5.70
1978	20847	1.94	9827	4.81
1979	26449	2.10	14596	4.17
1980	32446	2.16	17987	4.39
1981	27613	1.89	14492	3.97
1982	33314	2.18	23561	4.45
1983	30958	2.00	21245	4.25
1984	26157	1.42	15916	2.98
1985	21437	2.15	14962	2.26

* mean of the weighted, on catch, values for TC 2,3 and 4

Table 13. Recruitment indices for Atlantic cod calculated from USA offshore autumn bottom trawl survey from Georges Bank during 1963-85.

Year-class	Age Group	
	0 + 1	1 + 2
1962	-	0.412
1963	0.179	0.493
1964	0.333	0.657
1965	0.604	0.867
1966	2.972	2.430
1967	0.154	0.287
1968	0.159	0.537
1969	0.420	0.631
1970	0.586	0.582
1971	2.275	3.880
1972	1.434	0.654
1973	0.316	0.242
1974	0.734	0.939
1975	4.038	2.979
1976	0.075	0.182
1977	0.787	1.310
1978	1.038	0.749
1979	0.416	1.206
1980	1.484	1.810
1981	0.567	0.559
1982	0.498	0.195
1983	1.709	1.040
1984	0.281	-

Table 14. Catch per tow at ages 0-3 for the 1973-85 year-classes in the spring and autumn surveys. Only data for 1973-81 in the spring survey were used due to a change in gear after 1981.

	Spring	Age group			Autumn	Age group		
Year class	0	1	2	3	0	1	2	3
73	0.036	0.286	0.242	0.605	0.130	0.262	0.270	0.489
74	0.000	0.041	1.232	0.692	0.296	0.637	1.328	0.570
75	0.000	0.834	2.261	3.545	1.524	3.941	2.778	3.392
76	0.071	0.018	0.120	0.191	0.000	0.192	0.207	0.182
77	0.000	0.241	0.871	1.723	0.123	1.505	1.393	0.628
78	2.123	0.279	1.452	2.255	0.321	1.314	0.458	1.265
79	0.070	0.025	1.555	*	0.096	0.664	1.826	0.141
80	0.067	1.869	*	*	0.227	2.860	1.342	0.510
81	0.244	*	*	*	0.212	0.561	0.655	0.568
82	*	*	*	*	0.205	0.415	0.065	0.103
83	*	*	*	*	0.661	1.600	0.803	*
84	*	*	*	*	0.119	0.220	*	*
85	*	*	*	*	1.084	*	*	*

Correlation between indices at different age groups for the same year-class

	Age		
Age	0	1	2
1	-.102		
2	.185	.582	
3	.272	.889	.897

	Age		
Age	0	1	2
1	.791		
2	.704	.759	
3	.979	.788	.638

Table 15. Estimates of instantaneous total mortality (Z) and fishing mortality (F) with instantaneous mortality (M) assumed to be 0.20 for five time periods, derived from USA offshore spring and autumn bottom trawl survey data.

	Spring a		Autumn b	
Time Period	Z	F	Z	F
1964 - 67	-	-	0.73	0.53
1968 - 72 c	0.34	0.14	0.49	0.29
1973 - 76	0.70	0.50	0.56	0.36
1977 - 80	0.34	0.14	0.76	0.56
1981 - 83	0.74	0.54	0.98	0.78
1982 - 84	0.73	0.53	-	-
1981 - 85	-	-	0.89	0.69

a. ln ((age 4+ for years i to j) / (age 5+ for years i+1 to j+1))

b. ln ((age 3+ for years i-1 to j-1) / (age 4+ for years i to j))

c. excludes spring 1972-73 (4+/5+) since these gave negative Z value.

Table 16. Results of regression analysis of SPA on survey numbers and mean 3+ F on directed effort for trial values of fully recruited F in 1985.

	Ft	0.4	0.45	0.5	0.6
a) SPA 4+ vs RV 3+ 1978-86					
	Intercept	13023	12143	11441	10395*
	R-squared	0.628	0.665	0.671*	0.657
	SS residuals	2918*	3179	3704	5007
b) SPA 2+ vs RV 1+ 1978-84					
	Intercept	38926	37198	35820	33766*
	R-squared	0.536	0.589	0.621	0.650*
	SS residuals	1757	1615	1561*	1579
c) SPA 3 vs RV 2 1978-86					
	Intercept	6663*	6668	6754	6885
	R-squared	0.653	0.672	0.685	0.703*
	SS residuals	1366	1295	1249	1193*
d) 3+ F vs effort 1978-85					
	Intercept	0.319	0.316*	0.316	0.321
	R-squared	624	0.656*	0.550	0.338
	SS residuals	4.577*	5.376.	10.350	32.730

Table 17. Results of regression analysis of SPA numbers and survey catch per tow at ages one and two and derived estimate of partial recruitment (PR) with a fully recruited F of 0.45 in 1985.

	PR	1.0	0.796	0.6	0.4
a) Age 2					
	Intercept	6616	6720	6889	7233
	R-squared	0.919	0.947	0.911	0.702
	SS residuals	4907	3362	6452	3404
b) Age 1	PR	0.020	0.027	0.040	0.080
	Intercept	16021	10365	11215	9614
	R-squared	0.660	0.977	0.974	0.970
	SS residuals	2082	1731	1841	2446

Table 18. Results of SPA with a fully recruited fishing mortality of 0.45 and a partial recruitment vector of 0.027, 0.796, 1.... in 1985.

Population Numbers (ØØØ's)

Age	1978	1979	198Ø	1981	1982	1983	1984	1985	
1	291Ø6	24736	2Ø5Ø9	43984	187Ø3	12828	28674	1224Ø	-----
2	4729	23828	2Ø221	16711	35987	15Ø12	1Ø416	234Ø3	99ØØ
3	262Ø2	3514	17593	132Ø3	1Ø736	2Ø5Ø4	8774	735Ø	13392
4	8356	14311	1922	92Ø1	6893	5298	1Ø577	41Ø4	3837
5	2951	4754	7354	1133	5279	33Ø2	2451	5694	2143
6	1141	1669	2843	3927	718	2571	14Ø6	1257	2972
7	15ØØ	82Ø	958	1343	1961	346	1271	659	656
8	6Ø	918	6Ø3	38Ø	729	985	133	617	344
9	131	7	522	412	2Ø2	41Ø	5Ø2	66	322
1Ø	48	154	42	193	252	255	328	29Ø	186
1+	74224	74711	72568	9Ø486	8146Ø	61509	64532	5568Ø	33752
2+	45118	49975	52Ø6Ø	46502	62757	48681	35858	4344Ø	33752
3+	4Ø389	26147	31838	29791	26771	33669	25442	2ØØ37	23852
4+	14187	22633	14245	16589	16Ø34	13165	16668	12687	1Ø46Ø

Mean Population Biomass (t)

Age	1978	1979	198Ø	1981	1982	1983	1984	1985
1	1884Ø	19916	155Ø8	35189	12811	113Ø2	27324	1ØØØ3
2	5321	31Ø97	24Ø86	2Ø161	38477	17353	14378	25341
3	47692	56Ø7	31963	22835	19949.	36292	15Ø64	11247
4	22Ø65	44Ø03	5498	24Ø46	187Ø7	12589	28551	11691
5	9725	18296	3Ø957	469Ø	2Ø359	1Ø721	9257	21268
6	56Ø7	9179	134Ø7	2Ø39Ø	3347	11918	6534	5915
7	8756	6516	5241	8575	13272	1843	8Ø4Ø	3912
8	2Ø4	7247	4623	2768	553Ø	74Ø2	967	4634
9	1169	51	3264	4379	1824	3372	4116	558
1Ø	547	1732	469	2163	27Ø1	2744	3564	32ØØ
1+	119925	143644	135Ø16	145196	136978	115536	117795	97769
2+	1Ø1Ø85	123728	119Ø8	11ØØØ7	124167	1Ø4233	9Ø47Ø	87766
3+	95765	92631	95422	89846	8569Ø	8688Ø	76Ø92	62425
4+	48Ø72	87Ø24	63459	67Ø11	65741	5Ø588	61Ø28	51178

Fishing Mortality

Age	1978	1979	198Ø	1981	1982	1983	1984	1985
1	Ø.ØØØ	Ø.ØØ2	Ø.ØØ5	Ø.ØØ1	Ø.Ø2Ø	Ø.ØØ8	Ø.ØØ3	Ø.Ø12
2	Ø.Ø97	Ø.1Ø3	Ø.226	Ø.242	Ø.363	Ø.337	Ø.149	Ø.358
3	Ø.4Ø5	Ø.4Ø3	Ø.448	Ø.45Ø	Ø.5Ø6	Ø.462	Ø.56Ø	Ø.45Ø
4	Ø.364	Ø.466	Ø.329	Ø.356	Ø.536	Ø.571	Ø.419	Ø.45Ø
5	Ø.37Ø	Ø.314	Ø.428	Ø.257	Ø.52Ø	Ø.654	Ø.467	Ø.45Ø
6	Ø.13Ø	Ø.356	Ø.55Ø	Ø.494	Ø.529	Ø.5Ø4	Ø.558	Ø.45Ø
7	Ø.291	Ø.1Ø8	Ø.725	Ø.41Ø	Ø.489	Ø.755	Ø.524	Ø.45Ø
8	2.Ø13	Ø.365	Ø.18Ø	Ø.43Ø	Ø.377	Ø.473	Ø.494	Ø.45Ø
9	Ø.384	Ø.4Ø7	Ø.448	Ø.416	Ø.511	Ø.5Ø3	Ø.484	Ø.45Ø
1Ø	Ø.384	Ø.4Ø7	Ø.448	Ø.416	Ø.511	Ø.5Ø3	Ø.484	Ø.45Ø
3+	Ø.384	Ø.4Ø8	Ø.449	Ø.417	Ø.513	Ø.5Ø5	Ø.488	Ø.45Ø

