Not to be cited without permission of the authors[1]

Ne pas citer sans autorisation des auteurs[1]

Canadian Atlantic Fisheries Scientific Advisory Committee

Comité scientifique consultatif des pêches canadiennes dans l'Atlantique

CAFSAC Research Document 85/87

CSCPCA Document de recherche 85/87

Status of the Atlantic Cod Stock on Georges Bank, NAFO Division 5Z and Statistical Area 6, 1984

by

J.J. Hunt and K.G. Waiwood
Marine Fish Division
Fisheries and Oceans
St. Andrews, N.B. E0G 2X0

[1] This series documents the scientific basis for fisheries management advice in Atlantic Canada. As such, it addresses the issues of the day in the time frames required and the Research Documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research Documents are produced in the official language in which they are provided to the Secretariat by the author.

[1] Cette série documente les bases scientifiques des conseils de gestion des pêches sur la côte atlantique du Canada. Comme telle, elle couvre les problèmes actuels selon les échéanciers voulus et les Documents de recherche qu'elle contient ne doivent pas être considérés comme des énoncés finals sur les sujets traités mais plutôt comme des rapports d'étape sur les études en cours.

Les Documents de recherche sont publiés dans la langue officielle utilisée par les auteurs dans le manuscrit envoyé au secrétariat.

Abstract

Status of the Atlantic cod stock in Division 5Z and Statistical Area 6 is reviewed incorporating 1984 data. Total catch in 1984 was 39000 tons and Canadian catch was 6000 t, the lowest levels since 1980 and 1976, repectively. Catch rates also showed a decline in most gear components and research surveys were unchanged from the low 1983 levels. Sequential population analysis was carried out on the catch-at-age matrix for 1976-84 and indicated a fishing mortality of 0.6 in 1984 which is well above both the F 0.1 and F max levels. Projection of the 1986 catch with fishing at the F 0.1 level gives a yield of about 11000 t. Size of recruiting year-classes will have a substantial impact on future catches form this stock.

Résumé

On a fait le point sur l'état du stock de morue de l'Atlantique dans la Division 5Z et la zone statistique 6 en ajoutant les données de 1984. Les prises totales en 1984 ont été de 39 000 tonnes, dont 6 000 t de prises canadiennes, montants les plus bas depuis 1980 et 1976 respectivement. Les prises ont aussi chuté pour la plupart des engins de pêche, et les indices des relevés des croisières de recherche sont restés inchangés par rapport aux faibles niveaux de 1983. Une analyse séquentielle de la population portant sur la matrice des prises par âge de 1976 à 1984 a indiqué une mortalité par pêche de 0,6 en 1984, ce qui est bien au-dessus des niveaux $F_{0,1}$ et F_{max}. Les prises de 1986, en supposant un niveau $F_{0,1}$ par pêche, sont estimées à environ 11 000 t. La taille des classes d'âge de recrutement influera beaucoup sur les futures prises dans ce stock.

...../ 3

Introduction

The size of the cod population in NAFO Division 5Z and Statistical Area 6 (Fig. 1) was first evaluated by Brown and Heyerdahl (1972) through the examination of research survey data and commercial catch rates. Serchuck 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 (Serchuck 1979, 1980, 1981, 1982). Catches since 1977, when foreign fleets were subject to 200 mile jurisdiction by the USA, are thought to be more reliable and the amount of mis- or under-reporting is assumed to be nominal for the period 1978-84. There were no reported landings by foreign fleets since 1978.

Hunt and Waiwood (1984), in a review of stock status, suggested a probable 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.

The present report considers the catch data from 1978-84 and subjects these data to sequential population analysis (SPA) and attempts to estimate 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 were provided by the National Marine Fisheries Service (NMFS) through Dr. Frederic Serchuck 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 Statistical Area 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 48888 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.

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.

Canadian catches of cod are confined to the "northeast peak" of Georges Bank (NAFO unit areas 5ZEj and 5ZEm) and occur from April through November. Landings have been dominated by otter trawlers until 1984 (Table 3, Fig 3). This gear took 70% of the total catch in 1982, fell to 57 % in 1983 and was at a low level of 737 t in 1984. Catches of longliners increased from about

...../ 4

30% of the total in 1982 to about 85% in 1984. A trend for smaller TC 2 and 3 vessels to operate in this fishery has also been noted in recent years.

Preliminary Canadian catches from quota reports in 1985 show an increase in otter trawl catches to about 5500 t at the end of August and about 1300 t by longline.

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 (Table 3). Only 7 samples, all from longline gear, were taken in 1984 although total catch was less than 6000 t. From 400-800 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 and quarter and market category for USA landings.

Age Composition of the Commercial Catch

Estimated removals at age prior to 1978 given by Serchuck (1977) are probably under-estimated and are not considered reliable because of suspected under-reporting of catches by foreign fleets. Catch composition of USA commercial landings for 1978-84 were provided by NMFS.

Numbers at age estimated by O'Boyle (1983) were based on otter trawl samples only and as a result the data were re-analysed to take into consideration samples from longline gears. Age composition was estimated by gear and quarter and summed to annual totals for 1978-84. In some cases it was necessary to combine gears and/or quarters were sampling was inadequate. Percent at age from Canadian landings is given in Table 4. Total removals, in thousands of fish, by Canada and the USA are given in Table 5.

Commercial catch sampling by Canada included observation of weight for both round and gutted fish. A total of over 1500 measurements were taken from 1982-84 and these data used to regress length on weight. The resultant relationship gave an a=0.0000163 and b=2.9048 with gutted weight in kilograms and length in centimeters. This compares to values of a=0.000008104 and b=3.0521 for USA autumn surveys. Data from the surveys have not been modified since 1977 and were used to estimate numbers in the USA catch. The Canadian length weight relationship was assumed to be a better estimate of the commercial fishery and was used to estimate the Canadian removals at age for 1978-84. A comparison of calculated weight at age using the two values for a and b is given in Table 6 and summarized in Figure 4. In the central part of the commercial length range, the USA parameters estimate a higher gutted weight at length. Mean weight and length at age for combined Canadian and USA commercial catches are given in Tables 7 and 8.

Age groups 2-5 account for most of the yield but a difference in the age composition between Canada and USA is apparent (Fig 5). USA catches show

...../ 5

a higher proportion at age 2 in all years and in recent years this age group has accounted for more than twice the percentage taken by Canada at age two. These differences in age composition may be related to interpretation of otoliths and there appears to be a tendency for Canada to age fish older relative to USA ages at the same length. Differences in spatial, temporal length distribution of catches between countries may also be factors. An exchange of ageing material and discussion between USA and Canadian age readers has been initiated in an attempt to resolve this discrepancy. Pending results of this study, it was assumed that the best estimate of catch at age was derived from the sum of the independent USA and Canadian values and these data were therefore used as the input for SPA.

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 survey added in 1968. A summer survey was conducted from 1977 to 1981. One survey in Division 5Ze was completed by Canada in March, 1984. 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". Based on the peak season for the commercial fishery, the spring survey is assumed to be a current year index of abundance versus the autumn survey from the previous year.

The spring survey has shown a steady decline in 0+ numbers since 1981 and was at the lowest observed level in 1984 but increased to the second highest level since 1974 in the preliminary 1985 survey results. The autumn survey has also shown a steady decline since 1981 but appears to have leveled off in the 1984 survey. Serchuck (pers. comm.) notes that catches of all species were anomalously low in the 1982 autumn survey which may indicate a change in availability and this may also be a factor in the 1983 survey.

Commercial Catch Rates

Catch rates for Canadian TC 4 and 5 otter trawlers, landing cod as the primary species during July-September, are given in Table 11, Fig. 7. Rates were relatively stable at about 0.25 t/hour from 1970-76 and then increased by a factor of about three in 1977. Side trawlers were not used in 1983 and 1984. Rates for the TC 5 stern trawlers were stable in 1981-83 at a level of about 0.8 t/hour but fell to 0.28 in 1984 which corresponds to a tenfold decrease in otter trawl catch from 1983 to 1984. However, the decline in catch and CPUE may reflect a decision by industry not to deploy

...../ 6

vessels in the Georges Bank area. Discussions with Port Samples indicate that otter trawlers experienced low catches early in the spring and did not return to the area during the historical peak of the fishery when rates may have been higher. The low level of fishing effort would be a factor in the 1984 catch rates.

An index of CPUE in t/1000 hooks fished for TC 2 and 3 longliners landing >50% cod is shown in Table 12 for 1972-84. A decline in recent years, from the 1979 high of 0.69, is apparent, but the rate in 1982-84 has been stable with no change between 1983 and 1984.

Unpublished data on USA catch rates were provided by Serchuck and are reproduced in Table 13, Fig. 8. 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.

Survey Index of Recruitment

Indices of recruitment were obtained from the autumn survey catch per tow at ages 0, 1 and 2 for the 1962-83 year-classes. The catch per tow at age was normalized to the mean of the 1962-84 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 14 and summarized in Figure 9. The 1966, 1971 and 1975 are dominant, the 1980 year-class is above average, the 1981 and 1982 below average, and the 1983 year-class the highest since the 1975 year-class. The high 0+ catch in the 1985 spring survey may also indicate a strong 1985 year-class at age 0, although results by age group are not yet available.

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 co-efficients for ages 0 to 3, for the 1975-83 year-classes, are shown in Table 15.

Estimation of Current Stock Status and Fishing Mortality

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 16. Numbers at 4+/numbers at 5+ from spring surveys in five time intervals and numbers at 3+/numbers at 4+ from autumn surveys in the same five 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.

Additional estimates of Z were derived by taking the mean of the between year values for the same group of cohorts. For spring surveys, the 1983 4+ and 1982 3+ to the 1984 5+ and 1983 4+ were used and for the autumn survey the 1981 3+ and 1980 2+ to the 1984 5+ and 1983 4+ were included. The spring survey mean was 0.753 and the autumn 0.909 and the geometric mean of both surveys was 0.83 and a derived mean F of 0.63.

The overall mean estimate of total instantaneous mortality from surveys was calculated to be 0.86 and the resultant F was 0.66, assuming natural mortality of 0.2.

Sequential Population Analysis (SPA)

Based on resultsg Z estimated from survey data, SPA runs were made with terminal F set to 0.5-0.70 in 1984. Numbers at age 1-9+ in the catch from 1978-84 were input and F on the oldest age group with incomplete fishing (age 8) set to the mean of ages 3-7 as was the F on the plus age group. Population numbers at age 3 from each SPA were regressed on autumn numbers at age 2, lagged by one year. The mean 3+ F from each SPA was regressed on indices of CPUE.

Regression of SPA 3 numbers on autumn survey 2 numbers gave the best overall relationship at an F of 0.6 in 1984 and indicated full recruitment at age three. Correlation between the variables was 0.79 and the 1984 point was close to the predicted value.

Regression of SPA 3+ numbers on autumn survey 2+ numbers, lagged by one year, did not indicate good correlation (< 0.1) and could not be used to distinguish between SPA runs.

Regression of effective effort (total catch/CPUE) on mean SPA 3+ F identified the best overall relationship as total CPUE by USA otter trawlers with F set at 0.6 and correlation of 0.83.

Regression plots of the numbers and fishing mortality are given in Figures 10-11. The relationships produced both negative and positive residuals for 1980-83 and it is unlikely that further resolution of terminal F is possible and a value of 0.6 was selected for 1984.

Estimation of Partial Recruitment in 1984

Population numbers at age 1 and fishing mortality from the SPA run with terminal F set at 0.6 in 1984 were used to determine partial recruitment in 1984. Proportion of the maximum observed F for ages 1-6 was determined from the converged part of the F matrix for 1978-84 and the normalized mean was 0.004 at age 1, 0.355 at age 2 and full recruitment at ages 3+.

Assuming full recruitment to the survey gear by age one, the catch-at-age matrix from the survey was divided into the commercial catch-at age matrix to estimate partial recruitment. The autumn survey indicated a normalized vector of 0.003 at age 1, 0.326 at age 2, 0.722 at age 3 and 1.000 at age 4, while the spring survey indicated 0.049, 0.826 and 1.000 for ages one, two and three. The spring survey can be used in this instance since there is no within year effect of gear changes.

...../ 8

A further calculation was made by estimating size of the 1983 year-class at age 1 in 1984 from the relation of SPA numbers at age 1 and the survey catch-at-age 1. Numbers at age 1 from the SPA run with terminal F set at 0.6 in 1984 regressed on the autumn 0+1 index predicted 40679 with an R-squared of 0.75. The autumn catch-at-age 0, lagged by one year, showed poor correlation and could not be used. However, the autumn survey at age 1, without lag, gave an R-squared of 0.98 and a predicted value of 27521 for the 1983 year-class and can be used since the effect of fishing at age 1 appears to be small. The two estimates were averaged with the geometric mean number at age 1 from SPA for 1978-82 to obtain a value of 30158 for the 1983 year-class. This value was input in the catch equation to calculate the F required to take the 1984 age 1 catch and the proportion of the fully recruited F (0.6) determined to be 0.005.

Estimates of the 1982 year-class at age 2 in 1984 were made from the regression of SPA numbers at age 2 and autumn survey at age 1, lagged by one year, with an R-squared of 0.90. Predicted size of the 1982 year-class was 11298. This value was used to calculate the F required to take the 1984 catch-at-age 2 and the proportion of the fully recruited F determined to be 0.226. Regression plots of the relationships are given in Figures 12-14.

