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Status of the Atlantic Cod Stock on Georges Bank, NAFO Division 5Z and Subarea 6, in 1987

by

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Abstract

A review of the status of the Atlantic cod stock in NAFO Subdivision 5Ze and Subarea 6, incorporating 1987 catch, sampling and survey data was completed. Total landings increased by 5000 t from 1986 to 30900 t in 1987 and preliminary data indicate an 1988 catch of 37500 t. Stock abundance indices for this stock are variable but all show a general decline. The USA spring research surveys indicate decreasing abundance and the fall survey appears to be steady at low abundance. Catch rates continue to decline and the USA CPUE is at its lowest observed level. Canadian CPUE has been variable and appears to fluctuate with incoming recruitment. Sequential population analysis, using the ADAPT model, indicates a fully recruited fishing mortality of 0.802 in 1987, over 5 times the F0.1 level. Both population numbers and biomass are at their lowest level since 1978. Catch projection for 1989, assuming a catch of 37500 t in 1988, indicates a yield of 8000 t at F0.1 and 15000 t at Ft = 0.3, twice F0.1. Analysis of spatial and temporal stock distribution derived from survey data suggests that on average 30% of the stock is found in the Canadian zone but considerable seasonal and annual variability occurs.

Résumé

On a terminé une étude de l'état du stock de morues de l'Atlantique dans la subdivision 5Ze et dans la sous-zone 6 de l'OPANO, en incorporant les données de 1987 sur les prises, les données d'échantillonnage et les données des relevés. Les débarquements totaux ont augmenté de 5 000 t de 1986 à 30 900 t en 1987 et les données préliminaires indiquent qu'en 1988 la prise serait de 37 500 t. Les indices d'abondance du stock pour ce stock particulier sont variables, mais tous montrent un déclin général. Les relevés de printemps effectués par les Etats-Unis indiquent une diminution de l'abondance et le relevé d'automne indique une faible abondance qui s'est stabilisée. Les taux de prise continuent à décliner et la PUE américaine est à son niveau le plus bas jamais observé. La PUE canadienne a été variable et semble fluctuer en fonction du recrutement. L'analyse séquentielle de population, faisant appel au modèle ADAPT, indique une mortalité par pêche du stock pleinement recruté de 0,802 en 1987, soit cinq fois le niveau $F_{0,1}$. L'effectif de la population et la biomasse sont à leur plus bas niveau depuis 1978. Les prévisions des prises pour 1989, si l'on suppose une prise de 37 500 t en 1988, indiquent un rendement de 8 000 t à $F_{0,1}$ et de 15 000 t à $F_t = 0,3$, deux fois la $F_{0,1}$. L'analyse de la répartition spatio-temporelle du stock établie à partir des données des relevés de recherche semble indiquer qu'en moyenne 30 % du stock se situe dans la zone canadienne, mais qu'il y a des variations saisonnières et annuelles considérables.

Introduction

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 1985-87, with gear and tonnage class allocations.

Hunt and Waiwood (1984, 1985) and Hunt and Gavaris (1986), in reviews of stock status, suggested fully recruited fishing mortalities well above the Fmax of 0.25 since 1983. In the most recent assessment of this stock, Hunt (1987) reported a fully recruited fishing mortality of 0.7 in 1986 and 0.8 in 1985.

The present report incorporates 1987 commercial catch data and research survey results to estimate stock status in 1987.

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

Catches from this stock are thought to be under- or mis-reported prior to 1978 and estimates of population status prior to this time are suspect (Hunt, 1987). 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.

Annual Landings

The USA has been the main harvester of cod in Division 5Z and Subarea 6, (Fig 1) although landings by other countries were high in the mid-1960's (Table 1, Fig. 2). The Canadian catch was also high in this period, peaking 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, 38676 t in 1984, 37269 t in 1985 and declined to 25998 t in 1986, the lowest since 1976 and less than 50% of the peak 1982 catch. Reported landings in 1987 were 30878 t, an increase of about 5000 t from 1986.

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. Serchuk and Wigley, (1986) reported on the recreational fishery for cod

which takes 8000-9000 t annually. Most of this catch is taken inshore in Subarea 6 and it is excluded from the total catch.

Canadian catches of cod are 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). In 1987, both otter trawl and longline catches increased (22% and 60%, respectively) over 1986 and the catch by gillnet increased by 300% to 1155 t, the highest level in the time series.

The Canadian Fishery in 1988

Preliminary 1988 Canadian quota reports indicate a catch of 12000 t by late August. Samples of landings indicate a mode in the length frequency at 61 cm, which is primarily composed of age 3 fish from the 1985 year-class. Comparison of 1987 and 1988 otter trawl length frequencies and 1988 preliminary length frequencies are shown in Figures 4 and 5.

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. Only 7 samples, all from longline gear, were taken in 1984 from a total catch of less than 6000 t. In 1985, 18 samples were collected and 19 in 1986 with a substantial increase to 33 samples in 1987. Prior to 1978, sampling levels for Canadian catches were very low and it is unlikely that reliable estimates of removals could be obtained.