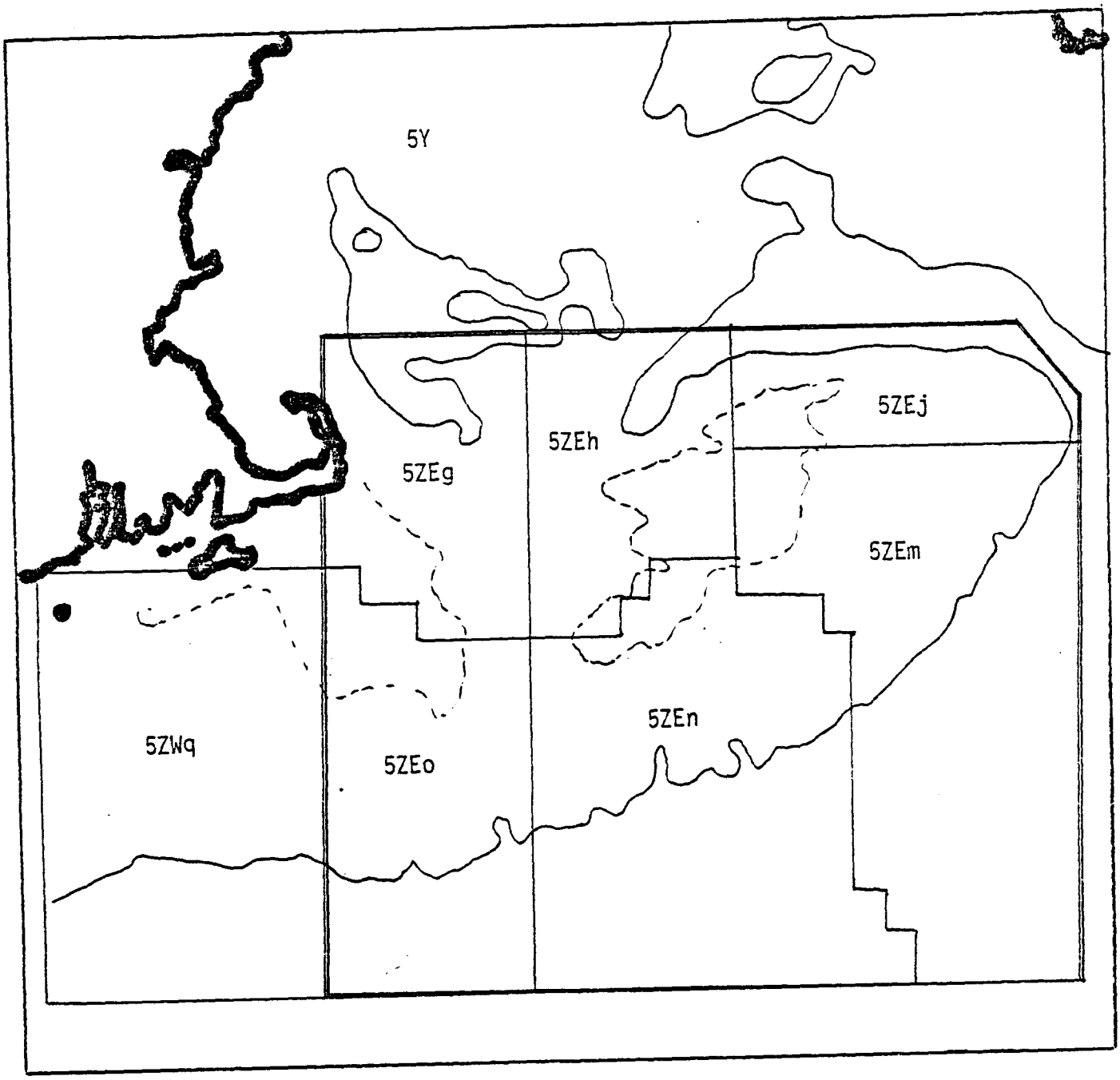


Figure 1. NAFO statistical areas for Georges Bank

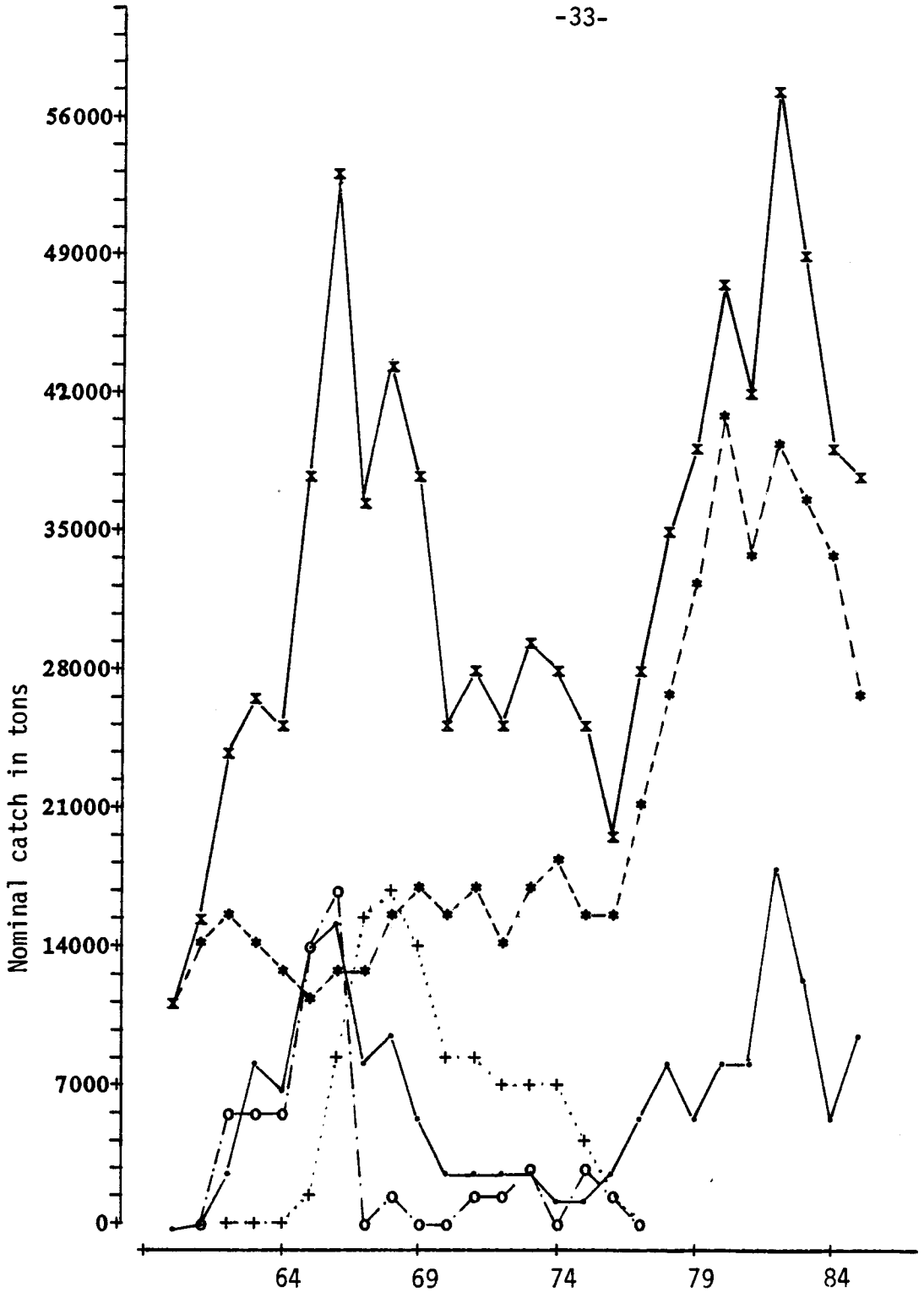


Figure 2. Nominal catches of cod in NAFO Division 5Z and Statistical Area 6 for 1960-85 by x- total, *- USA, .- Canada, o- USSR and +- other.

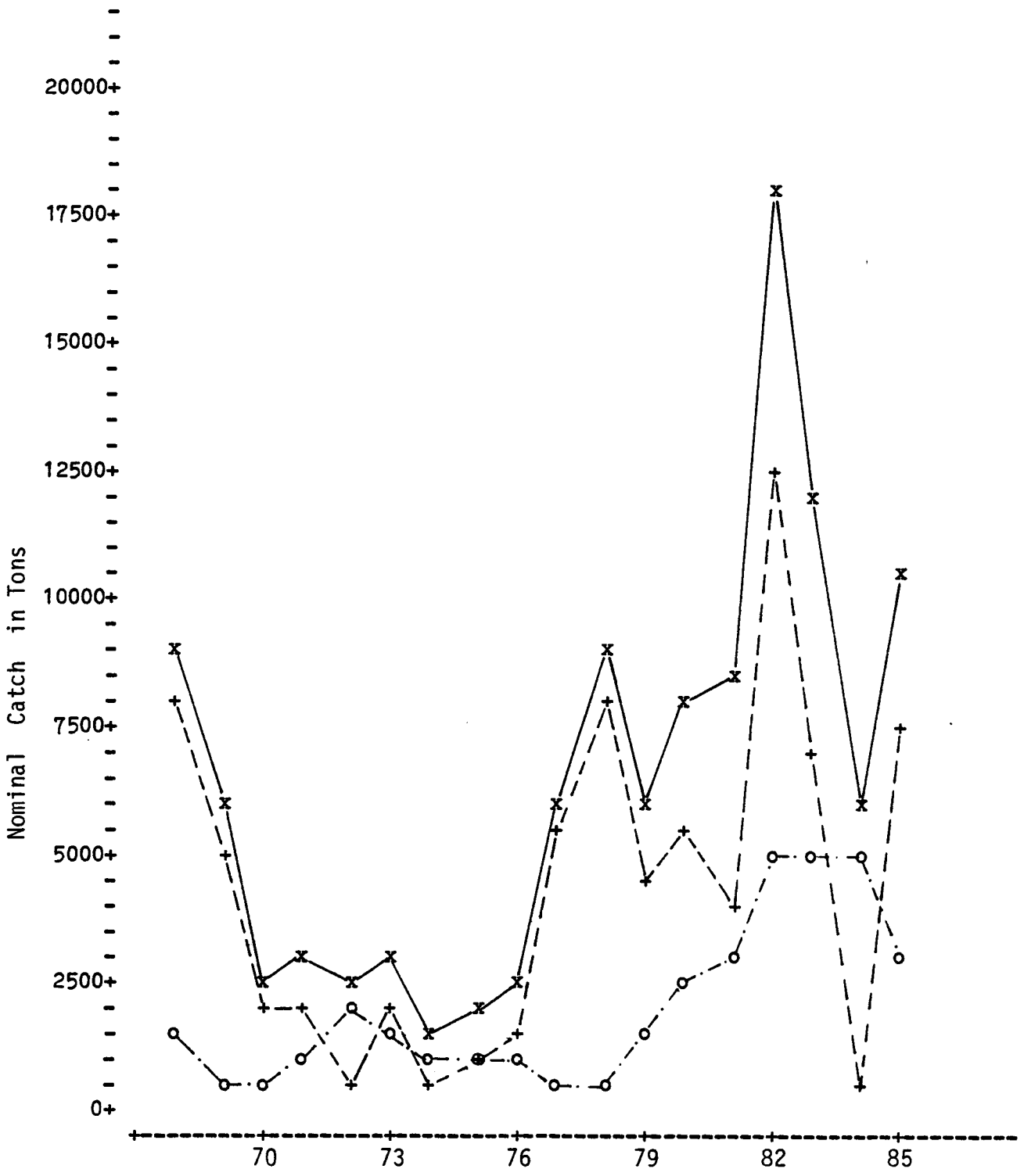


Figure 3. Nominal Canadian catch of cod from Georges Bank for 1968-85 by o- longline, +- otter trawl and x--total (includes misc.)