Results of each estimate are given in Table 17 and the geometric mean, normalized to one, gave a vector of 0.007, 0.383, 0.924, 1.000 0.742 and 0.759 for ages 1-6, indicating a dome-shaped recruitment curve. Mean length by age 6 is >85 cm and fish of this size may be less aggregated and therefore not as available to the commercial fishery as younger and smaller age-groups. However, full recruitment at age 3 was assumed and the historical recruitment pattern finalized as 0.008, 0.415 and 1 for ages 1, 2 and 3+.

Partial recruitment in 1984 was estimated from SPA with terminal F set at 0.6. Regression of SPA numbers at age 2 on autumn survey numbers at age 2, lagged by a year, indicated the best overall relationship at a fishing mortality of 0.135 on age 2 in 1984 and a resultant partial recuitment of 0.225. Similarily, partial recruitment at age 1 was determined from regression of SPA numbers at age 1 on autumn survey numbers at age 1 and gave an F at age one of .004 in 1984 and a partial recruitment of .0062.

Final SPA Run

Population number, biomass and fishing mortality were calculated from SPA using a fully recruited F in 1984 of 0.6 and a partial recruitment vector of 0.0062, 0.225, and 1 for ages 1, 2 and 3+ in 1984. Results are given in Tables 18 to 23.

Fishing mortality increased from a 3+ mean of 0.400 to a high of 0.609 in 1983 and averaged to 0.584 for 1982-84. Cumulative fishing mortality was above 2.0 for most age groups by 1980. An estimate of partial F for Canadian catches was calculated by division of the percent of the total catch-at-age taken by Canada into the F matrix given in Table 20. Results are given in Table 24 and indicate low fishing mortality for the Canadian catches.

...../ 9

Estimated 1+ population numbers ranged from 70-80 million from 1978-82 but fell to about 55 million in 1983 and 1984, reflecting the small size of the 1982 year-class at age 1 and 2. Numbers at age 3+ were 21 million in 1984, the lowest in the series, but the size of the 1981 year-class is a dominant factor. Similar results are apparent in the estimate of population biomass and the 3+ biomass was below 90000 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 1981 year-class.

Beginning of year estimates for 1985 were obtained by applying the 1984 fishing mortality and using the 1978-82 geometric mean recruitment of 22600 for the 1984 year-class at age 1 in 1985. Average mean weight at age for 1982-84 was used to calculate biomass. Results are summarized as follows:

Age Group	Population	
	Number	Biomass
1	22600	23707
2	19631	32568
3	8106	19747
4	3702	13481
5	3537	19139
6	881	6014
7	601	5420
8	518	5100
9+	374	4256
1+	59952	129432
3+	17721	73157

and indicate further reduction of both 3+ numbers and 3+ biomass from 1984. However, the 1+ numbers and biomass remain at about the 1984 level but are dependent on size of the recruiting 1983 and 1984 year-classes. Trends in mean 3+ fishing mortality and 3+ biomass for 1978-84 are shown in Figures 15 and 16.

Yield per Recruit Analysis

Mean weight at age for the combined USA and Canadian commercial catch data for 1982-84 and the mean partial recruitment vector derived from the 1982-84 SPA fishing mortality were used in the Thompson and Bell model.

Input data were as follows:

Age	Partial Recruitment	Mean Weight
1	0.016	0.936 kg
2	0.488	1.517
3	1.000	2.598
4	1.000	3.640
5	1.000	5.188
6	1.000	6.563
7	1.000	8.804
8	1.000	10.151
9	1.000	11.632
10	1.000	14.023
11	1.000	16.381
12	1.000	19.135
13	1.000	22.353
14	1.000	26.122
15	1.000	30.502
16	1.000	35.631

Results are summarized in Table 25 and indicate an F 0.1 of 0.150 and an F max of 0.262. With a maximum yield per recruit of 1.810 kg and geometric mean recruitment at age one of 22600 thousand fish, the long term yield from this stock is about 41000 t.

The Fishery in 1985

Preliminary Canadian quota reports indicate a catch of 5586 t by otter trawl and 1308 t by longline at the end of August for a total of 6894 t. Catches by small TC 2 and 3 otter trawlers account for 5149 t or about 75% 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 3 from longliners. Ageing for these samples has not yet been completed, but the estimated catch length frequency of the Canadian catch was calculated and is shown in Figure 17. Fish between 40-55 cm accounted for about 57% of the total catch at length and probably indicate strong contribution by the age-groups 2 and 3 and the 1983 year-class.

Anecdotal information from Port Technicians indicated high catch rates for the TC 2 and 3 vessels and the cod appeared to be well aggregated while feeding on sand lance. A total of 12 samples from these small vessels indicated days fishing per trip ranged between and 1 and 3 days with an average of 2.25 days. Vessels landed between 9 and 36 tons per trip and averaged 24576 kg round weight.

Catch Projection for 1986

...../11

No estimates of the total catch in 1985 are available and a value of 40000 t was assumed for illustrative purposes. Mean weight at age and partial recruitment for 1982-84 were used and a catch of 40000 t taken from the 1985 beginning of year population. A fully recruited F of 0.65 was required to take this catch and resulted in a catch in numbers of about 13 million fish of which the 1983 year-class accounted for 38 percent. The 1986 population was then fished at an F0.1 of 0.15 and gave an estimated yield of 10600 t in 1986. Results of the projection are given in Table 26.

Recent levels of fishing mortality on this stock have exceeded both the F0.1 and Fmax and substantial growth overfishing has occurred. Present stock biomass is at a low level and it is likely that some reduction in fishing mortality will be required to allow stock re-building. Catches from this stock are dependent on the size of recruiting year-classes and the apparent average size of the 1983 and possible below average 1984 year-class will have a substantial impact on catches in 1986.

....

References

Brown, B.E., and E.G. Heyerdahl. 1972. An assessment of the Georges Bank cod stock (Div. 5Z). ICNAF Res. Doc. 72/117

Hunt, J.J. and K.G. Waiwood. 1984. Status of the Atlantic Cod Stock on Georges Bank, NAFO Division 5Z and Statistical Area 6, in 1983. CAFSAC Res. Doc. 84/65.

Serchuck, F.M., R.S. Rak and J. Pentilla. 1982. Status of the Georges Bank and Gulf of Maine Atlantic cod stocks -1982. Natl. Mar. Fish. Serv., Northeast Fish. Centre, Lab. Ref. Doc. 82/33: 46p.

Serchuck, F.M. and P.W. Wood, Jr. 1981. Assessment and status of the Georges Bank and Gulf of Maine Atlantic cod stocks. Natl. Mar. Fish. Serv., Northeast Fish. Center, Lab Ref. Doc. 81/06: 66p.

Serchuck, F.M., P.W. Wood and B.E. Brown. 1978. Atlantic cod assessment and status of the Georges Bank and Gulf of Maine stocks. Natl. Mar. Fish. Serv., Northeast Fish. Center, Lab. Ref. Doc., 78/03, January 1978.

Serchuck, F.M., P. Wood, S.H. Clark and B.E. Brown. 1977. Assessment of the Georges Bank and Gulf of Maine cod stocks. Natl. Mar. Fish. Serv., Northeast Fish. Center, Lab. Ref. Doc. 77/24: 42p

Serchuck, F.M., P.W. Wood, Jr, and D.M Freid. 1980. Current assessment and status of the Georges Bank and Gulf of Maine Atlantic cod stocks. Natl. Mar. Fish. Serv., Northeast Fish. Center, Lab. Ref. Doc. 80/07: 52p

Serchuck, F.M., P.W. Wood, R. Lewis, J.A. Pentilla and B.E. Brown. 1979 Status of the Georges Bank and Gulf of Maine cod stocks. Natl. Mar. Fish. Serv., Northeast Fish. Center, Lab. Ref. Doc. 79/10: 32p

...../13

Table 1. Nominal catches (t, round) of Atlantic cod from Georges Bank and southward (NAFO Division 5Z and Statistical Area 6), 1960-84.

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	39334	17861	-	-	57195
1983	36757	12131	-	-	48888
1984 (c)	32915	5761	-	-	38676

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

...../14

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 Serchuck et al, 1982 and pers. comm.)

Landings (t, live)

Year	Otter Trawl	Line Trawl	Handline	Other Gear	Total
1965	10251	582	505	9	11347
1966	10206	787	757	19	11769
1967	10915	894	704	9	12522
1968	12084	936	524	1	13544
1969	13194	1371	387	1	14952
1970	11270	1676	404	1	13350
1971	12436	2334	230	2	15002
1972	10179	2071	217	10	12477
1973	12431	2185	206	24	14846
1974	14078	2548	11	12	16649
1975	12069	2435	84	4	14592
1976	12257	1519	153	9	13938
1977	18529	912	83	52	19576
1978	20862	1569	1180	140	23751
1979	26562	2707	860	779 a	30908
1980	32479	1102	-	4764 b	38345
1981	27694	120	584	3712 c	32110
1982	33371	385	624	3145	37525
1983	30981	831	441	1893	34146
1984	26161	366	753	2770	30050

a. Of 779 landed, 620 tons were by sinking gill nets
b. Of 4764 landed, 4491 tons were by sinking gill net, and 222 tons were by Danish seine
c. Of 3712 landed, 3513 tons were by sinking gill net, and 362 tons were by Danish seine

...../15

Table 3. Nominal catches (t, round) of Atlantic cod from Georges Bank (5Ze) by Canada, 1968-84. Number of biological samples taken shown in parenthesis.

Year	Gear					
	Otter Trawl		Longline		Other	Total
1968	7838	(3)	1263		24	9125
1969	5232	(3)	719		30	5981
1970	1879		683		19	2581
1971	2073		867		38	2978
1972	736	(2)	1776	(2)	35	2547
1973	1904	(1)	1291		21	3216
1974	475		897	(1)	1	1373
1975	927	(2)	918		-	1845
1976	1423	(2)	901	(1)	-	2324
1977	5520	(10)	644		4	6168
1978	7756	(28)	728		287	8771
1979	4630	(12)	1340		2	5972
1980	5407	(10)	2634		21	8062
1981	3971	(14)	2933	(3)	1602	8506
1982	12337	(6)	5126	(2)	398	17861
1983	6900	(13)	5175	(1)	56	12131
1984	737	(0)	4955	(7)	69	5761
1985 (a)	5586	(15)	1308	(3)	0	6894

(a) from Canadian quota reports to 04.09.85

...../16

Table 4. Age composition (percent by number) derived from biological samples of Atlantic cod from Georges Bank (5Ze) taken by Canadian vessels, 1975-84

	Year									
Age	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
1	-	-	-	-	-	-	0.1	0.1	0.5	-
2	8.9	16.9	87.3	2.1	24.9	27.7	7.4	32.0	9.7	1.8
3	44.6	39.9	9.7	66.6	27.1	41.4	30.3	25.2	38.6	9.3
4	38.5	33.3	1.8	20.6	32.0	7.6	25.3	15.7	31.6	27.6
5	6.9	6.5	0.4	6.1	12.1	16.5	7.1	14.0	8.0	29.5
6	0.3	2.8	0.5	2.2	2.5	4.4	20.7	3.2	6.3	15.2
7	0.3	0.4	0.1	1.6	0.8	1.0	4.6	5.9	1.8	8.6
8	0.2	0.1	0.1	0.4	0.4	0.4	2.7	2.2	2.0	2.4
9	0.1	-	0.1	0.3	0.1	0.6	1.0	0.7	1.1	2.6
10+	0.2	0.1	-	0.2	0.1	0.4	0.8	1.0	0.4	3.0
# Samples	2	3	10	28	12	10	17	8	14	7
# Aged	111	99	378	1364	591	536	791	341	601	412

...../17

Table 5. Removals at age (000's) by Canada and the USA for 1978-84

		Age Group								
		1	2	3	4	5	6	7	8	9	Total
1978	Cdn	1	67	2173	672	198	71	53	13	15	3263
	USA	-	331	5731	1636	625	53	288	35	36	8735
	Total	1	398	7904	2308	823	124	341	48	51	11998
1979	Cdn	-	521	566	669	253	53	17	9	4	2092
	USA	34	1618	572	4107	910	403	59	244	45	7992
	Total	34	2139	1138	4776	1163	456	76	253	49	10084
1980	Cdn	1	744	1105	205	442	117	28	12	29	2683
	USA	88	3002	4707	286	1888	951	413	76	153	11564
	Total	89	3746	5812	491	2330	1068	441	88	182	14247
1981	Cdn	2	143	585	490	138	401	88	53	34	1934
	USA	25	3060	3613	1960	101	1026	330	72	155	10342
	Total	27	3203	4198	2450	239	1427	418	125	189	12276
1982	Cdn	6	1584	1249	776	693	158	292	110	86	4954
	USA	325	7855	2466	1682	1258	117	452	116	107	14378
	Total	331	9439	3715	2458	1951	275	744	226	193	19332
1983	Cdn	19	353	1409	1153	291	229	67	72	54	3647
	USA	81	3542	5557	1244	854	722	85	218	150	12453
	Total	100	3895	6966	2397	1145	951	152	290	204	16100
1984	Cdn	-	19	98	290	310	160	90	25	59	1051
	USA	81	1281	3305	2961	500	393	386	25	235	9167
	Total	81	1300	3403	3251	810	553	476	50	294	10218

...../18

Table 6. Comparison of calculated gutted weight at age using Canadian and USA values for a and b.