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 foreign fleet catches (Serchuk & Wigley, 1986). Catch composition of USA landings in 1978-85 (Serchuk & Wigley, 1986) and for 1986-87 were provided by Dr. F. Serchuk, NMFS, Woods Hole, Mass.

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 may be significant in years lacking samples for this gear. A summary of catches and samples used to estimate removals at age for 1987 is given Table 4. Percent age composition of Canadian catches are shown in Table 5. The 1985 year-class accounted for 62% of the catch in numbers and 37% in weight. Percent catch at age 2, in numbers and weight, for 1978-87 is shown in Figure 6.

Values for a and b, in the length weight relationship, derived from Canadian commercial sampling data, were a=0.0000163 and b=2.9048 for round weight in kilograms and length in centimeters. These contrast with values of a=0.000008104 and b=3.0521 for USA survey data (Serchuk et al, 1982). Canadian estimates were considered to be more representative of the fishery since the USA values are derived from October samples when weight of fish is more influenced by maturity stage.

Age groups 2-5 account for most of the yield but a difference in the age composition between Canada and USA has been noted (Hunt and Gavaris, 1986; Hunt , 1987). 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 Canadian catch at age is influenced by the small otter trawl catch.

In 1987, percent catch at age by Canada and the USA were similar, although slightly greater numbers of the 1983 year-class at age 4 were reported in USA landings. Catch at age by country is given in Table 6.

Mean length and weight at age for Canadian and USA landings are given in Tables 7 and 8, with the plus agegroup set to 115 cm and 15kg. Means for combined landings are estimated by weighting with catch in numbers for each country.

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 was added in 1968. A summer survey was conducted from 1977 to 1981. Surveys in Subdivision 5Ze were completed by Canada in March 1984, 86-88. Mean catch per tow in numbers by age group for each of the USA surveys is given in Table 9a and the mean catch per tow in numbers and weight in Table 10, Fig. 7. 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".

New trawl doors have been used for both spring and autumn surveys since 1985. Preliminary analysis of a study to develop conversion factors indicates the new trawl doors are more effective and would increase the catches of cod and haddock (pers. comm., Dr. F. Serchuk, NMFS). The value of the conversion factor has not been resolved and catches since 1985 should be considered an over-estimate relative to pre-1985 levels.

The spring survey has shown a decline in 0+ numbers between 1981-84, when the same sampling gear was used, and was at the lowest observed level in 1984. An increase in 1985 was followed by a decline in 1986 and the 1987 survey was the second lowest level since 1971. The 1988 survey increased, primarily due to the strong evidence of the 1985 year-class at age 3. The autumn survey has been relatively stable since 1982 with below average catches and shows a slight increase in the 1986 followed by a decline in 1987.

Canada has conducted a stratified random bottom trawl survey using a Western IIa trawl in Subdivision 5Ze during March 1986-88. Results of this survey are given in Table 9b but catch levels are not directly comparable with USA catches due to the difference in vessel and gear type. The Canadian survey also uses different strata (7) boundaries than the USA survey and incorporates the International boundary in strata margins. Catch per tow in both numbers and weight have been adjusted from those reported by Hunt (1987) to account for untrawlable survey area. For the three survey years, abundance has been variable with similar numbers in 1986 and 1988 but lower in 1987. The 1984 year-class at age 2 in 1986 seems strong but is below average in 1987 and 1988, suggesting that the 1986 level is an over-estimate. The 1983 and 1985 year-classes account for most of the catch in numbers.

Hunt (1987) reported on a July fixed station survey in Division 5Ze and notes that most catches of cod were taken on the Canadian side of the International boundary. However his results were based on a survey designed to estimate age and spatial distribution of cod relative to the commercial fishery and cannot be considered an indicator of overall population abundance.

Commercial Catch Rates

Catch and effort statistics by month and gear, for the Canadian fishery, were derived from Table 5 of the NAFO/ICNAF Statistical Bulletins for 1967-83. Data for 1984-87 were obtained from the Canadian Department of Fisheries and Oceans. A multiplicative model (Gavaris, 1980) was used. All observations where either the catch was less than 10 t or the effort was less than 10 hours were excluded from the analysis.

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 (Figure 8) indicate fairly low CPUE 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. Both the 1986 and 1987 CPUE decreased from the 1985 level. Comparison of Canadian and total directed effort, derived from the Canadian CPUE, is shown in Figure 9. Canadian effort peaked in 1983 and has shown a steady increase since 1984. Total effort also peaked in 1983, declined until 1986 and increased slightly in 1987.

A 1978-87 subset of the Canadian total series was also examined. The shorter time series was assumed to minimize the effect of learning and potential improved efficiency which may have taken place in the early to mid 70's when fleet expansion occurred. Results of analysis of this data set were similar to the total for 1980-87 but the CPUE for 1978-79 appeared to be anomalous and further work is required to improve this estimate.

USA catch rates (Serchuk & Wigley, 1986) are given in Table 12 and Figure 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 1987 and the catch rates in 1987 were the lowest since 1978.