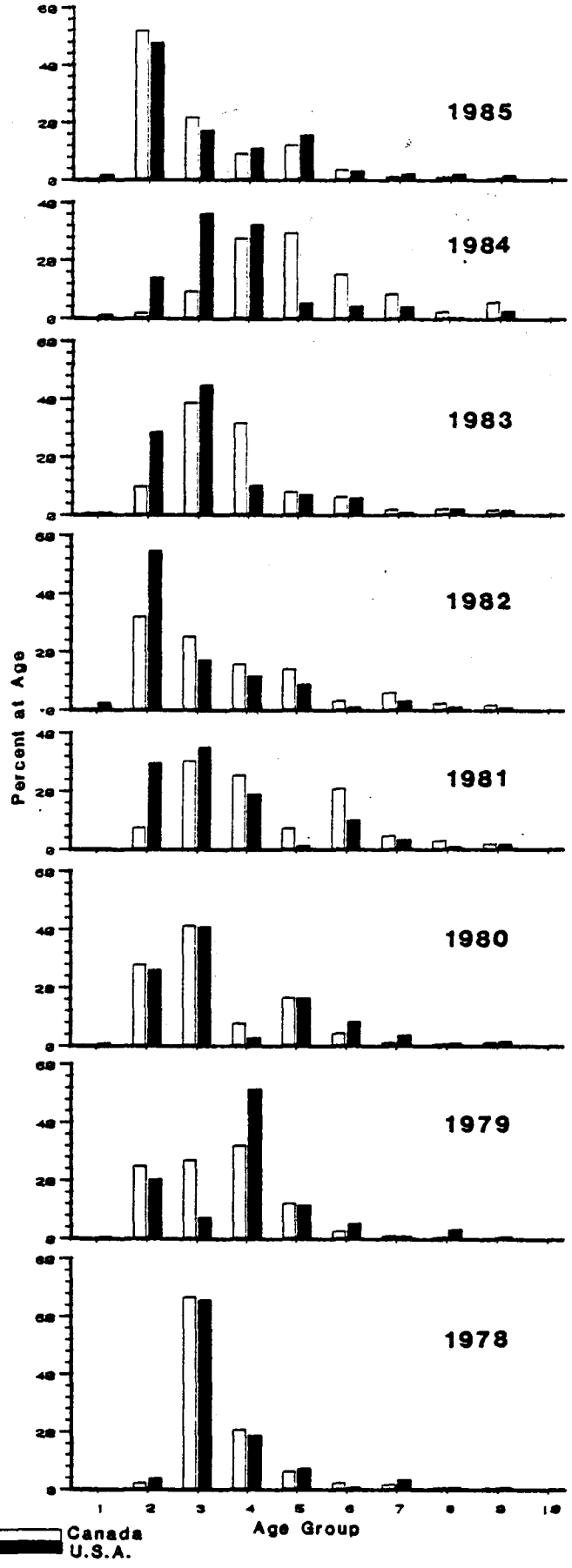


Figure 4. Percent age composition of Canadian and USA catch.

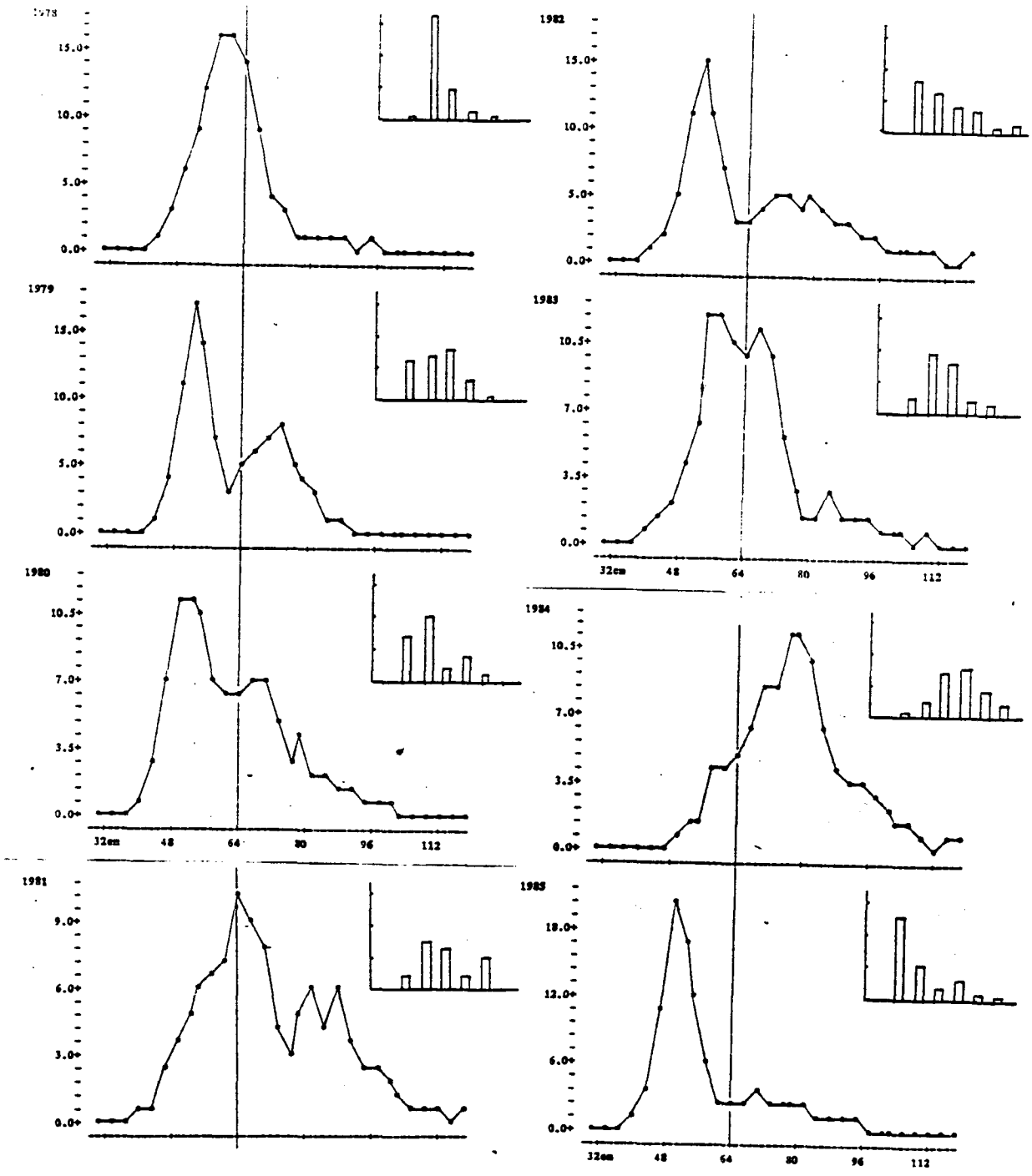


Figure 5. Length frequency distributions of cod in Subdivision 5Ze and corresponding percent age composition for Canadian landings.