Length	Canadian a=.0000163 b=2.9048	USA a=.000008104 b=3.0521
20 cm	0.098 kg	0.076 kg
25	0.187	0.150
30	0.318	0.261
35	0.498	0.418
40	0.734	0.629
45	1.034	0.900
50	1.404	1.242
55	1.852	1.661
60	2.384	2.167
65	3.008	2.766
70	3.731	3.468
75	4.559	4.281
80	5.499	5.213
85	6.558	6.273
90	7.742	7.469
95	9.059	8.809
100	10.514	10.301
105	12.115	11.956
110	13.868	13.780

...../19

Table 7. Commercial catch mean weight at age of cod in NAFO Division 5Z for Canadian and USA catches combined, in grams.

Year	1	2	3	4	5	6	7	8	9+	Mean
					Age Group					
1978	899	1290	2471	3692	4472	5197	7519	7935	12838	3043
1979	878	1522	2463	4301	4976	7306	9413	10273	12584	4085
1980	840	1490	2478	3988	5791	6705	8492	8861	8060	3464
1981	871	1501	2360	3389	5448	6459	9475	9956	14869	3273
1982	767	1395	2852	3845	5448	6459	9475	10320	12438	2736
1983	991	1497	2456	3435	4704	6406	7930	10290	11077	2952
1984	1049	1659	2436	3641	5411	6825	9008	9844	11380	3761

Table 8. Commercial catch mean length at age of cod in NAFO Division 5Z for Canadian and USA catches combined, in centimeters.

Year	1	2	3	4	5	6	7	8	9+	Mean
					Age Group					
1978	-	50.2	61.5	69.8	73.7	79.3	89.3	91.3	104.1	64.85
1979	44.6	52.9	61.0	73.9	77.5	88.2	95.3	99.5	104.7	70.87
1980	43.9	52.6	61.6	72.4	81.9	86.3	92.9	92.2	91.2	66.45
1981	44.6	52.3	60.4	68.5	78.4	88.7	93.1	98.2	118.0	64.61
1982	42.3	51.4	64.4	70.8	79.9	84.1	96.5	99.2	111.7	60.73
1983	46.3	52.7	61.5	68.1	75.9	84.5	90.7	99.1	107.9	63.27
1984	47.2	54.3	61.8	70.1	79.8	86.8	95.0	97.6	108.8	68.69

...../20

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, 1963-1985.

	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	-	.079	.350	1.141	.569	.289	.209	.138	.082	.046	.072	2.975	2.975	2.896	2.546	1.405	.836
1970	-	.244	.522	.308	.830	.104	.420	.176	.039	.087	.053	2.783	2.785	2.539	2.017	1.709	.879
1971	-	.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	.080	5.748	5.712	3.852	2.677	.984	.657
1973 a	.036	.334	7.464	1.403	1.628	.273	.201	.227	.032	.130	.249	11.927	11.941	11.607	4.143	2.740	1.012
1974	-	.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	-	.041	.242	1.309	1.982	.167	.440	.083	.060	.069	.025	4.418	4.418	4.377	4.135	2.826	.844
1976	.071	.834	1.232	.605	.443	1.008	.105	.168	.023	-	.035	4.524	4.453	3.619	2.387	1.782	1.339
1977	-	.018	2.261	.692	.335	.179	.466	.033	.042	-	.013	4.039	4.039	4.021	1.760	1.068	.733
1978	2.123	.241	.120	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	-	.069	8.467	8.223	6.354	4.799	2.544	1.191
1982	.120	.396	2.755	1.141	1.051	.843	.013	.242	.052	.013	.028	6.654	6.534	6.138	3.383	2.242	1.191
1983	.052	.211	1.261	1.954	.491	.447	.276	.035	.123	-	.087	4.937	4.885	4.674	2.720	1.459	.968
1984 f	-	.258	.296	.511	.744	.286	.272	.143	-	.100	.005	2.615	2.615	2.357	2.061	1.550	.806
1985 f												6.938					
Summer d																	
1977	.131	.195	5.121	1.111	.660	.164	.326	.051	.081	-	.026	7.866	7.735	7.540	2.419	1.308	.648
1978	.755	.350	.266	1.542	.369	.149	.057	.109	-	.028	-	3.625	2.870	2.520	2.254	.712	.343
1979	.236	1.459	1.767	.375	.943	.234	.050	.053	.115	-	.031	5.261	5.025	3.566	1.799	1.426	.483
1980	2.646	.640	4.135	2.371	.064	.415	.092	-	.031	-	-	10.394	7.748	7.108	2.973	.602	.538
1981	.024	3.347	1.657	1.224	.568	.035	.098	.048	-	-	-	7.001	6.977	3.630	1.973	.749	.181
Autumn b																	
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	-	.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	-	.021	.035	.035	.063	3.247	2.982	1.900	1.033	.697	.252
1971	.256	.386	.405	.250	.193	.305	.117	.027	.057	-	.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	-	.044	-	-	2.240	1.944	1.682	1.263	.288	.183
1975	1.524	.637	.270	.400	1.080	.072	.100	-	-	-	.024	4.107	2.583	1.946	1.676	1.276	.196
1976	-	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	-	.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	-	-	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 e	.205	.561	1.342	.141	.044	.062	-	.010	-	-	.014	2.379	2.174	1.613	.271	.130	.086
1983	.661	.415	.655	.510	.035	.030	.002	-	.008	-	.015	2.331	1.670	1.255	.600	.090	.055
1984 f	.119	1.600	.065	.568	.558	.011	.040	.025	.004	.025	.028	3.040	2.924	1.324	1.259	.691	.133

a. One anomalously large tow excluded from the calculation.

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, 19-20, 23-25. Summer survey in 1981 sampled strata 13, 16, 19-21, 23 and 25.

e. 1982 survey catches of most species anomalously low (pers. comm. Serchuck).
f. Preliminary

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) 1963-84.

	Spring a		Summer b		Autumn	
	Nos	Wgt (kg)	Nos	Wgt (kg)	Nos	Wgt (kg)
Year						
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	2.61f	9.5	-	-	3.04f	6.3
**********************						
1984 Cdn	5.83	24.4				
1985 USA	6.94	21.5				

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.

...../22

Table 11. Commercial catch rates (t/hr) of Atlantic cod for Canadian vessels fishing on Georges Bank (NAFO 5Ze), 1968-84. Directed effort (cod primary species) used in calculation.

Year	Side Otter Trawl TC 4, July-Sept			Stern Otter Trawl TC 5, July-Sept		
	Catch	Effort	t/hr	Catch	Effort	t/hr
1968	697	2215	0.315	317	897	0.353
1969	460	1402	0.328	571	1346	0.424
1970	106	546	0.194	169	650	0.260
1971	221	997	0.222	234	1065	0.220
1972	105	477	0.220	79	221	0.357
1973	394	1803	0.219	427	1423	0.300
1974	-	-	-	34	141	0.241
1975	5	36	0.139	132	472	0.280
1976	27	184	0.147	369	1505	0.245
1977	391	743	0.526	2428	2806	0.865
1978	190	365	0.521	683	993	0.688
1979	647	1686	0.384	258	530	0.487
1980	86	431	0.200	510	1012	0.504
1981	47	142	0.331	1296	1504	0.862
1982	53	143	0.371	3063	4027	0.761
1983	-	-	-	2230	2698	0.827
1984	-	-	-	42	148	0.284

Table 12. Commercial catch rates (t/1000 hooks) for TC 2 and 3 Canadian longliners with cod as primary species.

Year	Catch	CPUE
1972	80	0.374
1973	589	0.366
1974	498	0.292
1975	648	0.383
1976	639	0.414
1977	535	0.527
1978	544	0.534
1979	1110	0.687
1980	1185	0.610
1981	2153	0.536
1982	3591	0.429
1983	3373	0.498
1984	1884	0.496

...../23

Table 13. USA commercial landings and landings per day fished for otter trawl trips catching cod from Georges Bank (5Ze), 1965-84. (from unpublished data provided by Dr. F. Serchuck, NMFS, Woods Hole, Mass.)

Year	All Trips Landings	All Trips t/day Fished	50% Trips Landings	50% Trips 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

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

...../24

Table 14. Recruitment indices for Atlantic cod calculated from USA offshore autumn bottom trawl surveys on Georges Bank from 1962-84.

Year-class	Age Group 0 + 1	1 + 2
1962	-	0.396
1963	0.192	0.487
1964	0.326	0.632
1965	0.611	0.834
1966	3.029	2.352
1967	0.160	0.274
1968	0.165	0.513
1969	0.409	0.610
1970	0.626	0.558
1971	1.996	3.731
1972	1.523	0.631
1973	0.335	0.233
1974	0.777	0.899
1975	4.248	2.866
1976	0.073	0.175
1977	0.791	1.259
1978	1.078	0.724
1979	0.425	1.156
1980	1.492	1.746
1981	0.596	0.537
1982	0.528	0.189
1983	1.801	-

...../25

Table 15. Catch per tow at ages 0-3 for the 1973-84 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	*
83	*	*	*	*	0.661	1.600	*	*
84	*	*	*	*	0.119	*	*	*

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

...../26

Table 16. 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		Geometric Mean	
Time Period	Z	F	Z	F	Z	F
1964 - 67	-	-	0.73	0.53	0.73	0.53
1968 - 72 c	0.34	0.14	0.49	0.29	0.41	0.21
1973 - 76	0.70	0.50	0.56	0.36	0.63	0.43
1977 - 80	0.34	0.14	0.76	0.56	0.51	0.31
1981 - 83	0.74	0.54	0.98	0.78	0.85	0.65
1982 - 84	0.73	0.53	-	-	0.73	0.53

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.

...../27

Table 17. Estimates of partial recuitment pattern derived from USA survey results, fishing mortality from converged part of the F matrix and predicted size of year-classes based on an SPA run with terminal F set to 0.6 in 1984.

	Age Group					
Estimate	1	2	3	4	5	6
A.	0.049	0.826	1.000	1.000	0.743	0.861
B.	0.003	0.326	0.722	1.000	0.616	0.441
C.	0.004	0.355	0.958	0.850	0.775	1.000
D.	0.005	-	-	-	-	-
E.	-	0.250	-	-	-	-
Geometric mean	0.007	0.393	0.884	0.947	0.708	0.724
Normalized mean	0.007	0.412	0.924	1.000	0.742	0.759

A. - mean commercial catch-at-age divided by spring survey catch per tow at age for 1978-84.

B. - mean commercial catch-at-age n for 1978-84 divided by autumn survey catch per tow at age n-1 for 1977-83.

C. - mean proportion of the maximum F observed in the converged part of the F matrix.

D. - mean estimate of the number at age one in 1984 (see text) used to calculate F at age one in 1984 and PR derived from terminal F.

E. - mean estimate of the number at age two in 1984 (see text) used to calculate F at age two in 1984 and PR derived from terminal F.

...../28

Table 18. Catch in numbers (000's) by Canada and the USA for 1978-84

	YEAR						
AGE	1978	1979	1980	1981	1982	1983	1984
1	1.	34.	89.	27.	331.	100.	81.
2	398.	2139.	3746.	3203.	9439.	3895.	1300.
3	7904.	1138.	5812.	4198.	3715.	6966.	3403.
4	2308.	4776.	491.	2450.	2458.	2397.	3251.
5	823.	1163.	2330.	239.	1951.	1145.	810.
6	124.	456.	1068.	1427.	275.	951.	553.
7	341.	76.	441.	418.	744.	152.	476.
8	48.	253.	88.	125.	226.	290.	50.
9+	51.	49.	182.	189.	193.	204.	294.

Table 19. Estimate population in numbers (000's) with terminal F set to 0.6 in 1984.

	YEAR						
AGE	1978	1979	1980	1981	1982	1983	1984
1	28670.	23242.	19586.	38365.	17875.	13952.	24067.
2	4764.	23472.	18998.	15955.	31386.	14336.	11332.
3	25389.	3542.	17288.	12184.	10182.	17227.	8240.
4	7975.	13696.	1879.	8944.	6213.	5008.	7872.
5	2930.	4458.	6934.	1097.	5123.	2887.	1961.
6	621.	1660.	2605.	3588.	683.	2447.	1339.
7	1335.	397.	950.	1177.	1661.	314.	1153.
8	159.	787.	256.	384.	589.	695.	121.
9+	169.	152.	530.	580.	503.	489.	712.
1+	72013.	71405.	69026.	82274.	74215.	57354.	56797.
2+	43343.	48163.	49440.	43909.	56340.	43403.	32729.
3+	38579.	24691.	30442.	27954.	24954.	29066.	21397.

Table 20. Fishing mortality for 1978-84 with terminal F set to 0.6 in 1984.

	YEAR						
AGE	1978	1979	1980	1981	1982	1983	1984
1	.000	.002	.005	.001	.021	.008	.004
2	.097	.106	.244	.249	.400	.354	.135
3	.417	.434	.459	.474	.509	.583	.600
4	.382	.481	.338	.357	.566	.738	.600
5	.368	.337	.459	.273	.539	.568	.600
6	.248	.359	.594	.570	.579	.553	.600
7	.329	.236	.706	.492	.671	.752	.600
8	.400	.434	.471	.441	.544	.609	.600
9+	.400	.434	.471	.441	.544	.609	.600
3+ MEAN	.400	.434	.471	.441	.544	.609	.600

...../29

Table 21. Cummulative fishing mortality for 1978-84

Age	1978	1979	1980	1981	1982	1983	1984
				Year			
1	2.614	2.454	2.101	1.584	.974	.143	.004
2	3.073	2.614	2.452	2.096	1.583	.954	.135
3	3.807	2.976	2.508	2.208	1.847	1.183	.600
4	2.957	3.390	2.542	2.049	1.735	1.338	.600
5	2.418	2.575	2.909	2.204	1.692	1.168	.600
6	1.397	2.050	2.238	2.450	1.931	1.153	.600
7	1.234	1.149	1.691	1.644	1.880	1.352	.600
8	.835	.905	.913	.985	1.152	1.209	.600

Table 22. Catch biomass in tons by Canada and the USA for 1978-84

AGE	1978	1979	1980	1981	1982	1983	1984
				YEAR			
1	1.	29.	74.	24.	252.	98.	85.
2	499.	3172.	5522.	4898.	13062.	5794.	2158.
3	18991.	2731.	14250.	10093.	10511.	17000.	8295.
4	8286.	20012.	1937.	8459.	9376.	8182.	11845.
5	3579.	5638.	13350.	1327.	10544.	5352.	4386.
6	627.	3246.	7085.	9390.	1762.	6054.	3777.
7	2493.	697.	3705.	4035.	6993.	1198.	4291.
8	370.	2532.	772.	1268.	2314.	2965.	493.
9+	637.	601.	1451.	2863.	2381.	2245.	3348.
1+	35483.	38656.	48147.	42357.	57195.	48888.	38676.
2+	35482.	38627.	48073.	42333.	56943.	48790.	38591.
3+	34983.	35455.	42551.	37435.	43881.	42996.	36433.