An index of relative CPUE, to account for between country differences in CPUE units (t/day vs. t/hr), was calculated by standardizing values to the 1978-87 mean. The resultant relative index for each country is shown in Figure 11. A similar pattern is observed for both series, although the decline in Canadian CPUE is less pronounced.

Survey Index of Recruitment

Indices of recruitment were obtained from the autumn survey catch per tow at ages 0, 1 and 2 for the 1962-87 year-classes. The catch per tow at age was normalized to the mean of the 1962-87 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 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 also above average. The 1984 year-class is well below average while the 1985 year-class catch at age 0+1 is the highest since the 1975 year-class. The 1986 year-class at age 0+1 appears to be well below average and comparable to the weak 1984 year-class.

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 14. 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 the autumn survey in several time intervals were used to estimate mortality. Using the time series for 1982-87 in spring surveys avoids the change in gear used and yields a Z of 0.38 and an F of 0.18. The 1982-87 autumn surveys indicate a Z of 0.65 and 0.45 fishing mortality over the last five years of the fishery. For the last three years (1985-87), the spring survey indicates a Z of 0.96 and the autumn survey a Z of 0.70 with fishing mortalities of 0.76 and 0.50.

Estimates derived from the Canadian March survey for ages 3+, 4+ and 5+ between 1986 and 1988 indicate a Z of 0.3 to 0.7 with a resultant fishing mortality of 0.1 to 0.5 over the time period. However, the short time series as well as some negative Z values may compromise these results.

Sequential Population Analysis (SPA)

Estimates of total mortality (Z) derived from survey results indicate 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 1978-87 catch at age and terminal fishing mortality (Ft) between 0.4 and 0.8 were made to estimate population numbers and fishing mortality. Results of SPA were regressed on the corresponding index from the autumn research survey and the weighted (by population) 3+ F on directed effort derived from Canadian, USA and combined CPUE.

Mean 3+ fishing mortalities, weighted by population numbers, were regressed on standardized effort derived from the Canadian OTB CPUE. Poor correlation occurred with Ft's greater than 0.30 and this relationship was rejected. Regression of mean 3+F on total effort derived from the USA CPUE indicated highest correlation and minimization of residuals with Ft's of 0.8 or greater.

An estimate of 3+ CPUE was derived by partitioning the overall CPUE for Canadian and USA catch rates with percent catch at age. This value was then regressed on 3+ biomass derived from SPA. Results for Canadian data indicate best correlation with Ft's of 0.7 or greater but residuals for 1984-87 were all negative. USA data gave better correlation and also indicated a terminal fishing mortality of greater than 0.7 and residuals were more balanced in the last four years.

Results of these "traditional" tuning methods for estimating fishing mortality in the last year indicate high levels (above 0.7) in 1987. The contrast in degree of change in the USA and Canadian CPUE makes it inappropriate to select one over the other and further work is required to construct a combined index of catch and effort. Therefore, only the 1978-87 catch at ages 1-9 and USA fall survey catch per tow at ages 1-9 were used for input to the ADAPT model (Gavaris, 1988). A non-zero intercept term was included in the first analysis but examination of results indicated non-significant values for intercepts and substantial trends in residuals were noted. Therefore the model was constrained with zero intercepts. A logarithmic transformation of the data was used since no estimate of standard error was available for catch data. Trial values for slope and population numbers were derived from preliminary regression analysis. Initial trials with the entire age range produced non-significant slopes for ages five and older and therefore the final formulation of the model used ages 1-4. Beginning of year estimates of population were fished down to coincide with the October survey month.

Formulation of the model is summarized as follows:

Parameters

- Year-class estimates N_i, 1987 $i = 1$ to 4
- Calibration constants for RV numbers K_i $i = 1$ to 4

Structure

- natural mortality was set to 0.2
- error in catch at age assumed negligible
- F for agegroups 5-9 in 1987 and at age 9 for other years was calculated as the weighted F for ages 3 and 4
- intercepts not included

Input

- $C_{i,t}$ i = 1 to 9, t = 1978 to 1987
- $RV_{i,t}$ i = 1 to 9, t = 1978 to 1987

Objective function

- minimize $\sum (\text{obs } (\ln RV_{i,t}) - \text{pred } (\ln RV_{i,t}))^2$
- beginning of year estimates of population size were fished down to coincide with the median month of the survey (October)

Summary

- number of observations = 40
- number of parameters = 8

Convergence of the model, with the above formulation, occurred with fishing mortalities of 0.004, 0.267, 1.011 and 0.686 for ages 1 to 4 and a fully recruited fishing mortality of 0.802 in 1987. Corresponding population numbers in 1978 were 8015, 36011, 2510 and 4564 thousand for ages 1 to 4. Examination of residual plots for ages 1 to 4 indicated no substantial trends against either the predicted RV index or time. Age by age relationships for 1978-86 were similar to those reported in the previous assessment (Hunt, 1987) and these are summarized in Figure 12(a)-(d).