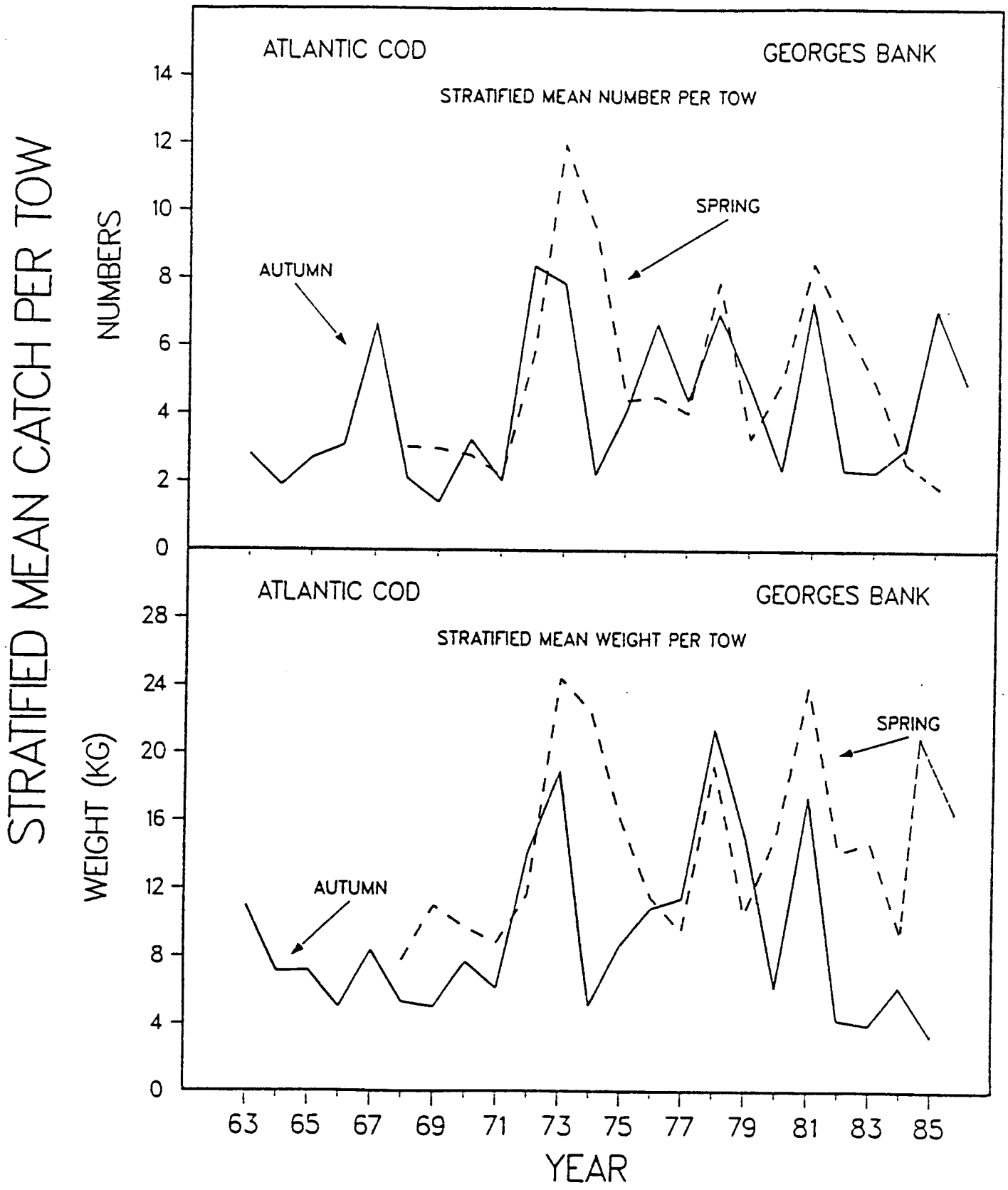


Figure 6. Stratified mean number per tow and stratified mean weight (kilograms) per tow of Atlantic cod in NEFC spring and autumn offshore bottom trawl surveys on Georges Bank (Strata 13-25), 1963-1985.

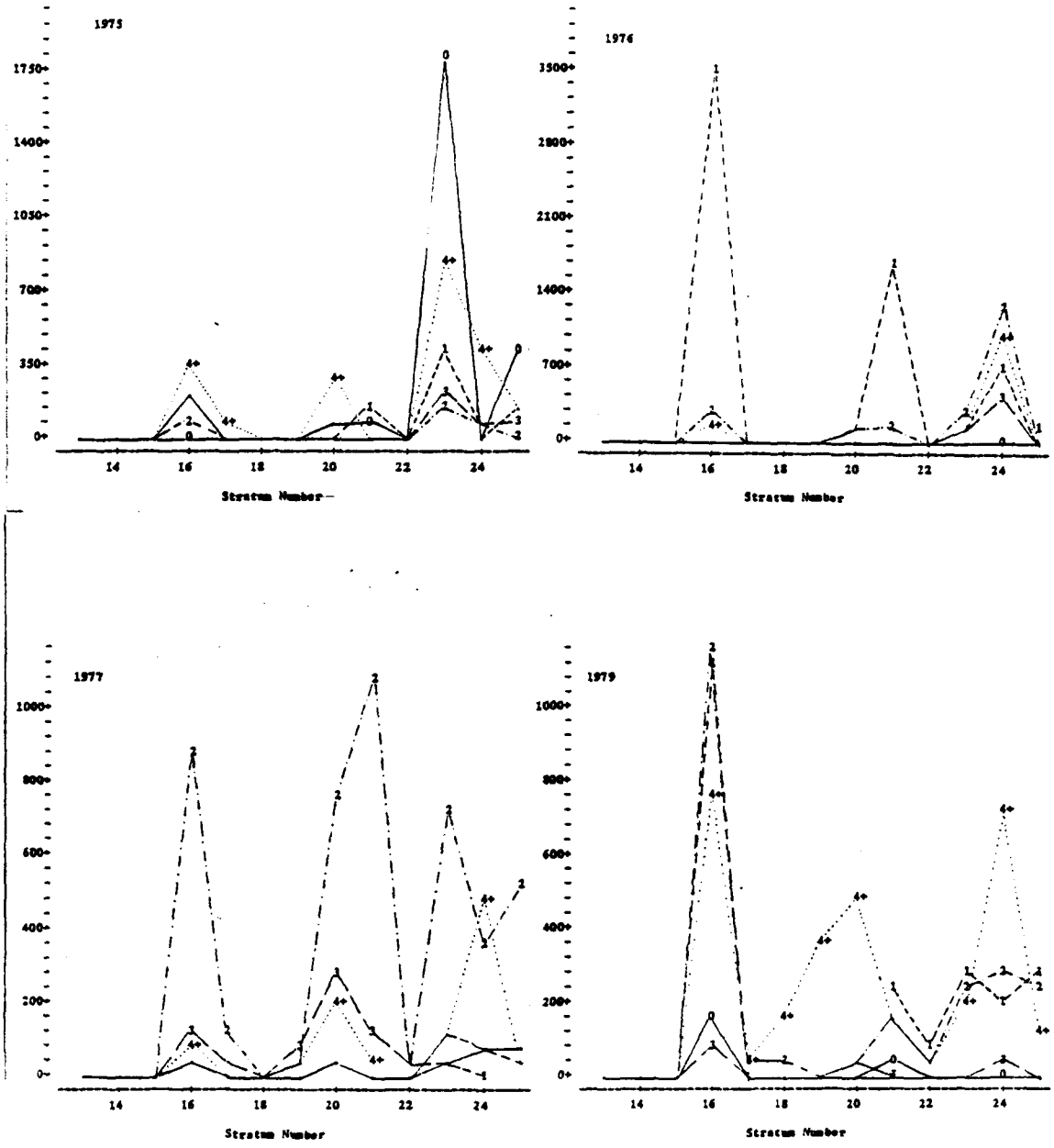


Figure 7. Stratified mean catch per tow in numbers for USA autumn survey, ages 0-4+.

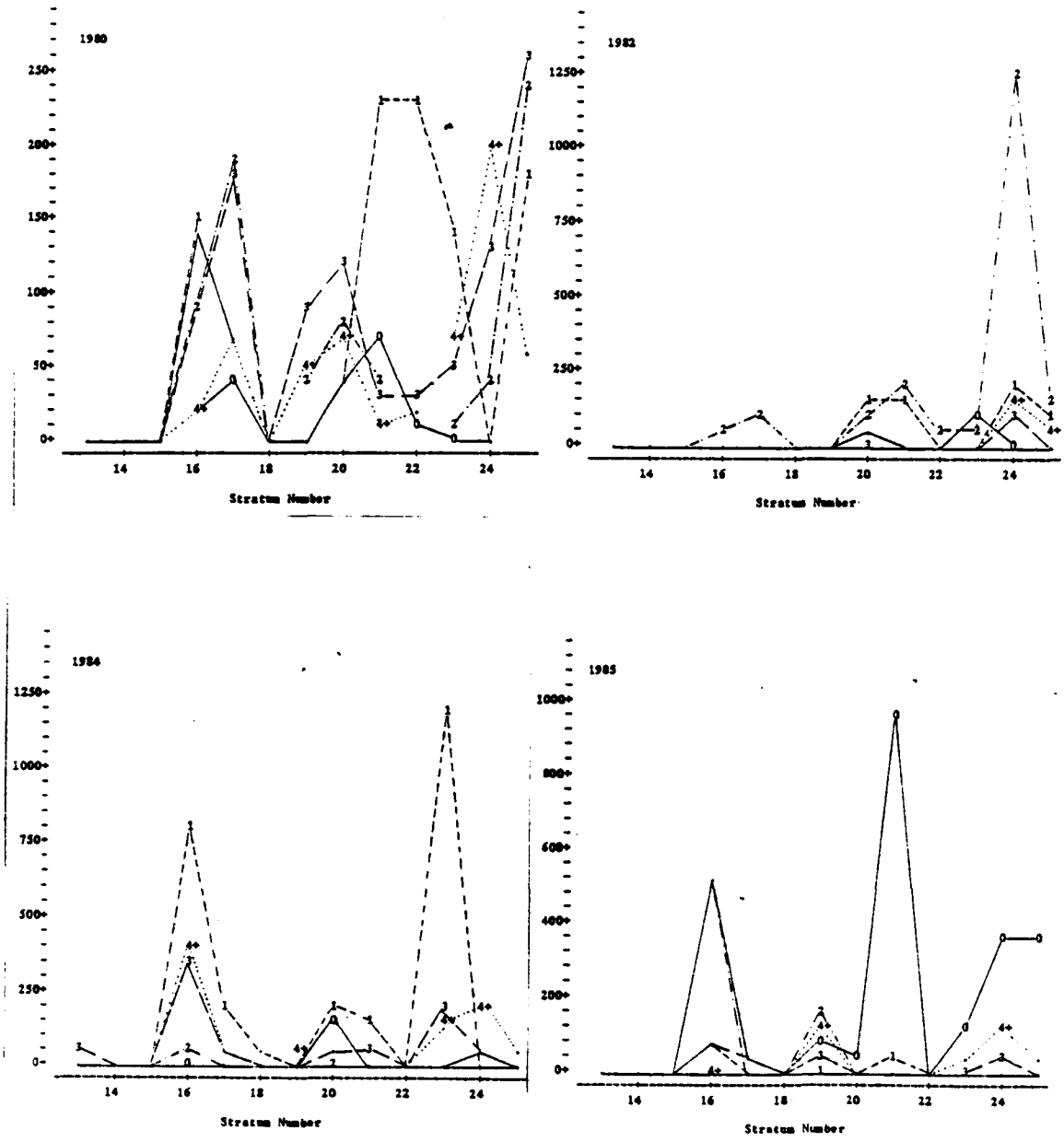


Figure 7. Con'd. USA catch per tow.