Table 23. Estimated population biomass in tons with terminal F set to 0.6 in 1984

AGE	1978	1979	1980	1981	1982	1983	1984
				YEAR			
1	25062.	19880.	16278.	34044.	13601.	13739.	25263.
2	5976.	34803.	28007.	24399.	43434.	21325.	18813.
3	61005.	8498.	42387.	29294.	28806.	42041.	20085.
4	28630.	57388.	7414.	30881.	23698.	17094.	28679.
5	12741.	21609.	39727.	6090.	27686.	13494.	10619.
6	3137.	11814.	17280.	23609.	4379.	15579.	9144.
7	9762.	3638.	7978.	11365.	15608.	2470.	10389.
8	1230.	7874.	2248.	3891.	6034.	7104.	1193.
9+	2115.	1868.	4229.	8787.	6210.	5380.	8106.
1+	149659.	167372.	165549.	172360.	169457.	138227.	132290.
2+	124596.	147492.	149271.	138317.	155856.	124488.	107027.
3+	118620.	112689.	121264.	113918.	112421.	103163.	88215.

...../30

Table 24. Partial F for Canadian catches calculated from the total F at age and proportion of Canadian catch-at-age in numbers.

	Year						
Age	1978	1979	1980	1981	1982	1983	1984
1	.000	.000	.000	.000	.000	.002	.000
2	.016	.026	.048	.011	.067	.032	.002
3	.115	.216	.087	.066	.171	.118	.017
4	.111	.067	.141	.071	.179	.355	.054
5	.089	.073	.087	.158	.191	.144	.230
6	.142	.042	.065	.160	.333	.133	.174
7	.051	.053	.045	.104	.263	.331	.113
8	.108	.015	.064	.187	.265	.151	.300
9+	.118	.035	.075	.079	.242	.161	.182

Table 25. Yield per recruit analysis using 1982-84 mean weight at age and partial recruitment

Fishing Mortality	Yield	Average Weight	Yield per Recruit
.01	1.474	5.991	1.000
F 0.1-----.1500	1.693	5.309	.766
.20	1.783	4.771	.605
F max----.2623	1.810	4.254	.468
.30	1.804	4.003	.408
.40	1.758	3.500	.298
.50	1.701	3.154	.231
.60	1.648	2.903	.186
.70	1.601	2.714	.155
.80	1.561	2.566	.132
.90	1.526	2.448	.115
1.00	1.493	2.351	.101

Table 26. Catch projection for 1985 and 1986 assuming a catch of 40000 t in 1985 and fishing at F 0.1 in 1986. Geometric mean recruitment for 1978-84, 1982-84 mean weight at age and partial recruitment used.

Age	1985 Population Number (000's)	1985 Population Weight t	1985 Catch=40000 Number (000's)	1985 Catch=40000 Weight t	1986 F0.1 Catch Number (000's)	1986 F0.1 Catch Weight t	Mean Weight Kg	PR
1	22600	23707	213	200	49	46	0.936	.016
2	19631	32568	4891	7421	1173	1779	1.517	.488
3	8106	19747	3567	9269	1478	3840	2.598	1
4	3702	13481	1629	5930	436	1587	3.640	1
5	3537	19139	1557	8076	199	1034	5.188	1
6	881	6014	388	2545	190	1250	6.563	1
7	601	5420	265	2329	47	418	8.804	1
8	518	5100	228	2314	32	325	10.151	1
9+	374	4256	165	1915	28	324	11.632	1
1+	59952	129432	12904	40000	3634	10608		
3+	17721	73157	7800	32379	2412	8783		
F	-	-	-	0.650	-	0.150		

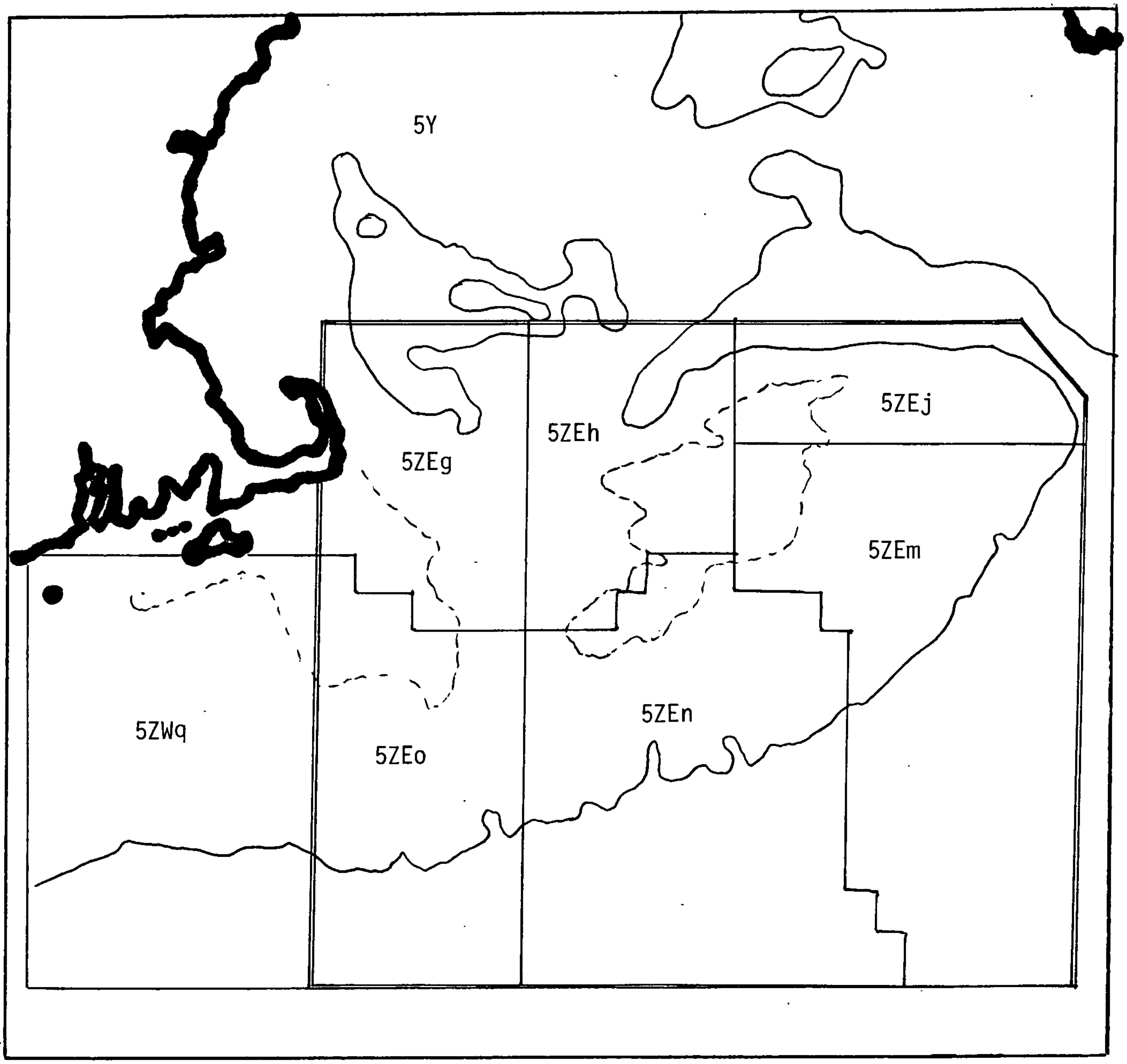

Figure 1. NAFO statistical areas for Georges Bank

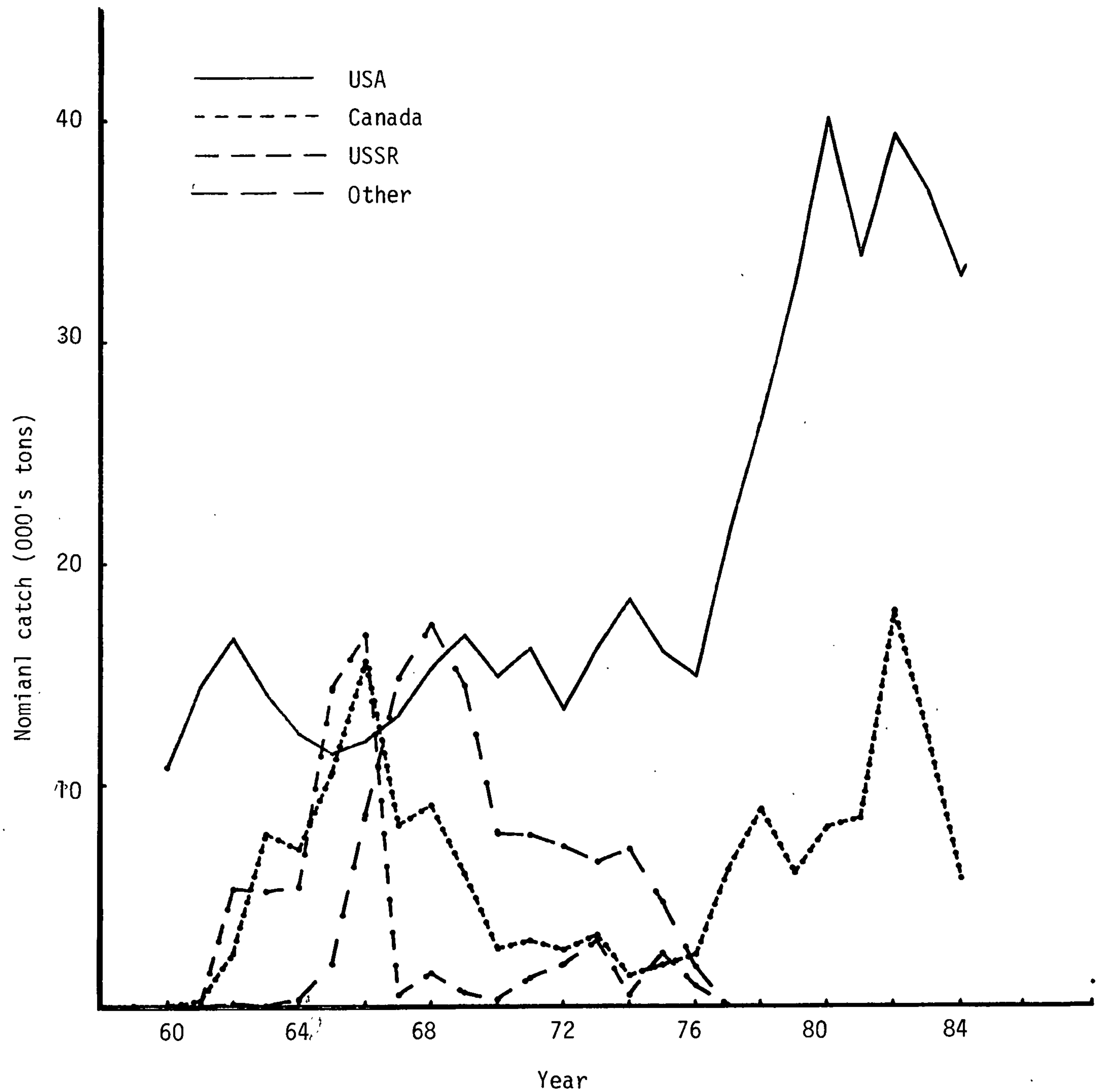

Figure 2 . Nominal catches of Atlantic cod from Georges Bank by country and year from 1960-84.