Final SPA Run

Population number, biomass and fishing mortality were calculated from SPA using an F vector in 1987 of 0.004, 0.267, 1.011, 0.686 and 0.802 for ages 1 to 4 and 5+. This corresponds to a partial recruitment vector of 0.005, 0.333 and 1 for ages 1, 2 and 3+ in 1987. Results are given in Table 15.

Fishing mortality (3+) averaged to 0.464 between 1978-81 but increased to an average of 0.716 in the 1983-87 time period. Fishing reached a high of 0.809 in 1985 and decreased to 0.671 in 1986. Fishing mortalities have exceeded F_{max} over the entire time series and are now five times the $F_{0.1}$ (0.15) exploitation level (Figure 13).

Estimated 1+ population numbers ranged from 70-84 million for 1978-82 but decreased to a low of 40 million in 1985, reflecting the small size of of the 1982 and 1984 year-classes. The increase in 1986 to 64 million is

a result of the strong 1985 year-class and the decline to 53 million in 1987 indicates the impact of catch at age two and the apparent below average abundance of the 1986 year-class. Numbers at age 3+ were 9 million in 1987, the lowest in the series, but the small size of the 1984 year-class is a dominant factor. Similar results are apparent in the estimate of population biomass and the 3+ biomass of 25000 t in 1987 is the lowest in the series. Estimated recruitment at age 1 and estimated 3+ biomass are given in Figures 14 and 15.

Discussion

Indices of abundance for this stock are inconsistent. USA research survey results indicate either a slight increase in stock numbers (spring) or a steady state at low stock size in recent years (autumn). Three data points available in the Canadian survey are insufficient to assess any trend in abundance, but they appear to track the USA spring survey. The USA CPUE for both directed and all trips are now less than 50% of the pre-1983 levels with a similar reduction in total catch. Canadian standardized CPUE has remained at relatively high levels with some fluctuation associated with strong recruiting year-classes. Results of SPA indicate high levels of fishing mortality, exceeding F0.1 by a factor of 5 in recent years and a decease of 50% in the 3+ biomass.

Recognition of the International boundary has probably changed the exploitation pattern in the commercial fishery with a more pronounced impact on the USA fleet. The historical distribution of catches indicates high catches by both the USA and Canada in the Northeast peak area of the Bank (Table 16) but USA effort in this area was eliminated in 1985 and, assuming a stable stock distribution, a reduction in CPUE could be expected. The proportion of catches from the four NAFO unit areas on the northeast part of the bank for 1979-83 and 1985-87 are summarized as follows:

	5Zeh	5Zej	5Zem	5Zen	Total
79-83 Canada	-	0.965	0.035	-	1.000
79-83 USA	0.167	0.106	0.086	0.046	0.405
85-87 USA	0.149	0.099	0.174	0.039	0.461

Mean catch by the USA in NAFO Unit areas 5Zej and 5Zem, both of which are now divided by the International boundary, was 9080 t in 1981-84 and declined to 5770 t in 1985-87. This reduction would, however, reflect accessibility rather than stock abundance. Canadian CPUE would not have been influenced to the same degree. Distribution of catches of cod in the Canadian 1987-88 March survey indicate that catch per tow in numbers and weight were higher by a factor of 3-5 in the Canadian part of Subdivision 5Ze (two strata) and accounted for 40% of the total number and biomass.

Estimated Canadian partial F's (total F times ratio of Canadian to total catch) are given in Table 17. Results indicate mean 3+ fishing mortalities of 0.1 to 0.25 with a maximum value of 0.251 in 1985. The low 1984 value is associated with low levels of effort by the otter trawl fleet. The levels of partial F are close to the F0.1 and Fmax for this stock.

Serchuk & Wigley (1986), using 1978-85 catch at age, report results similar to those of this analysis. Their estimate of terminal F in 1985 was based on the relationship between mean 3+F from SPA and directed effort derived from indices of USA CPUE. The relationship, based on minimization of residuals and correlation coefficient, was optimized at an Ft of 0.82 in 1985. Autumn survey 3+ biomass and SPA 4+ biomass were also correlated and indicated a 1985 Ft of 0.78, although the relationship was not as well defined as that for F and effort. In an unpublished report presented to the September meeting of CAFSAC, a USA analysis of 1978-87 data concludes that fully recruited fishing mortality was 0.95 in 1987.

Catch Projection

Population numbers at age for the beginning of 1988 were used to project catches for 1989. Mean weights at age and mean partial recruitment for 1985-87, assuming fully recruitment at ages 3+, were used. Geometric mean recruitment for 1978-87 (18,090 thousand) was used for population size at age 1 in 1988 and 1989. Catch in 1988 was set to 37,500 t based on preliminary estimates by Canada and the USA. Input parameters are summarized in Table 18.

The estimated catch of 37,500 t in 1988 would require a fishing mortality of 0.745 for ages 3+ and result in a decline in stock biomass from 72500 t in 1987 to 68000 t in 1988. Fishing at the F0.1 level in 1989 would produce a yield of 8000 t. The projected catch in 1989 with Ft set to 0.3, twice the F0.1 level, would be 15000 t. Results are summarized in Table 18.