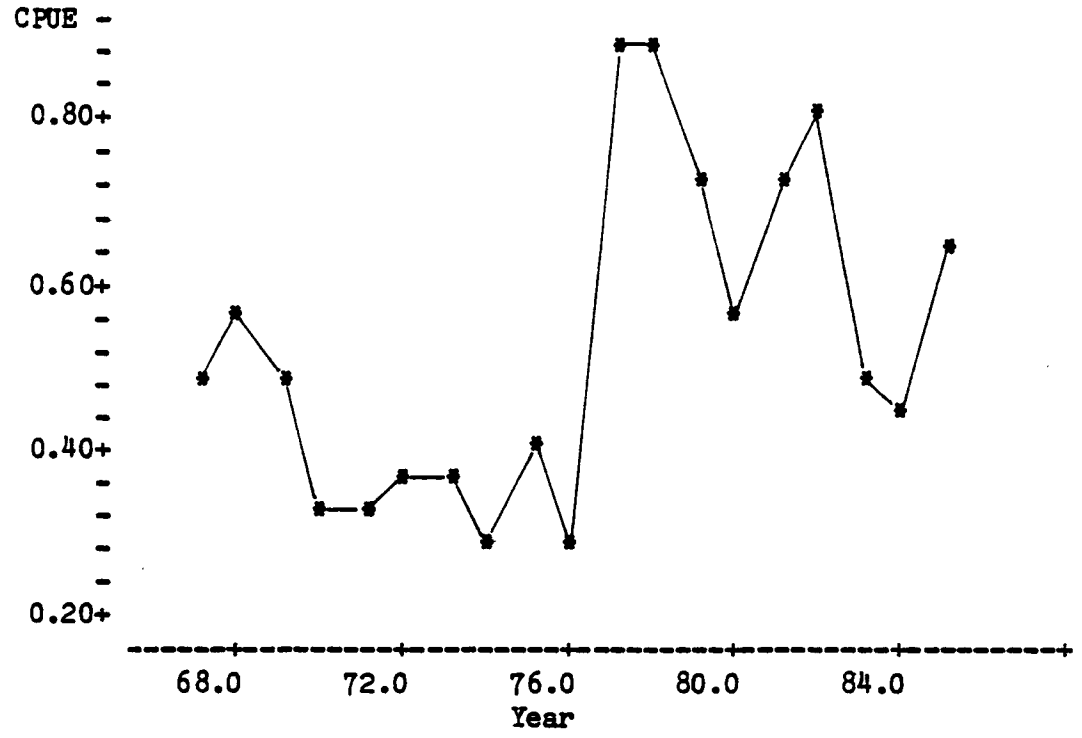


Figure 8. Calculated CPUE (t/hour) derived from Canadian OTB landings for 1967-85.

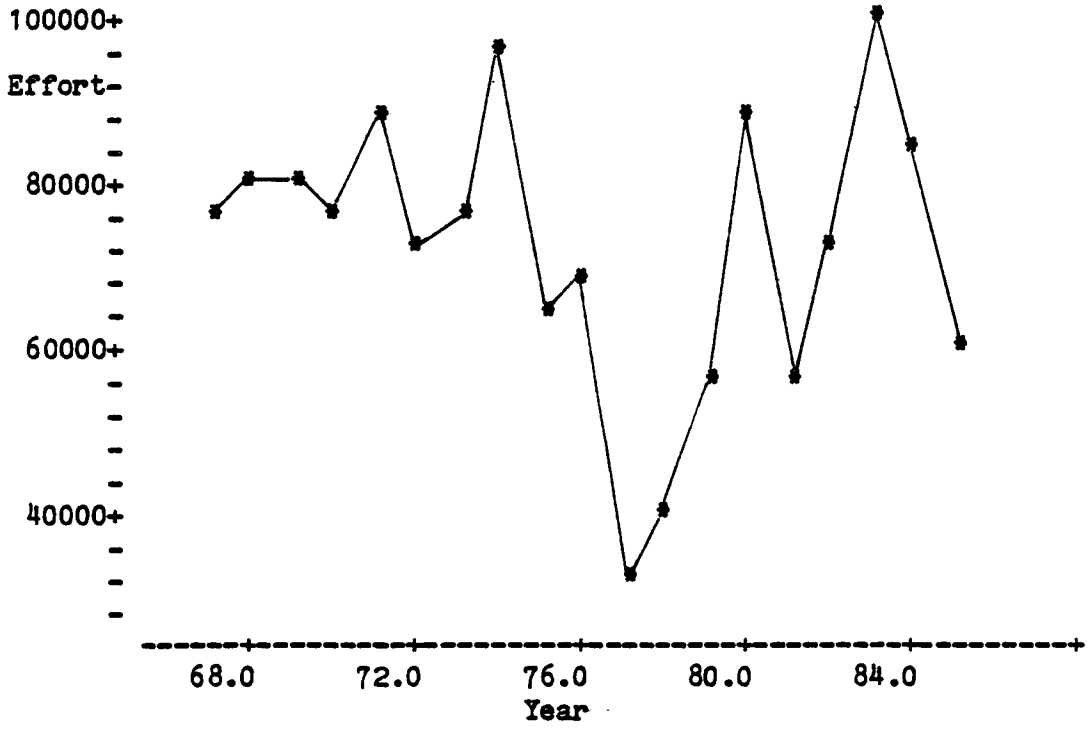


Figure 9. Calculated total directed effort derived from Canadian OTB landings for 1967-85.

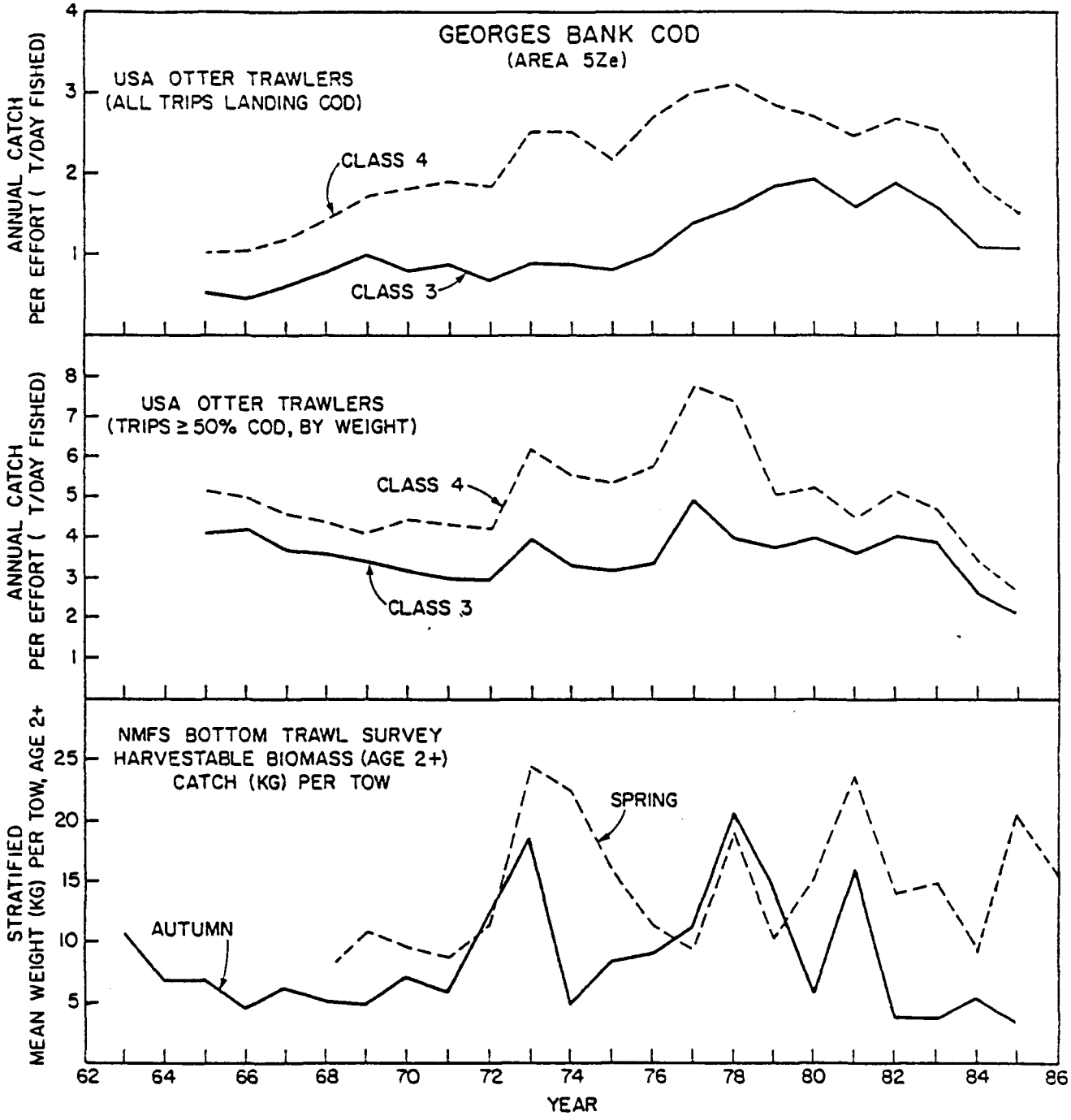
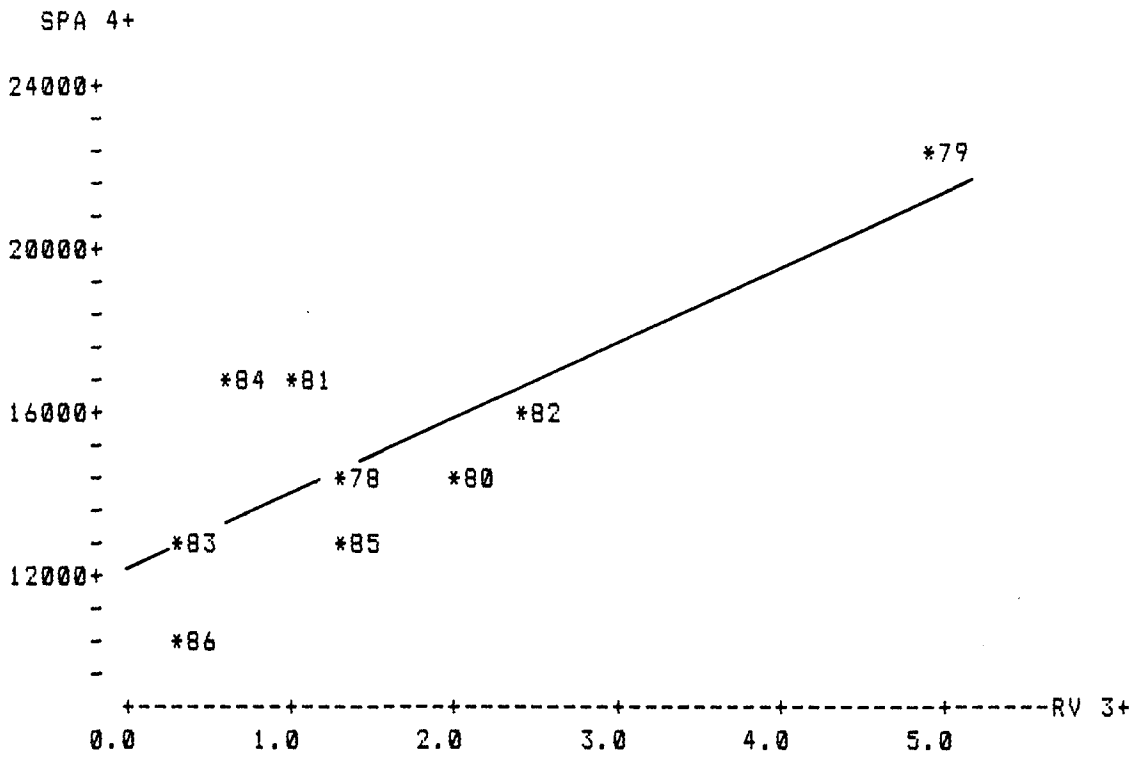