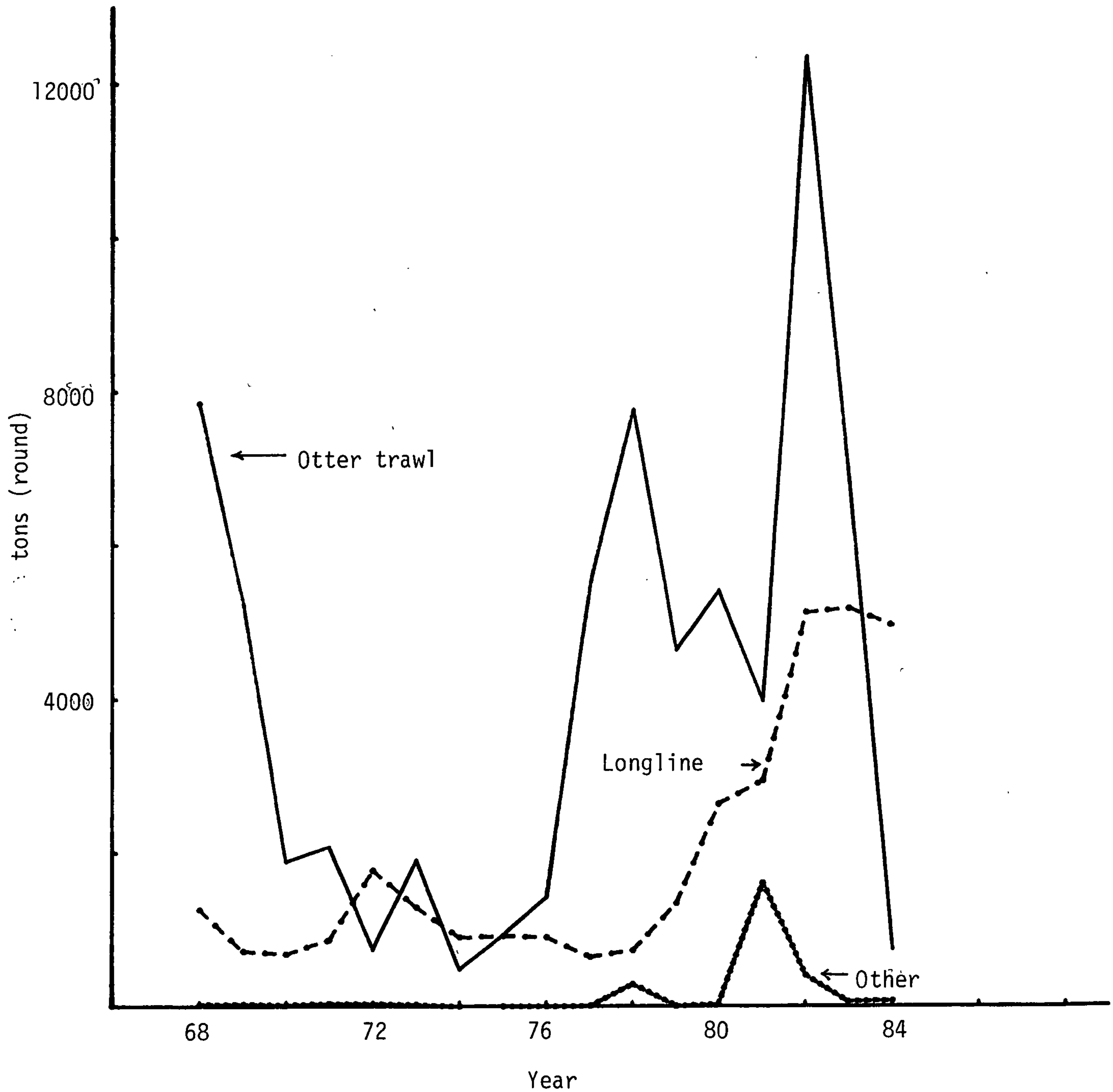

Figure 3 . Nominal catch of cod by Canadian gear on Georges Bank from 1968-84.

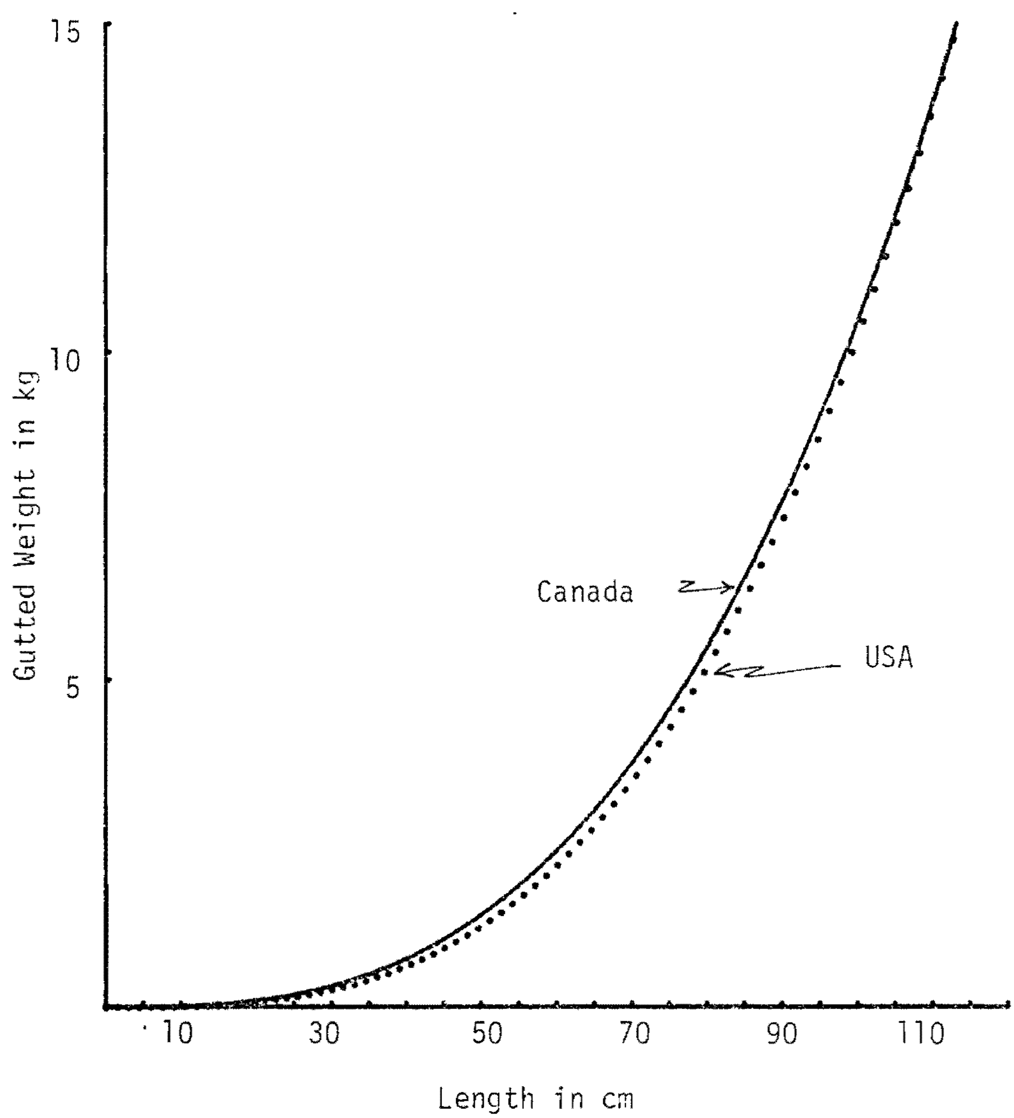

Figure 4. Comparison of calculated weight at length using Canadian and USA values for a and b.

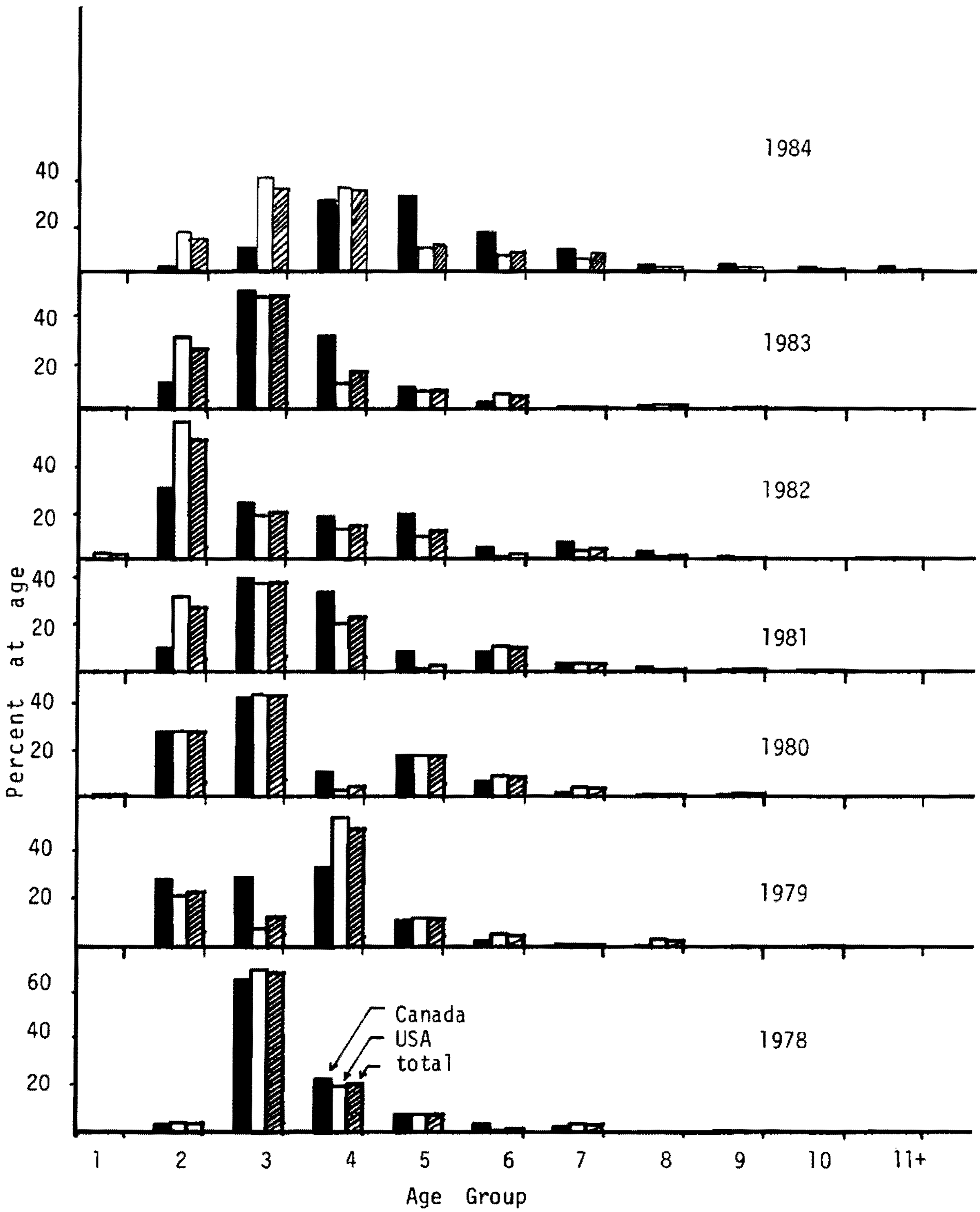

Figure 5 . Percentage catch at age of cod from Georges Bank by Canada and the USA from 1978-84.

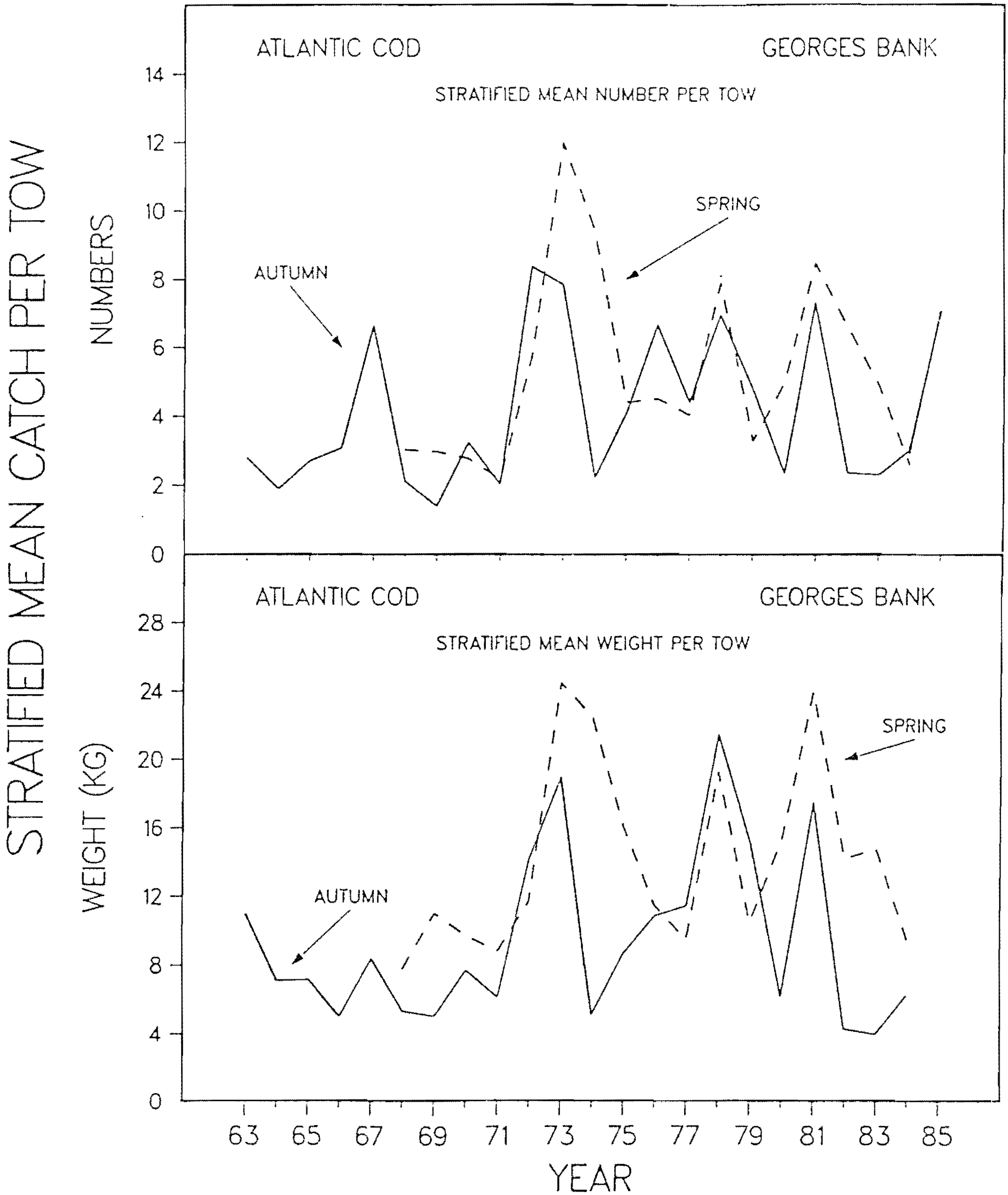

Figure 6. Stratified mean number per tow and stratified mean weight (kilograms) per tow of Atlantic cod in NEFC spring and autumn offshore bottom trawl surveys on Georges Bank (Strata 13-25), 1963-1984.