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.

Partitioning of the total allowable catch relative to the International boundary requires some knowledge of stock distribution on either side of the line. Canadian research surveys incorporate the line for strata boundaries and allow direct estimates of the Canadian proportion of the total stock in 5Ze. Several strata in the USA survey are divided by the boundary line and it was necessary to adjust catches based on the proportion of affected strata on either side of the line. Examination of sampling locations within strata indicated that, in some years, there were no tows in the partitioned parts of strata. It was therefore necessary to estimate abundance using the overall mean catch per tow and area of the partitioned strata. This approach assumes that fish density within partitioned strata is uniform and results should be considered preliminary pending further work.

Estimated proportion of the total abundance (numbers) taken in Canadian waters for 1970-87 by USA spring and fall surveys and the Canadian spring survey are shown in Table 20 for ages 1-9+, total

and for ages 3+. Note that data for the 1981 USA surveys was not available. Considerable variability exists in the proportion of the stock found in the Canadian zone both by season and year. On average the 82-86 fall survey suggests 23 and 19% for the total and 3+ numbers, the spring survey 21 and 22% and the Canadian survey 47 and 49%. Higher aggregations in the Canadian zone during spring may be due to spawning. The overall proportion of the stock found in the Canadian zone may be 30% with both seasonal and annual variation.

Reducing catches by Canada to a level consistent with an F0.1 management strategy would not result in substantial increases in yield to the Canadian fleet and any decrease in effort by Canada would result in increased catch rates for the USA. Reduced effort by Canada could help rebuild the stock, but this is likely to be negated by increased effort by the USA in response to increased catch rates. Reducing Canada to 30% (based on average biomass in the Canadian zone) of the F0.1 projected catch would be consistent with current management strategy but would result in an immediate reduction in yield with no foreseeable increase.

References

Gavaris, S. 1980. Use of a multiplicative model to estimate catch rate and effort from commercial data. Can. J. Fish. Aquat. Sci. 37:2272-2275.

Gavaris, S and C. Gavaris. 1983. Estimation of catch at age and its variance for groundfish stocks in the Newfoundland region, p. 178-182. In W.G. Doubleday and D. Rivard (ed). Sampling of commercial catches of marine fish and invertebrates. Can. Spec. Publ. Fish. Aquat. Sci. 66.

Gavaris, S. 1988. An adaptive framework for the estimation of population size. CAFSAC Res. Doc. 88/29

Judge, G.G., W.E Griffiths, R.C. Hill and T.C. Lee. 1980. The theory and practice of econometrics. John Wiley and Sons, New York, 793 p.

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.

Hunt, J.J. and K.G. Waiwood. 1985. Status of the Atlantic cod stock on Georges Bank, NAFO Division 5Z and Statistical Area 6, in 1984. CAFSAC Res. Doc. 85/87.

Hunt, J.J. and S. Gavaris. 1986. Status of the Atlantic cod stock on Georges Bank, NAFO Division 5Z and Subarea 6, in 1985. CAFSAC Res. Doc. 86/95.

Hunt, 1987. Status of the Atlantic cod stock on Georges Bank, NAFO Division 5Z and Subarea 6, in 1987. CAFSAC Res. Doc. 87/94.

Serchuk, 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. Center, Lab. Ref. Doc. 82/33: 46p.

Serchuk, F.M., and S.E. Wigley. 1986. Assessment and status of the Georges Bank and Gulf of Maine Atlantic cod stocks - 1986. Natl. Mar. Fish. Serv., Northeast Fish. Center, La. Ref. Doc. 86/12

Table 1. Nominal catches (t, round) of Atlantic cod from Georges Bank and southward (NAFO Division 5Z and Subarea 6), 1960-87.

Year	USA	Canada	USSR	Other (a)	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	26828	10441	-	-	37269
1986	17490	8508	-	-	25998
1987 (b)	19035	11843	-	-	30878

a. Primarily Spain
b. Preliminary

Table 2. Distribution of USA commercial landings (t, round) of Atlantic cod from Georges Bank (5Ze), by gear type, 1965-1987. Data only reflect landings which could be identified by gear type. (from Serchuk and Wigley, 1986 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	30050
1985	21444	436	284	2482	163	24809
1986	13576	692	305	1679	95	16347
1987	13703					

Table 3. Nominal landings of cod by gear and month for Canada(M) in NAFO Division -5Z. (Ot - otter trawl; LL - longline; Misc - miscellaneous, mostly gillnet)

		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	24	9	19	4	2	1	1	92
	Total	-	32	56	195	331	1606	2800	2992	1343	938	34	110	10441
86	Ot	15	9	-	15	6	2364	3137	477	49	11	4	22	6109
	LL	-	58	81	12	24	146	120	538	606	409	12	-	2006
	Misc	1	2	9	15	10	47	89	76	42	1	-	-	292
	Total	16	69	90	42	40	2557	3346	1091	697	421	16	22	8407
87	Ot	18	1	3	-	-	2485	3811	889	145	2	78	44	7476
	LL	-	6	112	68	8	292	591	1032	747	310	13	33	3212
	Misc	5	11	15	17	9	142	466	391	89	2	6	2	1155
	Total	23	18	130	85	17	2919	4868	2311	981	314	97	78	11843

Table 4. Summary of 1987 catch and samples used to estimate catch at age for Canadian landings.