Figure 10. Commercial catch rates (t/day fished) of Atlantic cod from USA tonnage class 3 and 4 otter trawlers fishing on Georges Bank (NAFO Subdivision 5Ze), 1965-1986, compared with NMFS spring and autumn offshore bottom trawl survey harvestable biomass (age 2+) catch per tow indices, 1963-1985. Commercial USA catch rates are presented for all otter trawl trips landing cod and for trips in which cod comprised 50% or more of the trip catch, by weight. (from Serchuk, unpublished)



SPA 4+ = 12143 + 1930 RV 3+

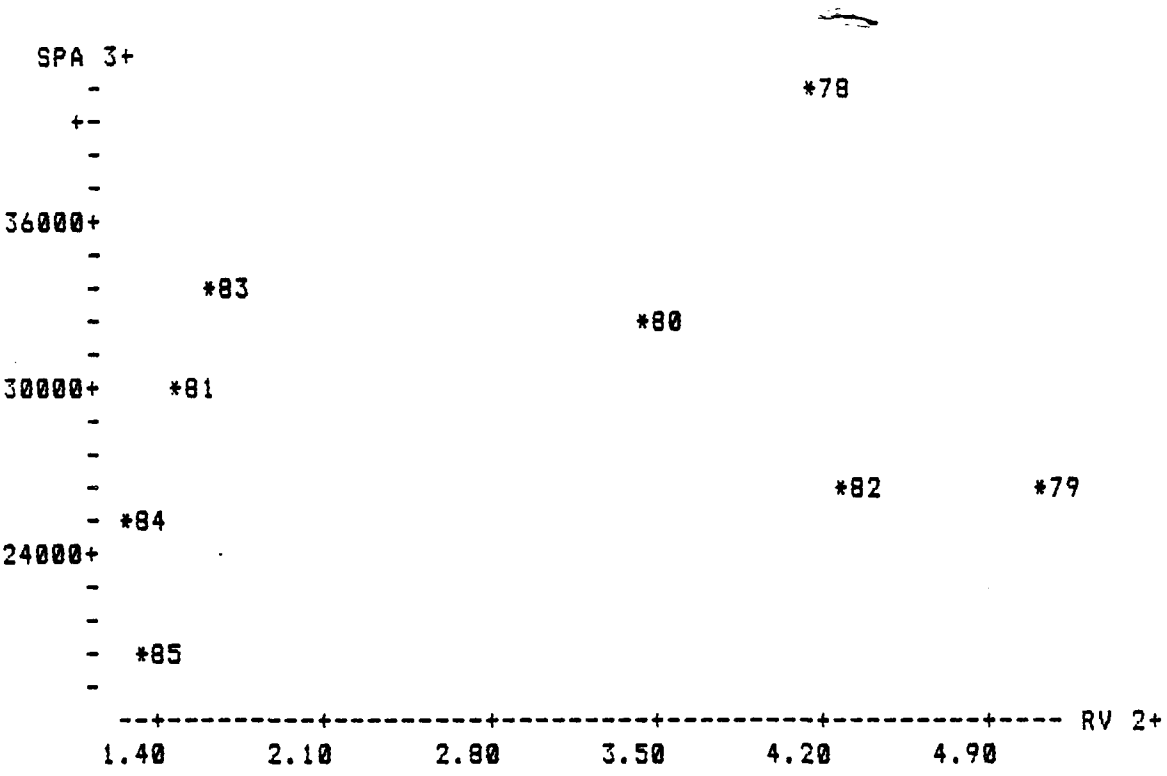
R-sq = 66.5% R-sq(adj) = 61.7%

Analysis of Variance

SOURCE	DF	SS	MS
Regression	1	63096048	63096048
Error	7	31793588	4541941
Total	8	94889632	

Obs.	RV 3+	SPA 4+	Fit	Stdev.Fit	Residual	St.Resid
78	1.33	14187	14704	722	-517	-0.26
79	4.93	22633	21669	1879	964	0.96
80	2.02	14245	16048	747	-1803	-0.90
81	1.01	16589	14094	768	2495	1.26
82	2.44	16034	16847	839	-813	-0.41
83	0.27	13165	12666	981	499	0.26
84	0.60	16668	13301	872	3367	1.73
85	1.26	12687	14573	729	-1886	-0.94
86	0.32	10460	12766	962	-2306	-1.21

Figure 11. Regression of SPA 4+ numbers on US fall survey 3+ numbers, lagged by one year, with Ft set to 0.45 for NAFO Division 5Ze cod.



SPA 3+ = 26227 + 1075 RV 2+

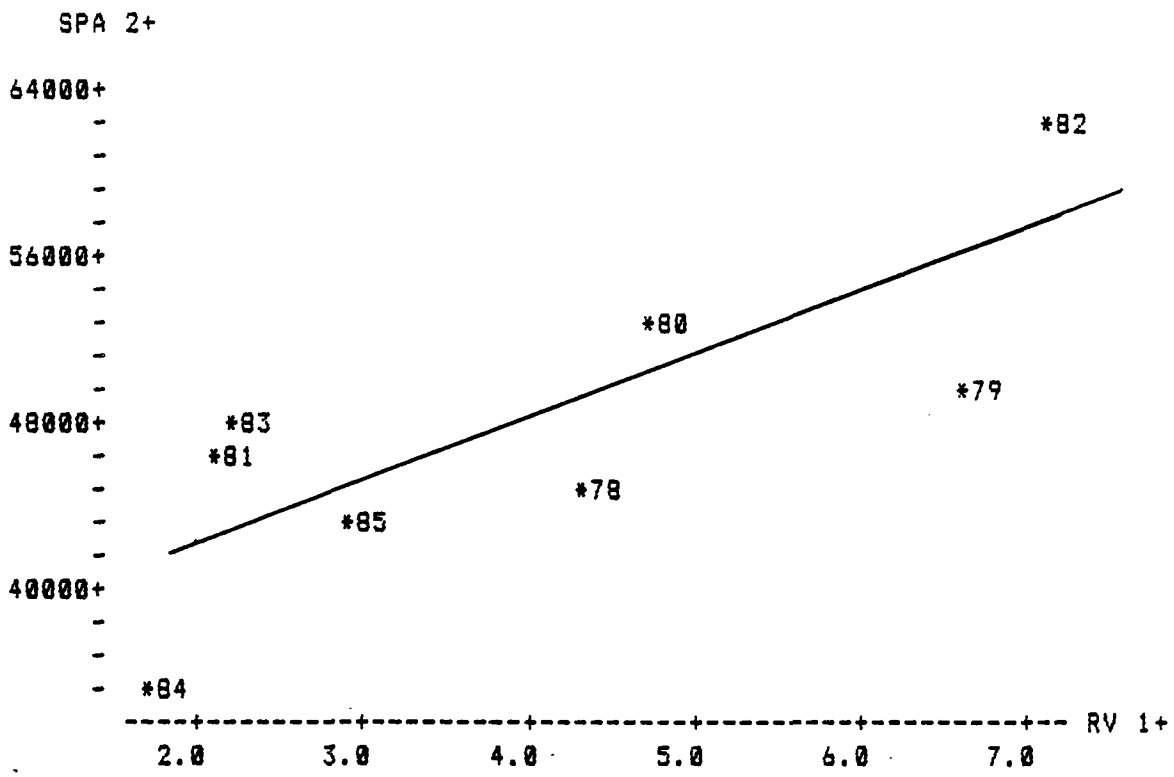
R-sq = 7.6% R-sq(adj) = 0.0%

Analysis of Variance

SOURCE	DF	SS	MS
Regression	1	20149408	20149408
Error	6	245599296	40933216
Total	7	265748704	

Obs.	RV 2+	SPA 3+	Fit	Stdev.Fit	Residual	St.Resid
1	4.10	40389	30638	2995	9751	1.72
2	5.14	26147	31752	4210	-5605	-1.16
3	3.42	31838	29897	2437	1941	0.33
4	1.47	29791	27805	3069	1986	0.35
5	4.26	26771	30807	3159	-4036	-0.73
6	1.61	33669	27960	2925	5709	1.00
7	1.25	25442	27575	3300	-2133	-0.39
8	1.32	20037	27649	3223	-7612	-1.38
9	1.13	*	27437	3446	*	*

Figure 12. Regression of SPA 3+ numbers on US fall survey 2+ numbers, lagged by one year, with Ft set to 0.45 for NAFO Division 5Ze cod.