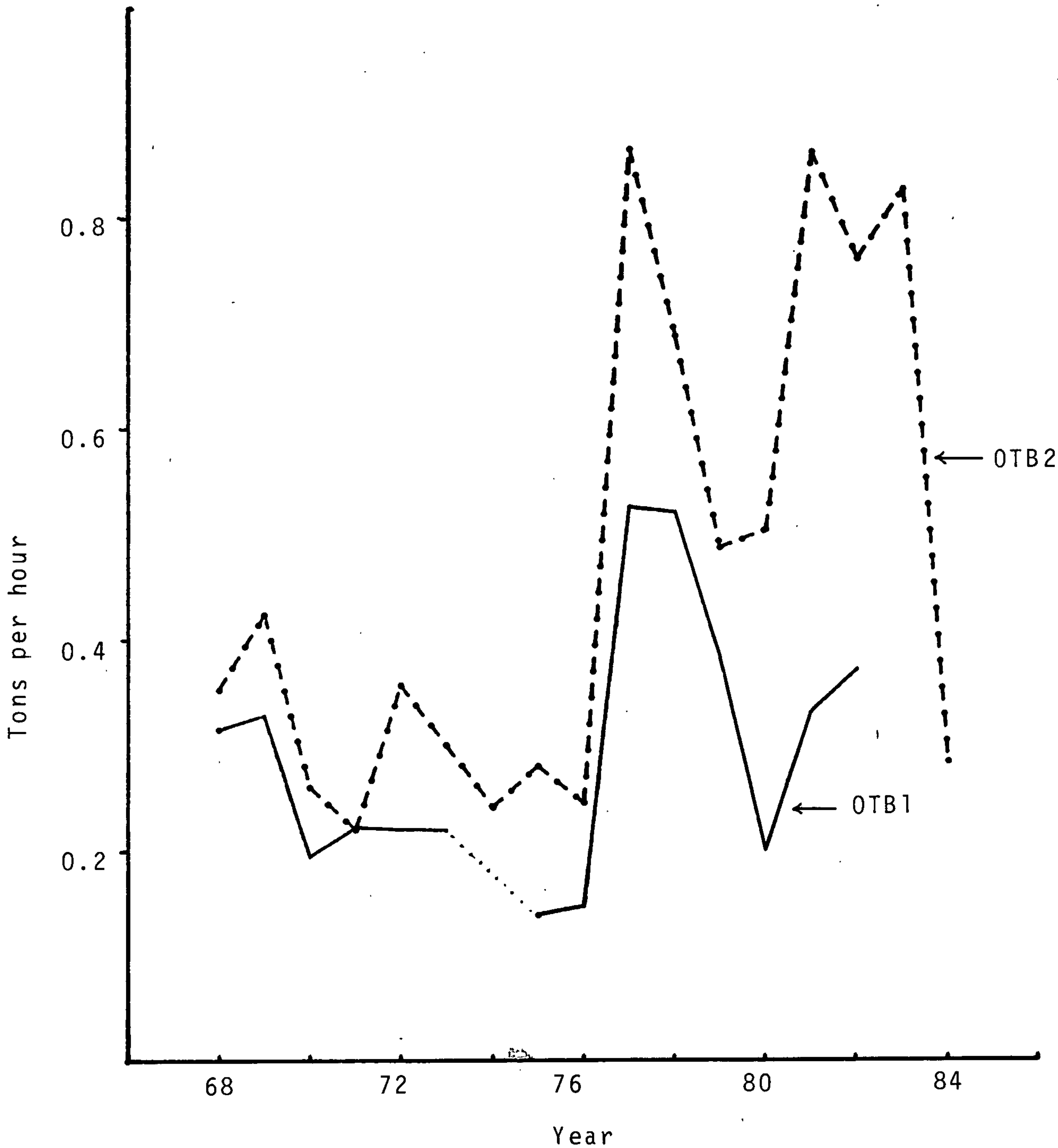

Figure 7 . Commercial catch rates (t/hr) of cod by Canadian side (OTB1) and stern (OTB2) otter trawlers. 1968-84.

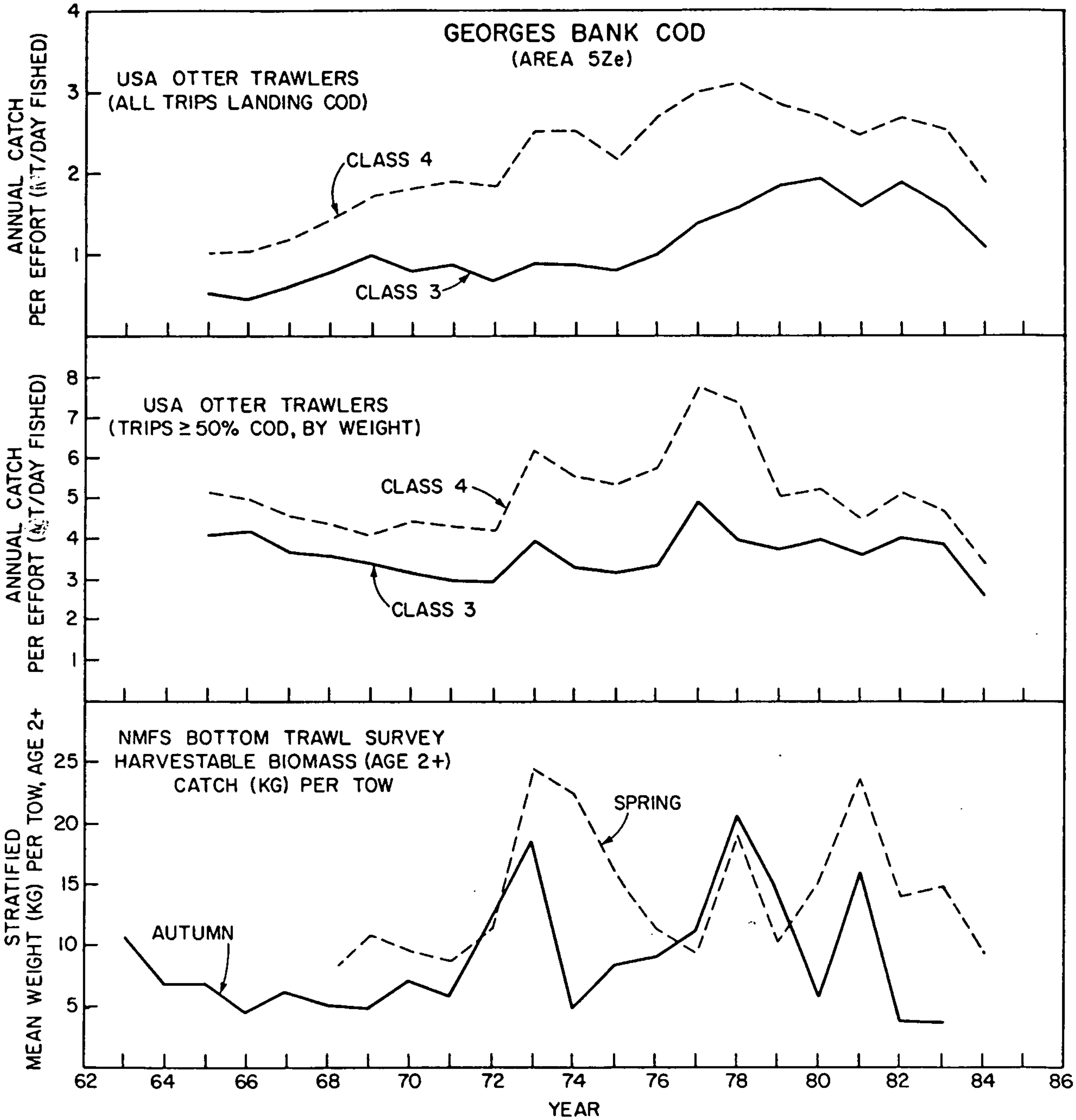

Figure 8. Commercial catch rates (mt/day fished) of Atlantic cod from USA tonnage class 3 and 4 otter trawlers fishing on Georges Bank (NAFO Subdivision 5Ze), 1965-1984, compared with NMFS spring and autumn offshore bottom trawl survey harvestable biomass (age 2+) catch per tow indices, 1963-1984. Commercial 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.

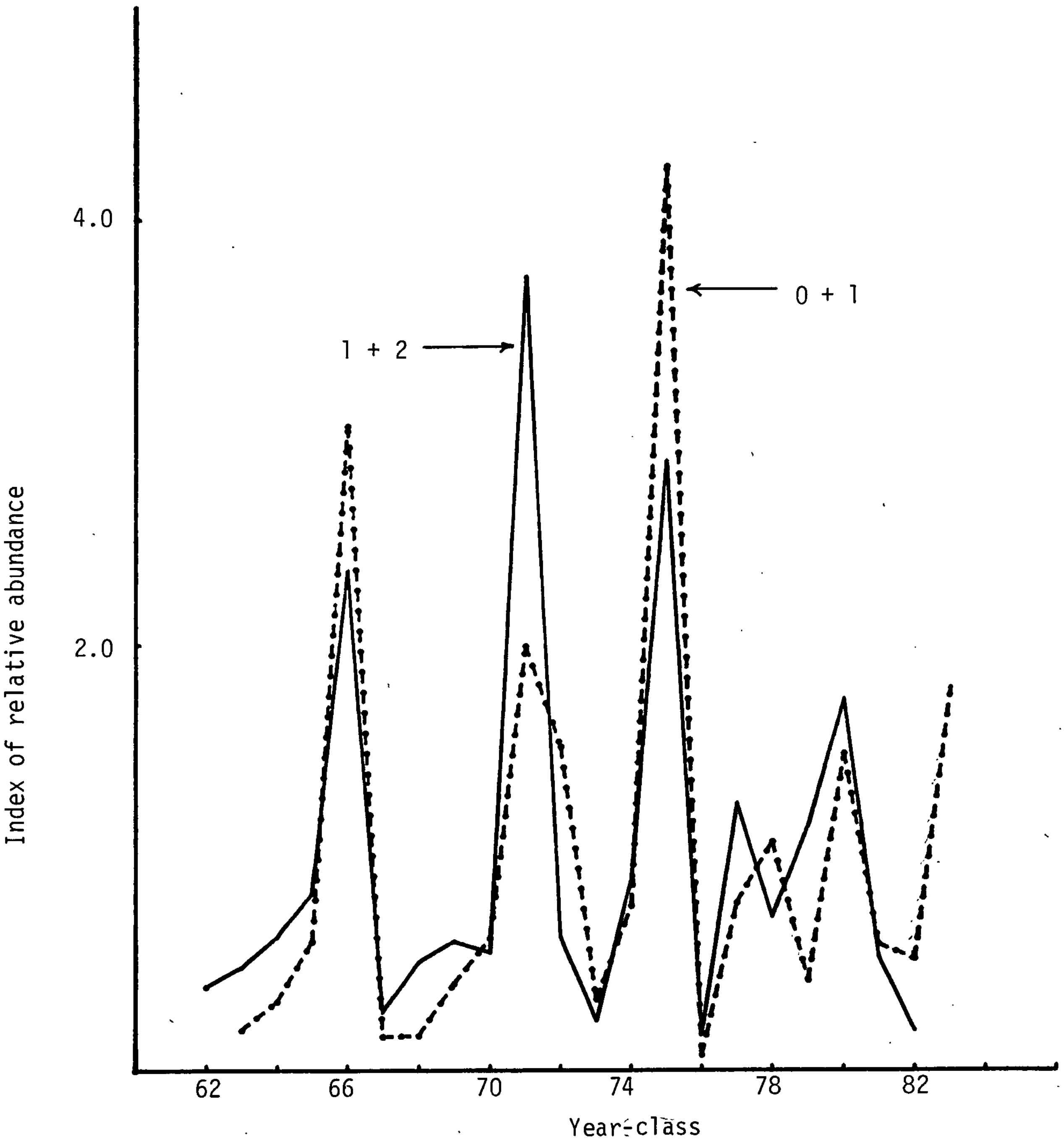

Figure 9. Index of relative abundance of cod at age groups 0 +1 and 1 +2 derived from USA research surveys for the 1962-83 year-classes.