Gear	Month	Weight (t)	Lengths	Ages	Total
OTB	Jan	18\			
	Feb	1|			
	Mar	3|	2507	2773	307
	Apr	-|			
	May	-|			
	Jun	2485/			
	Jul	3812\			
	Aug	890|	4847	2344	176
	Sep	145/			
	Oct	2\			
	Nov	78|	124	703	140	7478
	Dec	44/			
LL	Jan	-\			
	Feb	6|			
	Mar	112|			
	Apr	68|			
	May	8|	2857	1490	287
	Jun	293|			
	Jul	591|			
	Aug	1032|			
	Sep	747/			
	Oct	310\			
	Nov	13|	356	1280	241	3213
	Dec	33/			
GN	Jan	5\			
	Feb	11|			
	Mar	15|			
	Apr	17|			
	May	9|			
	Jun	145|	1154	543	85	1154
	Jul	466|			
	Aug	390|			
	Sep	89|			
	Oct	2|			
	Nov	6|			
	Dec	2/			
Total					11844

Table 5. Age composition (percent by number) derived from biological samples of Atlantic cod from Georges Bank (5Ze) taken by Canadian vessels, 1978-87

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.06	0.00	0.03	0.09	0.12	0.45	0.00	0.09	0.83	0.38
2	1.99	24.64	27.12	9.31	36.71	10.53	1.95	51.57	9.96	62.25
3	66.40	23.85	40.19	34.14	25.00	39.87	9.10	21.48	54.59	14.92
4	20.60	35.25	7.74	25.35	16.24	25.67	29.46	8.97	16.01	15.59
5	6.14	12.29	16.45	6.25	12.15	8.54	30.48	11.93	6.35	1.88
6	2.24	2.41	5.31	17.19	2.69	6.07	14.03	3.44	9.53	1.70
7	1.68	0.83	1.31	3.77	4.19	2.47	7.71	1.08	1.30	2.44
8	0.01	0.02	0.02	0.10	0.02	0.11	0.19	0.02	0.87	0.45
9	0.30	0.09	0.73	0.90	0.43	1.83	2.13	0.24	0.39	0.29
10+	0.18	0.09	0.54	0.67	0.80	0.91	3.06	0.24	0.17	0.11
#samples	29	13	10	17	17	15	7	18	19	33
#aged	1364	591	536	491	956	601	412	1064	888	1236

Table 6. Removals at age (000's) by Canada and the USA for 1978-87.

	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	102	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	1134	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	82	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
1986 Cdn	19	232	1270	372	148	222	30	20	9	4	2326
USA	137	1091	3290	432	337	412	58	53	38	26	5874
Total	156	1323	4560	804	485	634	88	73	47	30	8200
1987 Cdn	17	2784	667	697	84	76	109	20	13	5	4472
USA	12	4878	804	1380	188	173	153	41	23	18	7670
Total	29	7662	1471	2077	272	249	262	62	34	23	12142

Table 7. Mean length-at-age of cod derived from Canadian and USA samples 1978-87. Total weighted by catch in numbers for each country.

Year	Age group 1	2	3	4	5	6	7	8	9	10+
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	36.7	49.3	60.1	66.7	78.0	85.7	87.6	105.6	105.2	115.0
	43.9	52.6	61.6	72.4	81.9	86.3	92.9	92.2	91.2	115.0
	41.8	50.7	60.7	69.7	80.8	85.6	92.5	95.6	92.9	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
1986	39.6	51.7	63.5	71.0	79.7	86.9	92.8	96.2	94.5	115.0
	45.8	52.0	60.1	67.6	81.1	88.2	95.2	98.7	108.2	115.0
	45.1	51.9	61.0	69.2	80.7	87.7	94.4	98.0	105.6	115.0
1987	38.5	51.9	60.3	73.5	82.5	88.1	96.2	100.3	106.0	115.0
	43.3	51.7	61.3	72.7	81.6	90.9	93.2	96.6	101.1	115.0
	40.5	51.8	60.8	73.0	81.9	90.1	94.4	97.8	102.2	115.0

Table 8. Mean weight-at-age of cod from Canadian and USA samples 1978-87. Total weighted by catch in numbers for each country.