SPA 2+ = 36695 + 2865 RV 1+

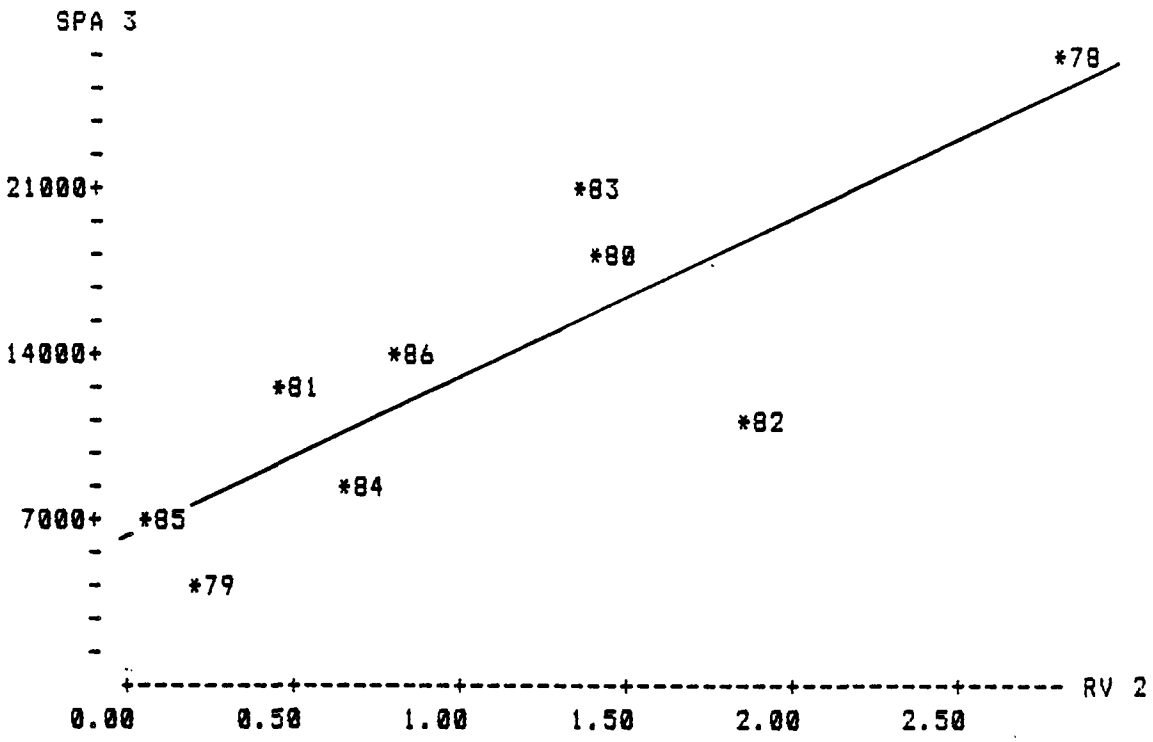
R-sq = 60.5% R-sq(adj) = 54.0%

Analysis of Variance

SOURCE	DF	SS	MS
Regression	1	252695712	252695712
Error	6	164673888	27445648
Total	7	417369600	

Obs.	RV 1+	SPA 2+	Fit	Stdev.Fit	Residual	St.Resid
1	4.30	45118	49008	1879	-3890	-0.80
2	6.65	49975	55742	3140	-5767	-1.38
3	4.73	52060	50249	1989	1811	0.37
4	2.13	46502	42807	2533	3695	0.81
5	7.12	62757	57106	3513	5651	1.45
6	2.17	48681	42925	2506	5756	1.25
7	1.67	35858	41481	2849	-5623	-1.28
8	2.92	43440	45074	2096	-1634	-0.34
9	1.35	*	40552	3088	*	*

Figure 13. Regression of SPA 2+ numbers on US fall survey 1+ numbers, lagged by one year, with Ft set to 0.45 for NAFO Division 5Ze cod.



SPA 3 = 6497 + 6591 RV 2

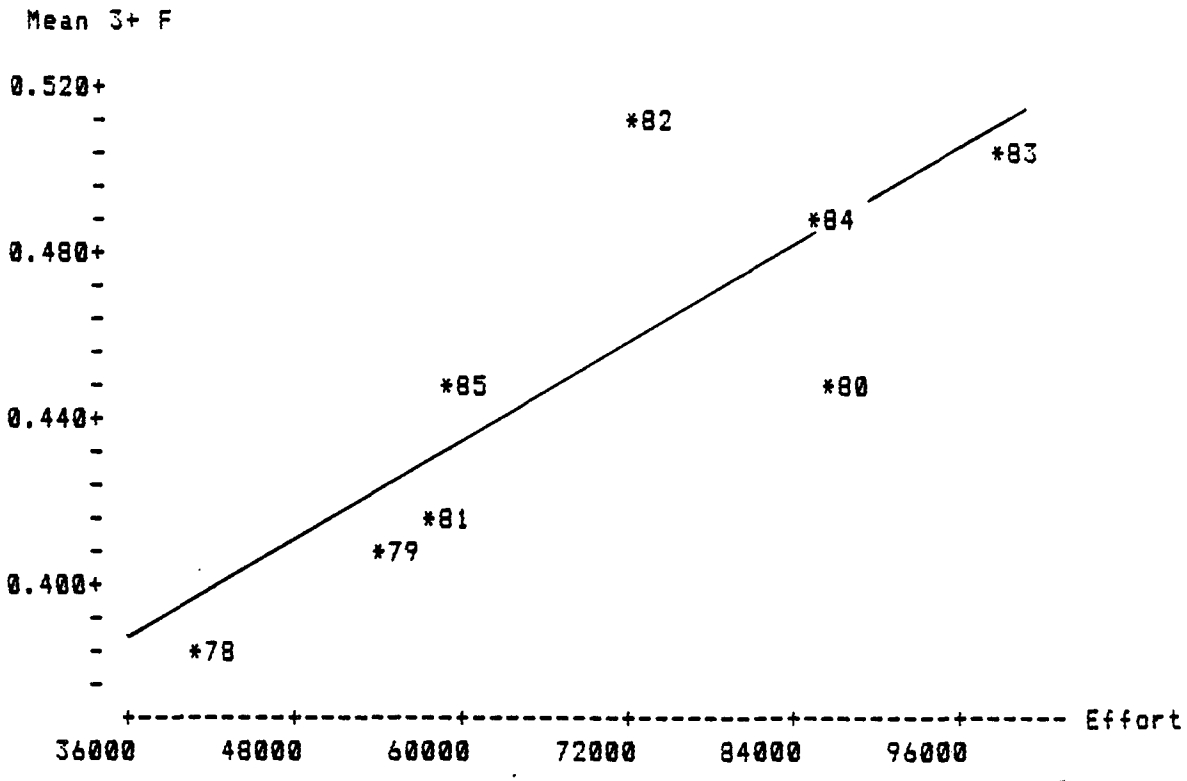
R-sq = 66.4% R-sq(adj) = 61.7%

Analysis of Variance

SOURCE	DF	SS	MS
Regression	1	262317056	262317056
Error	7	132443760	18920536
Total	8	394760832	

Obs.	RV 2	SPA 3	Fit	Stdev.Fit	Residual	St.Resid
1	2.78	26202	24807	3371	1395	0.51
2	0.21	3514	7862	2091	-4348	-1.14
3	1.39	17593	15678	1566	1915	0.47
4	0.46	13203	9516	1798	3687	0.93
5	1.83	10736	18532	1987	-7796	-2.01R
6	1.34	20504	15342	1534	5162	1.27
7	0.65	8774	10814	1616	-2040	-0.51
8	0.06	7350	6926	2279	424	0.11
9	0.80	13392	11790	1519	1602	0.39

Figure 14. Regression of SPA 3 numbers on US fall survey 2 numbers, lagged by one year, with Ft set to 0.45 for NAFO Division 5Ze cod.



Mean 3+ F = 0.316 +0.000002 Effort

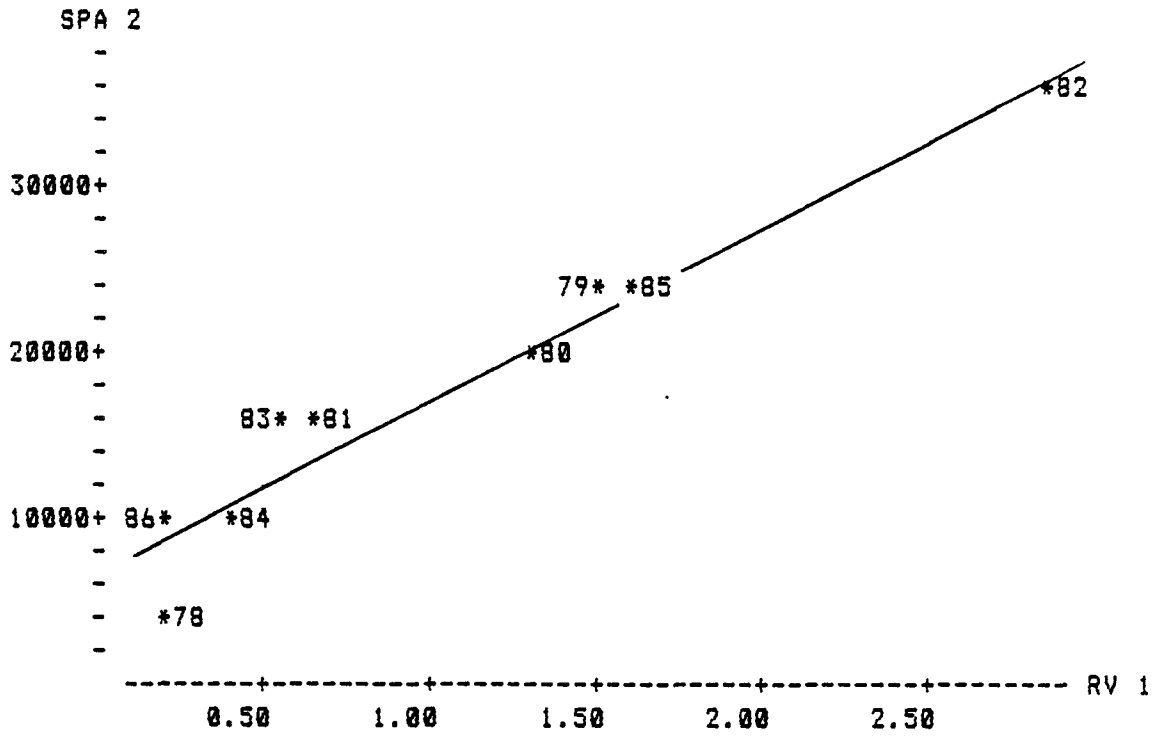
R-sq = 65.6% R-sq(adj) = 59.9%

Analysis of Variance

SOURCE	DF	SS	MS
Regression	1	0.010248	0.010248
Error	6	0.005376	0.000896
Total	7	0.015623	

Obs.	Effort	3+ F	Fit	Stdev.Fit	Residual	St.Resid
1	40768	0.3840	0.3961	0.0196	-0.0121	-0.54
2	54520	0.4080	0.4230	0.0136	-0.0150	-0.56
3	86443	0.4490	0.4854	0.0145	-0.0364	-1.39
4	57736	0.4170	0.4293	0.0125	-0.0123	-0.45
5	71891	0.5130	0.4569	0.0107	0.0561	2.01R
6	98293	0.5050	0.5085	0.0198	-0.0035	-0.16
7	85553	0.4880	0.4836	0.0142	0.0044	0.17
8	58687	0.4500	0.4311	0.0122	0.0189	0.69
9	*	*	*	*	*	*