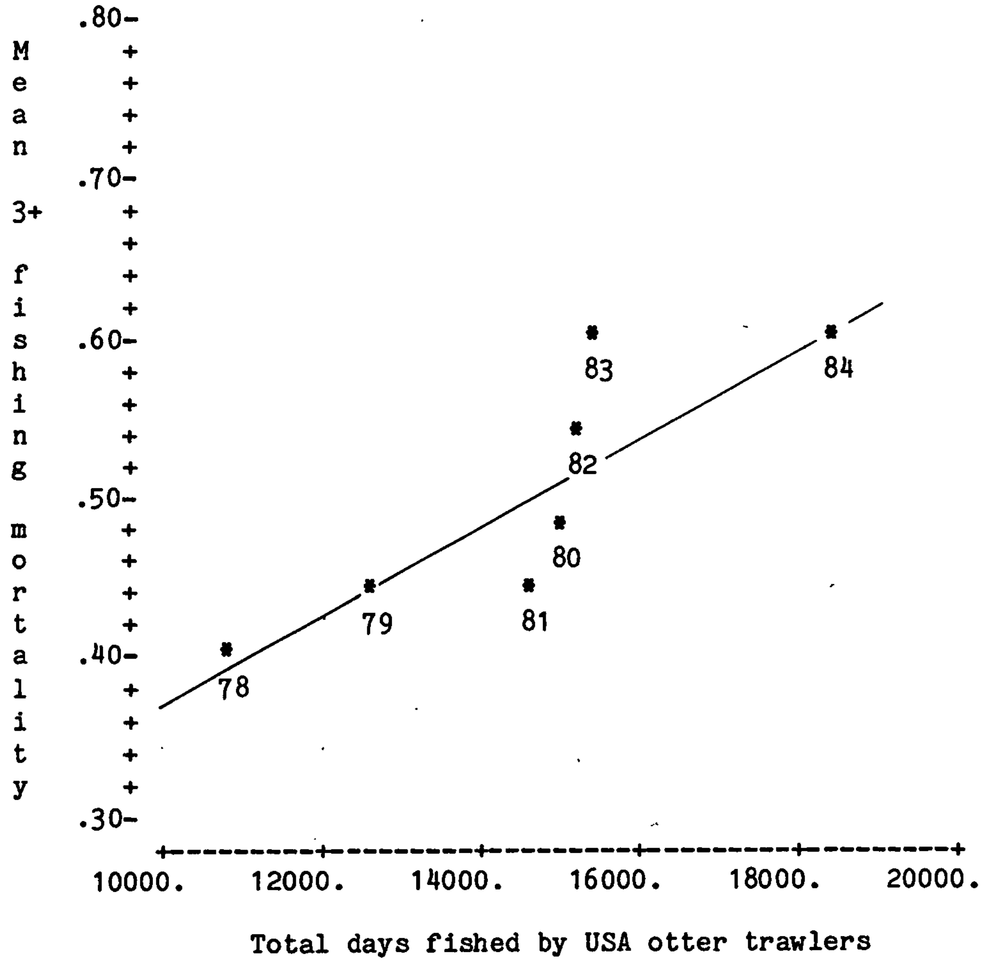

Figure 10. Regression of total days fished by USA otter trawlers on mean fully recruited fishing mortality from 1978-84 with terminal F set at 0.6 in 1984.

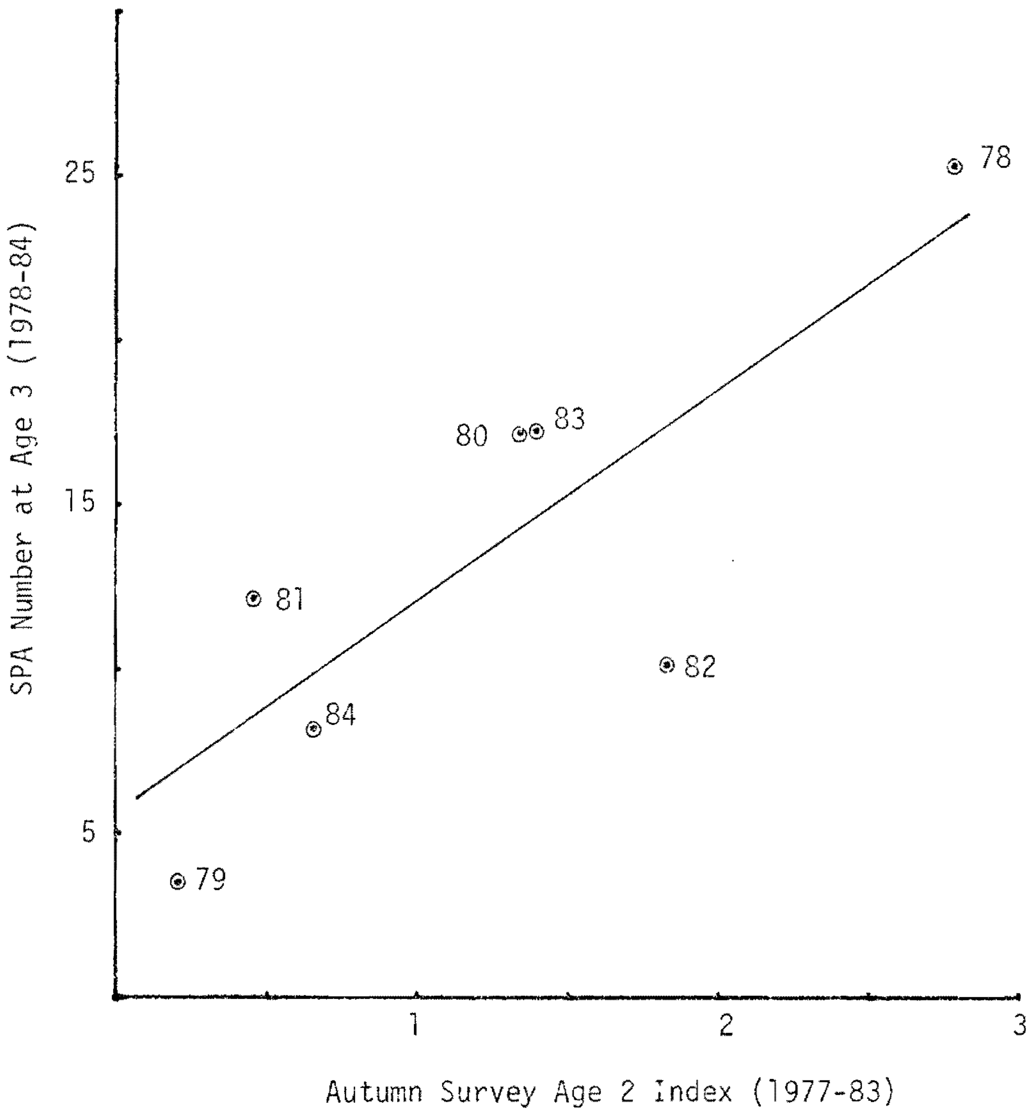

Figure 11. Regression of SPA number at age 3 on autumn survey catch per tow at age 2 for 1978-84 with terminal F set at 0.6

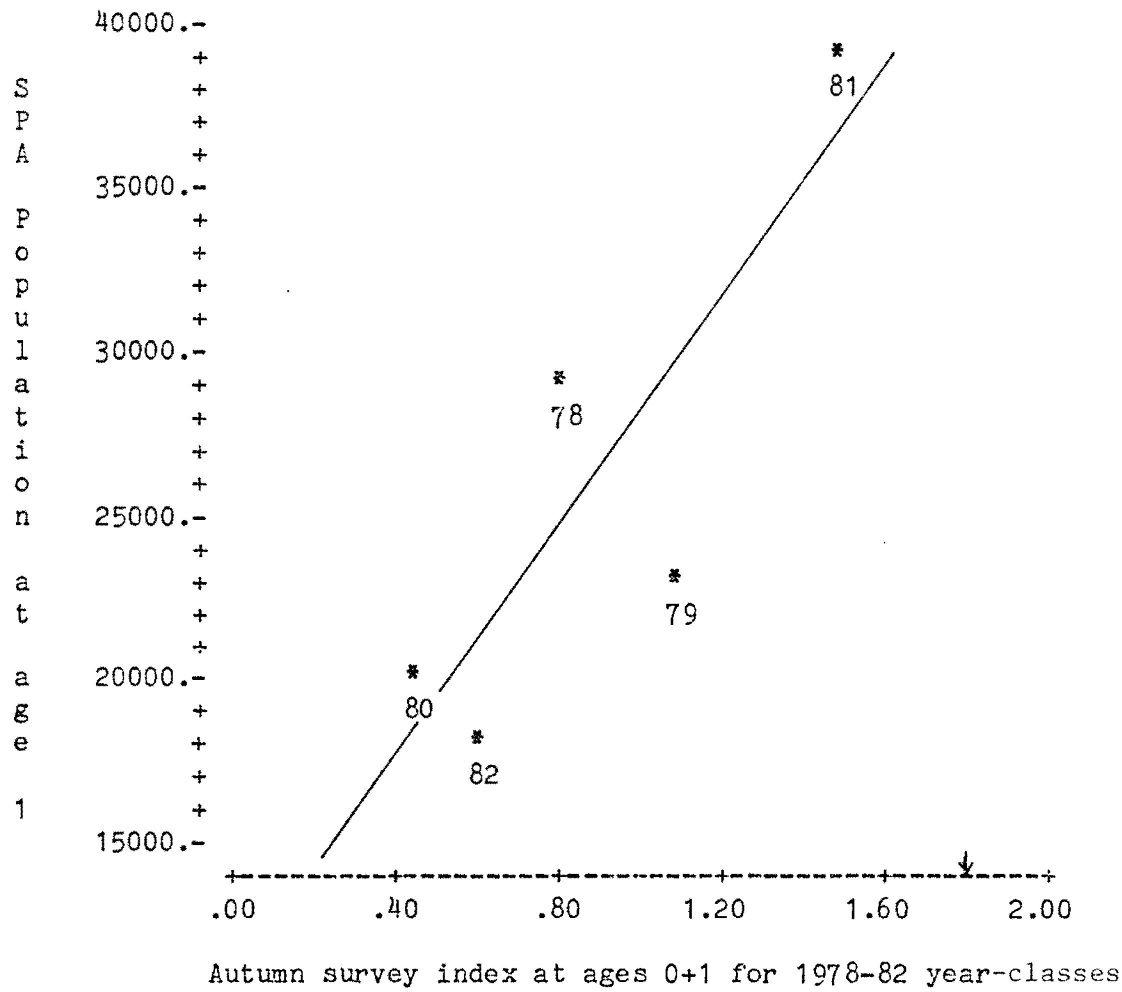

Figure I2. Regression of USA autumn survey index of abundance for the 1978-82 year-classes at ages 0+1 on SPA population estimate at age one for the 1978-82 year-classes.

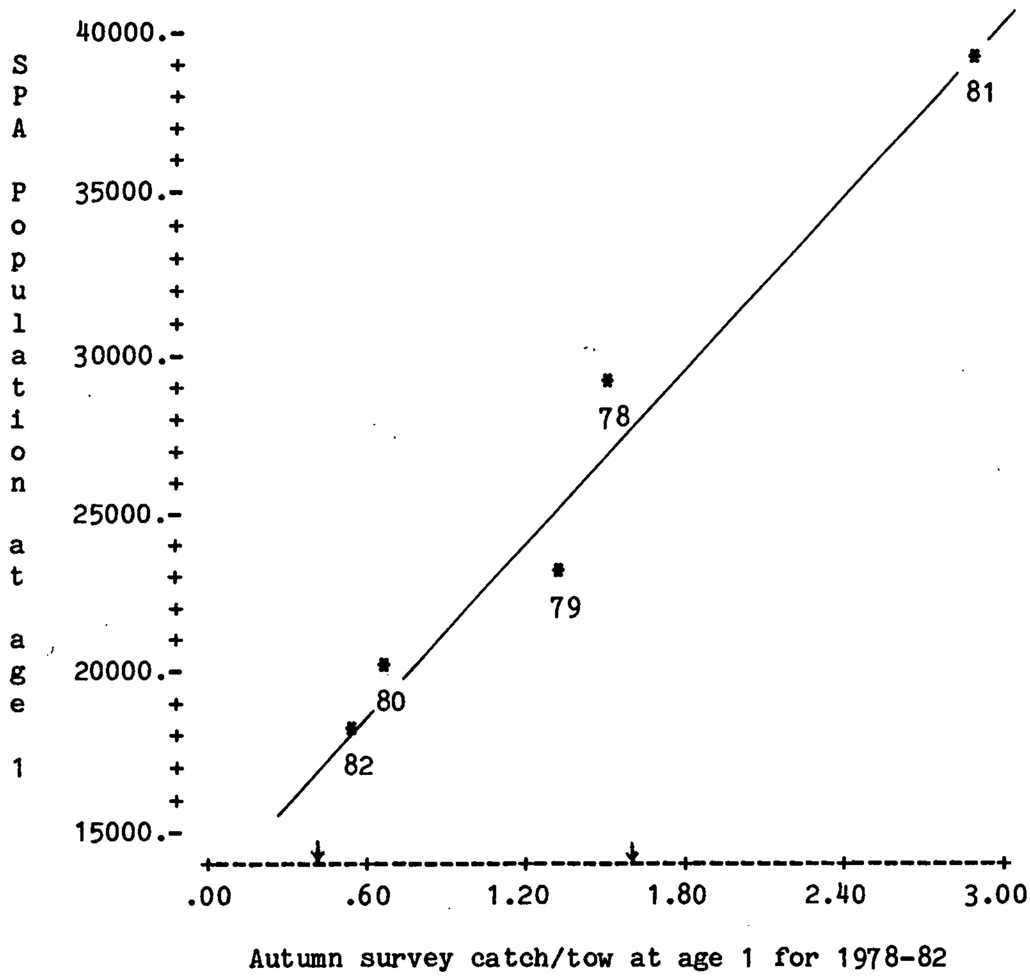

Figure 13. Regression of USA autumn survey catch per tow at age one for 1978-82 on SPA population estimate at age 1 for 1978-82