Year		1	2	3	4	5	6	7	8	9	10+
1978	Cdn	0.656	1.206	2.121	2.644	3.540	5.682	6.140	9.268	8.399	15.0
	USA	-	1.298	2.470	3.692	4.473	5.199	7.522	7.924	12.794	15.0
	Total	0.656	1.283	2.374	3.387	4.247	5.479	7.300	8.267	11.637	15.0
1979		-	1.483	1.723	3.691	4.730	5.986	9.586	12.058	10.412	15.0
		0.889	1.522	2.464	4.301	4.974	7.309	9.127	10.264	-	15.0
		0.889	1.513	2.125	4.211	4.922	7.166	9.230	10.335	10.412	15.0
1980		0.572	1.348	2.427	3.241	5.116	6.707	7.148	12.324	12.169	15.0
		0.839	1.490	2.478	3.992	5.792	6.703	8.489	8.648	8.046	15.0
		0.836	1.463	2.469	3.682	5.667	6.704	8.387	9.220	8.501	15.0
1981		0.864	1.368	2.312	3.467	5.113	6.816	9.108	9.575	10.485	15.0
		0.885	1.501	2.360	3.389	5.209	7.339	8.397	9.988	14.884	15.0
		0.883	1.493	2.352	3.406	5.155	7.203	8.534	9.823	14.231	15.0
1982		0.592	1.410	2.128	3.814	5.335	6.656	9.158	9.574	12.941	15.0
		0.767	1.395	2.852	3.845	5.449	6.457	9.473	10.297	12.434	15.0
		0.763	1.398	2.591	3.834	5.409	6.569	9.366	9.979	12.598	15.0
1983		0.885	1.466	2.265	3.371	5.210	6.641	8.593	10.428	11.999	15.0
		0.993	1.497	2.456	3.434	4.703	6.407	7.955	10.280	11.091	15.0
		0.976	1.494	2.420	3.409	4.828	6.458	8.266	10.332	11.459	15.0
1984		-	1.438	2.477	3.841	4.977	6.310	8.541	10.486	11.034	15.0
		1.053	1.638	2.450	3.597	5.308	6.751	8.960	9.710	11.361	15.0
		1.053	1.635	2.451	3.621	5.177	6.629	8.886	10.073	11.318	15.0
1985		0.680	1.391	1.950	3.571	4.742	6.399	8.074	9.664	10.584	15.0
		0.914	1.424	2.157	3.989	5.201	6.398	8.075	10.355	12.107	15.0
		0.907	1.413	2.081	3.874	5.080	6.398	8.075	10.223	11.415	15.0
1986		0.723	1.573	2.897	3.944	5.623	7.208	8.618	9.512	9.996	15.0
		0.957	1.453	2.280	3.413	5.608	7.198	9.066	10.135	13.338	15.0
		0.927	1.474	2.451	3.658	5.613	7.201	8.913	9.965	12.698	15.0
1987		0.660	1.600	2.506	4.447	6.148	7.484	9.538	10.759	12.565	15.0
		0.801	1.412	2.429	4.043	5.657	7.811	8.520	9.464	10.621	15.0
		0.713	1.480	2.464	4.179	5.809	7.711	8.944	9.729	11.989	15.0

Table 9a. Stratified mean catch per tow at age (numbers) of Atlantic cod in offshore spring and autumn bottom trawl surveys on Georges Bank a, 1963-1988.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	1.405	.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	.080	5.748	5.712	3.852	2.677	.984	.657
1973 d	.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	1.309	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	.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	.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	.000	.069	8.467	8.223	6.354	4.799	2.544	1.191
1982 e	.120	.396	2.755	1.141	1.051	.843	.013	.242	.052	.013	.028	6.654	6.534	6.138	5.000	2.242	1.191
1983	.052	.211	1.261	1.954	.491	.447	.276	.035	.123	.000	.087	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	.150	6.938	6.694	6.596	3.963	3.206	2.148
1986	.092	.871	.423	1.824	.360	.545	.633	.063	.119	.095	.015	5.040	4.948	4.077	3.654	1.830	1.470
1987	.000	.034	1.612	.403	.752	.060	.179	.147	.016	.027	.025	3.255	3.255	3.221	1.609	1.206	.454
1988 f	(.180)	(.752)	(.664)	(3.545)	(.335)							(5.861)					
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	1.080	.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	.008	.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	1.084	.220	.803	.103	.115	.101	.000	.000	.004	.000	.000	2.430	1.346	1.126	.323	.220	.105
1986	.096	2.280	.153	.382	.010	.061	.090	.016	.000	.008	.028	3.124	3.028	.748	.595	.213	.203
1987	.204	.414	1.353	.112	.195	.028	.012	.000	.000	.007	.000	2.325	2.121	1.707	.354	.242	.047

a. Spring and autumn cover USA strata 13-25

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. Excludes unusually high catch of 1894 cod (2558 kg) at Station 230 (Strata tow 20-4)

e. Excludes unusually high catch of 1032 cod (4096 kg) at Station 323 (Strata tow 16-7)

f. Preliminary estimate from length distribution

Table 9b. Catch per tow at age for Canadian March survey using Western IIa trawl, 1986-88.