Figure 15. Regression of mean 3+ F on standardized total effort for NAFO Division 5Ze cod with Ft set to 0.45



SPA 2 = 6933 + 10482 RV 1

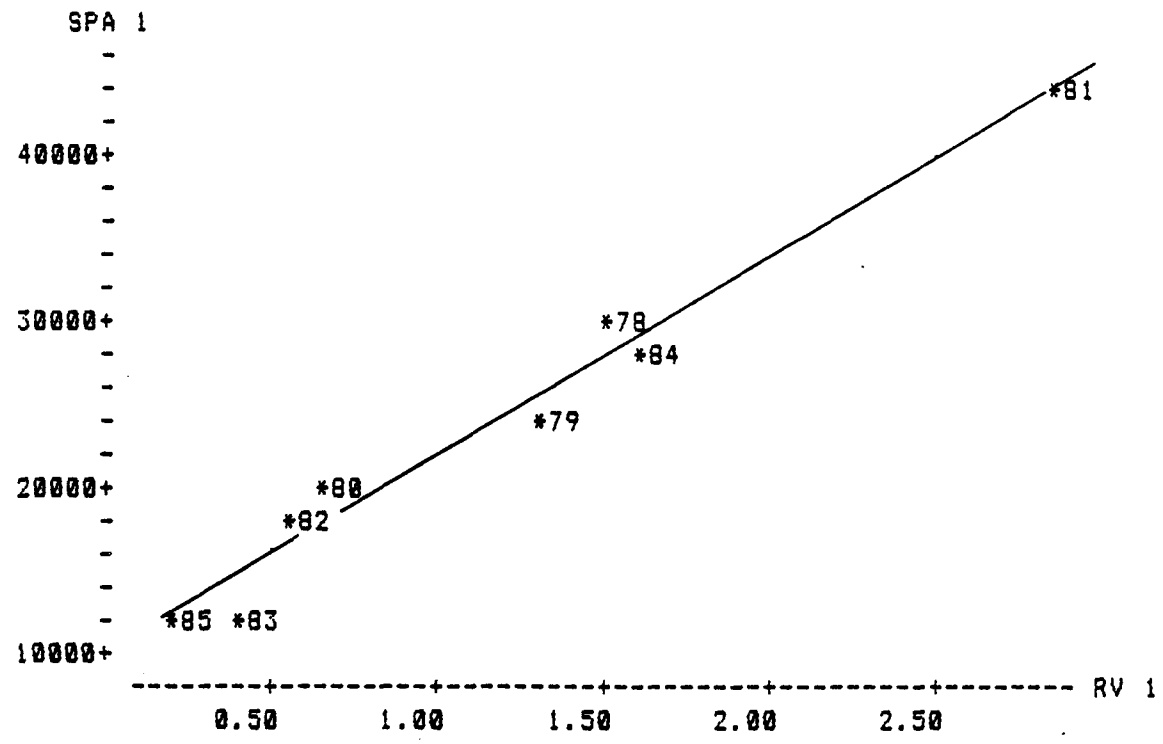
R-sq = 95.1% R-sq(adj) = 94.4%

Analysis of Variance

SOURCE	DF	SS	MS
Regression	1	666924800	666924800
Error	7	34177032	4882433
Total	8	701101824	

Obs.	RV 1	SPA 2	Fit	Stdev.Fit	Residual	St.Resid
1	0.19	4729	8946	1057	-4217	-2.17R
2	1.50	23828	22709	848	1119	0.55
3	1.31	20221	20707	777	-486	-0.23
4	0.66	16711	13893	809	2818	1.37
5	2.86	35987	36912	1793	-925	-0.72
6	0.56	15012	12814	851	2198	1.08
7	0.41	10416	11283	924	-867	-0.43
8	1.60	23403	23704	893	-301	-0.15
9	0.22	9900	9239	1039	661	0.34

Figure 16. Regression of SPA 2 numbers on US fall survey 1 numbers, lagged by one year, with Ft set to 0.45 for NAFO Division 5Ze cod.



SPA 1 = 10365 + 11802 RV 1

R-sq = 97.7% R-sq(adj) = 97.3%

Analysis of Variance

SOURCE	DF	SS	MS
Regression	1	733669504	733669504
Error	6	17320308	2886718
Total	7	750989824	

Obs.	RV 1	SPA 1	Fit	Stdev.Fit	Residual	St.Resid
1	1.50	29106	28127	658	979	0.62
2	1.31	24736	25873	614	-1137	-0.72
3	0.66	20509	18202	697	2307	1.49
4	2.86	43984	44119	1406	-135	-0.14
5	0.56	18703	16986	739	1717	1.12
6	0.41	12828	15263	807	-2435	-1.63
7	1.60	28674	29248	690	-574	-0.37
8	0.22	12240	12962	909	-722	-0.50
9	*	*	*	*	*	*

Figure 17. Regression of SPA 1 numbers on US fall survey 1 numbers, without lag, with Ft set to 0.45 for NAFO Division 5Ze cod.

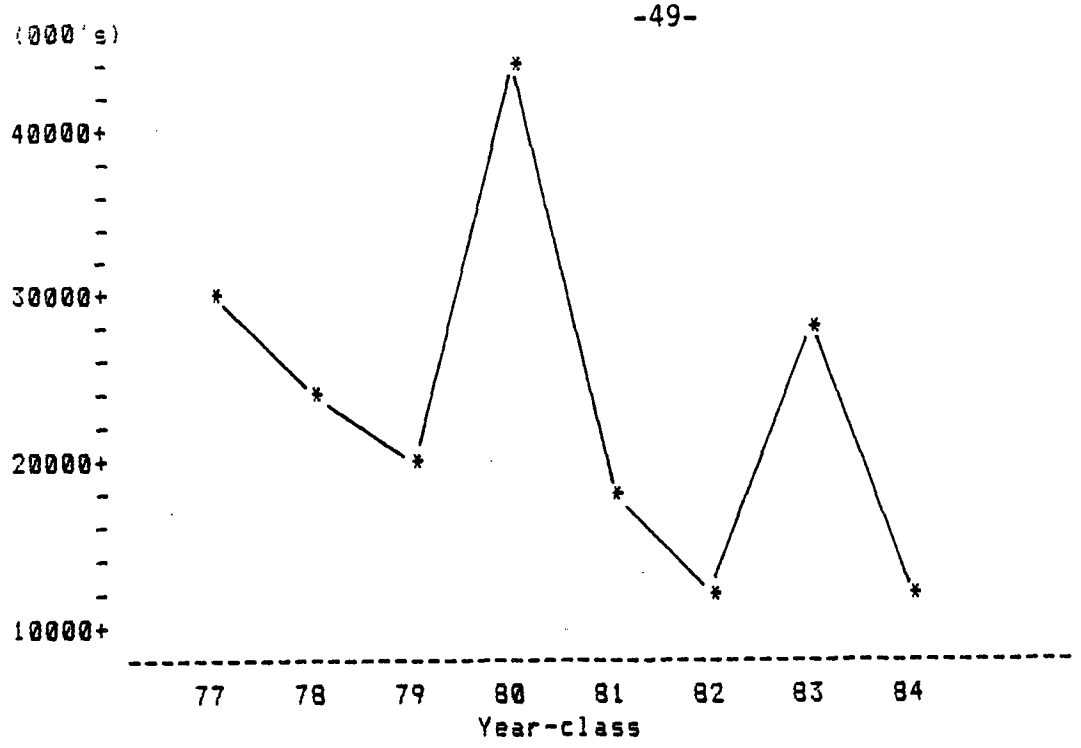


Figure 18. Estimated recruitment at age 1 for the 1977-84 year-classes with a fully recruited fishing mortality of 0.45 in 1985

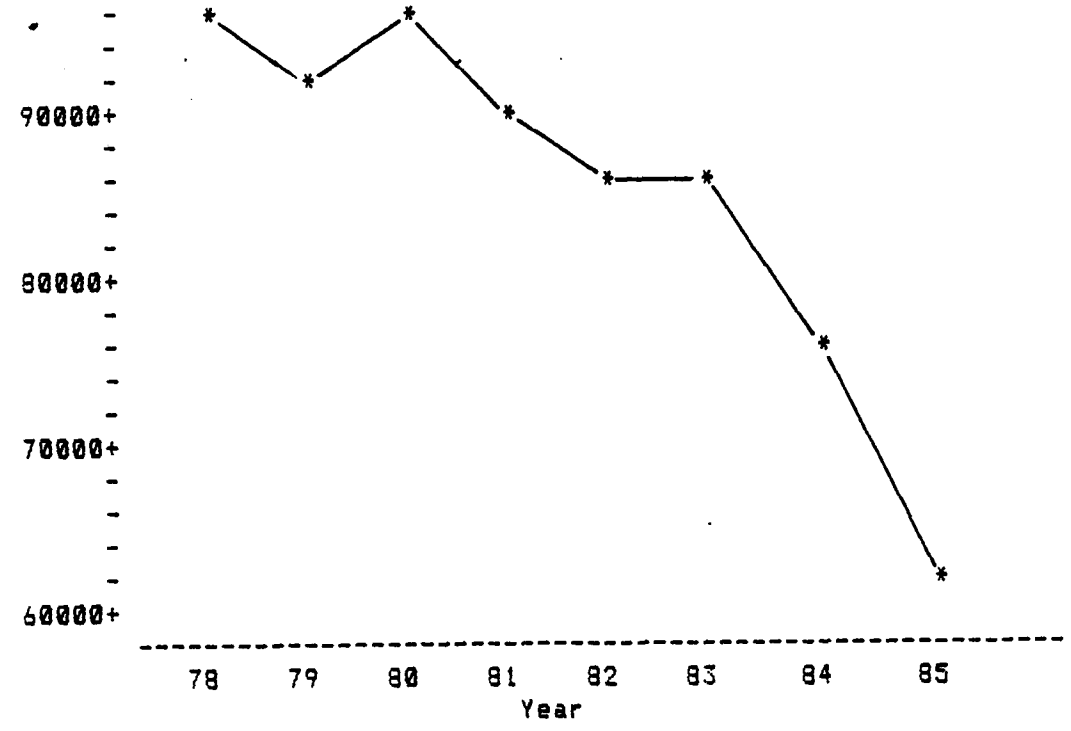


Figure 19. Estimated 3+ biomass (t) for 1978-85 with a fully recruited fishing mortality of 0.45 in 1985.