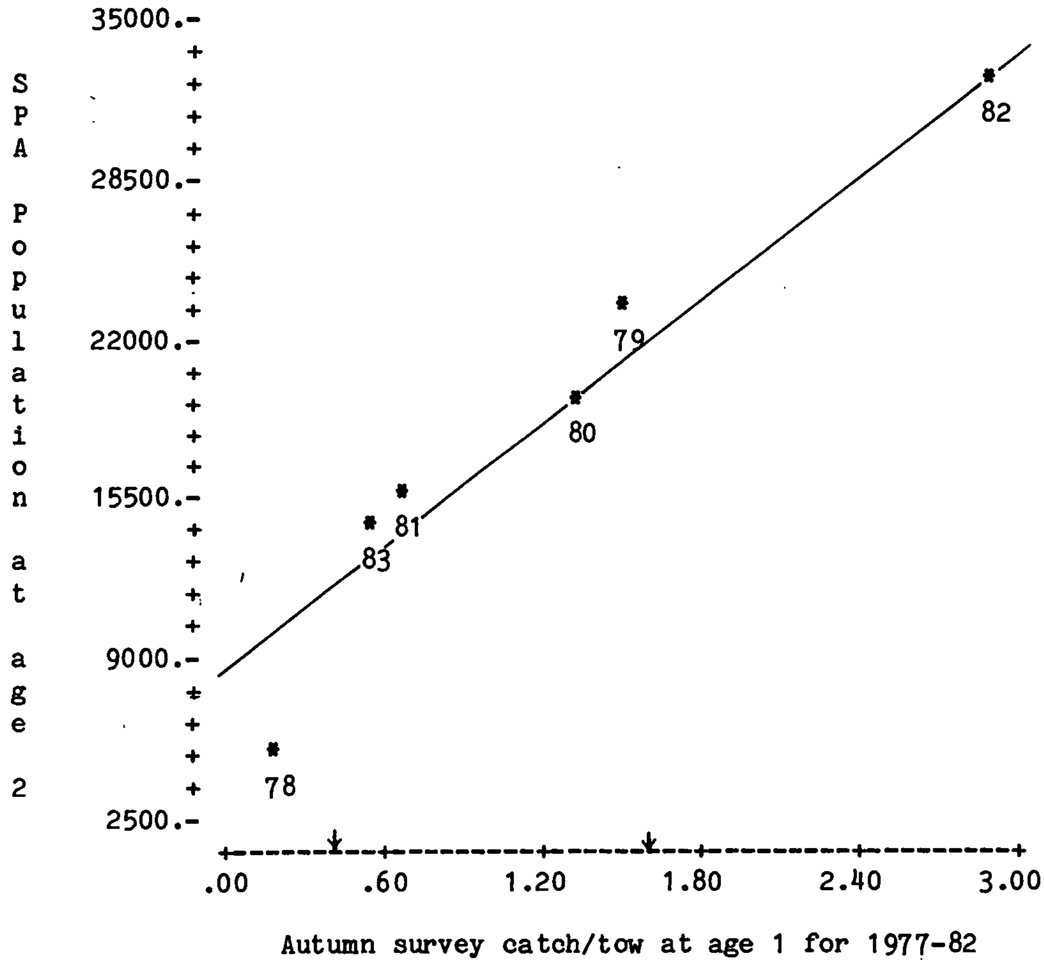

Figure 14. Regression of USA autumn survey catch per tow at age one for 1977-82 on SPA population estimate at age two for 1978-83.

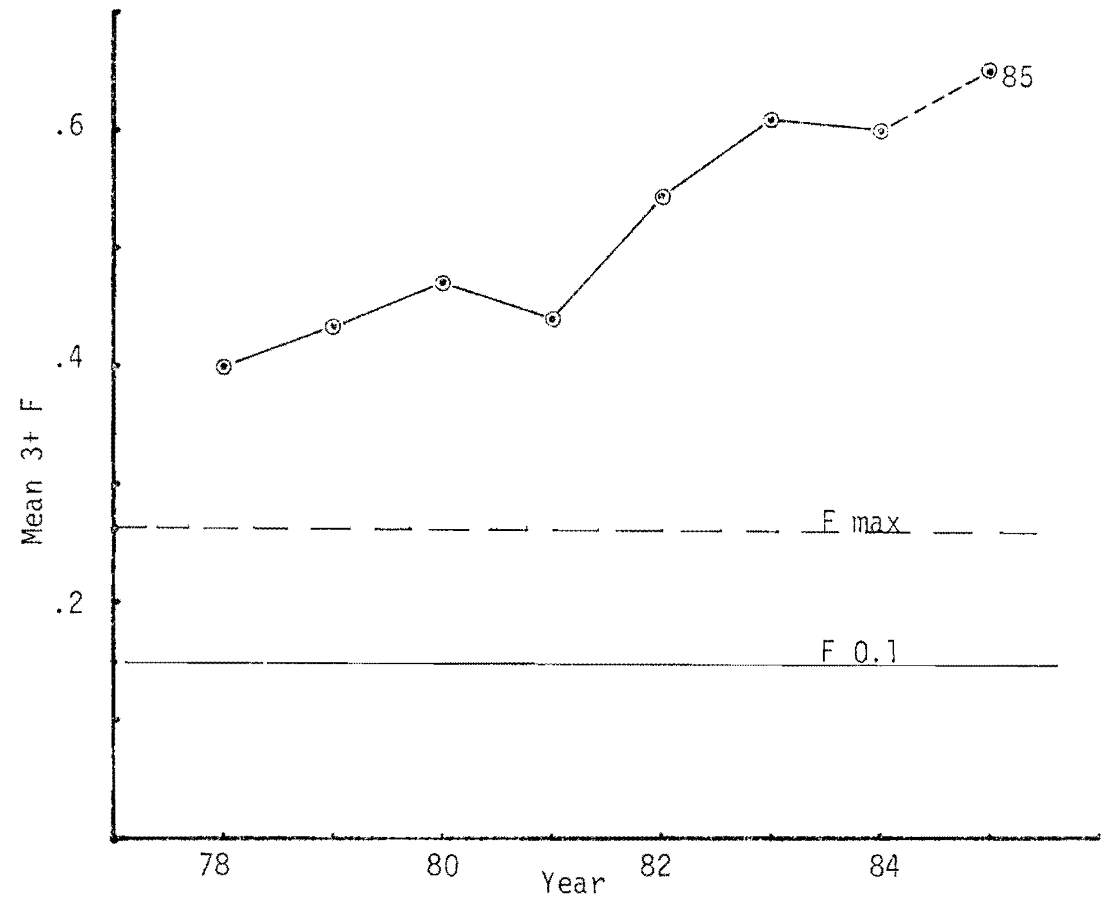

Figure 15. Trends in mean 3+ F for 1978-84

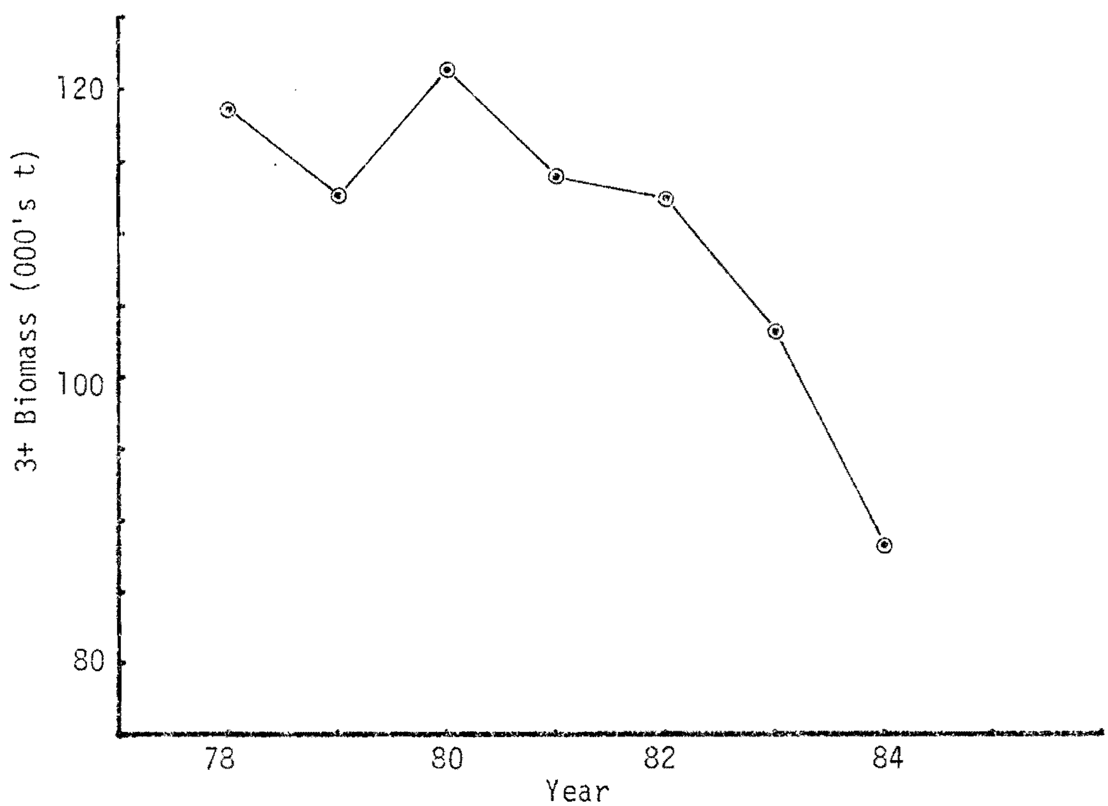

Figure 16. Trends in 3+ biomass for 1978-84

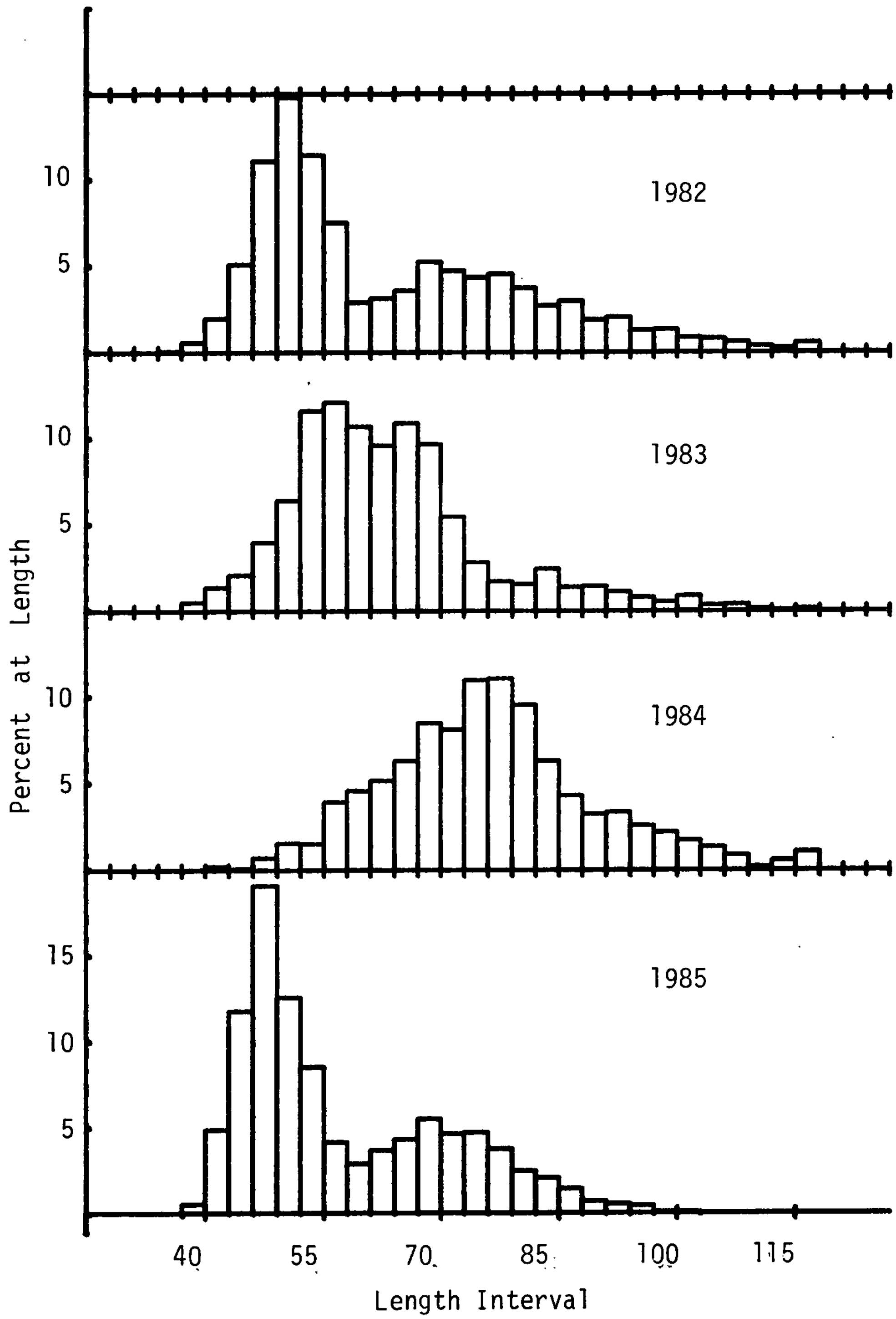

Figure 17. Percent length frequency distribution of Canadian cod catches for 1982-85 with three cm intervals.