1986	.00	.66	2.67	3.06	.40	.67	.45	.26	.05	.09	.03	8.34	8.34	7.68	5.01	1.95	1.55
1987	.00	.25	2.13	.93	1.09	.34	.12	.22	.08	.03	.07	5.25	5.25	5.00	2.87	1.94	.85
1988	.00	.28	1.01	4.65	.58	1.02	.13	.08	.17	.04	.06	8.02	8.02	7.74	6.73	2.08	1.50

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) 1963-88. Results of Canadian survey using Western IIa trawl are included for information.

	Spring a		Summer b		Autumn	
Year	Nos	Wgt (kg)	Nos	Wgt (kg)	Nos	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
1985	6.94	21.5	-	-	2.43	3.5
1986	5.04	16.7	-	-	3.12	4.7
1987	3.25	10.3	-	-	2.33	-
1988	5.86	-	-	-	-	-
1986 Cdn	8.34	19.5	-	-	-	-
1987 Cdn	5.25	13.1	-	-	-	-
1988 Cdn	8.02	21.1				

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 Canadian March stratified random survey of Division 5Ze

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
67	0.511	36752	71901	-0.75610
68	0.547	43136	78807	-0.68660
69	0.472	37939	80434	-0.83660
70	0.333	25652	77110	-1.18300
71	0.328	28179	85857	-1.19780
72	0.347	25059	72129	-1.13470
73	0.375	28923	77144	-1.06300
74	0.311	27331	87917	-1.21730
75	0.396	25008	63105	-0.99890
76	0.285	19926	69891	-1.33310
77	0.859	27367	31872	-0.23360
78	0.878	35483	40409	-0.21510
79	0.716	38656	54007	-0.41890
80	0.559	48147	86075	-0.66520
81	0.707	42357	59870	-0.42790
82	0.795	57195	71971	-0.31510
83	0.509	48928	96088	-0.75980
84	0.465	37676	83180	-0.84060
85	0.633	37269	58912	-0.54040
86	0.576	25998	45135	-0.63160
87	0.504	30878	61293	-0.7670

Gear	ln power
OTB1-4	.000
OTB2-2	.104
OTB2-4	.190
OTB2-3	.264
OTB2-5	.415

Month	ln power
Nov	-0.420
Sep	-0.214
Oct	-0.195
Aug	-0.154
Dec	-0.099
May	-0.070
Feb	-0.064
Jul	-0.015
Jun	0.000
Jan	0.070
Apr	0.274
Mar	0.511

Regression of Multiplicative model

Multiple r-squared 0.531

Analysis of Variance

Source	DF	Sum Squares	Mean Squares	f-value
Intercept	1	3.097 E2	3.097 E2	
Regression	35	6.119 E1	1.748 E0	9.699
Gear	4	8.202 E0	2.051 E0	11.376
Month	11	6.094 E0	5.540 E-1	3.073
Year	20	2.922 E1	1.461 E0	8.105
Residuals	300	5.408 E1	1.803 E-1	
Total	326	4.250 E2		

Table 12. USA commercial landings and landings per day fished for otter trawl trips catching cod from Georges Bank (5Ze), 1965-86. (from Serchuk and Wigley, 1986)

	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	0.86	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	33214	2.18	23561	4.45
1983	30958	2.00	21245	4.25
1984	26157	1.42	15916	2.98
1985	21437	1.15	14962	2.26
1986	13575	0.96	9071	2.15
1987	13703	0.84	9133	1.63

* 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 1963-87. Catch per tow normalized to mean of the 1963-87 values.

Year-class	Age Group	
	0 + 1	1 + 2
1962	-	0.416
1963	0.179	0.498
1964	0.332	0.662
1965	0.610	0.874
1966	3.009	2.430
1967	0.157	0.290
1968	0.162	0.545
1969	0.419	0.634
1970	0.603	0.590
1971	2.284	3.911
1972	1.473	0.656
1973	0.324	0.245
1974	0.753	0.951
1975	4.133	2.999
1976	0.074	0.184
1977	0.793	1.321
1978	1.058	0.752
1979	0.421	1.226
1980	1.495	1.819
1981	0.580	0.565
1982	0.512	0.195
1983	1.751	1.045
1984	0.289	0.166
1985	2.738	1.600
1986	0.325	-

Table 14. Estimates of instantaneous total mortality (Z) and fishing mortality (F) with instantaneous mortality (M) assumed to be 0.20 for different time periods, derived from USA and Canadian 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
1982 - 87	0.38	0.18	0.65	0.45
1985 - 87	0.96	0.76	0.70	0.50
1986 - 88 d	0.50	0.30	-	-
1986 - 88 e	0.67	0.47	-	-
1986 - 88 f	0.28	0.08	-	-

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 to j) / (age 4+ for years i+1 to j+1))
c. excludes spring 1972-73 (4+/5+) since these gave negative Z value
d. Canadian survey ln((4+ in '86)/(5+ in '88))
e. Canadian survey ln((3+ in '86)/(4+ in '88))
f. Canadian survey ln((2+ in '86)/(3+ in '88))

Table 15. Results of SPA for Georges Bank cod, 1978-87.

(a) Population Numbers (000's)

	Year									
Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	28052	23290	19152	39568	16488	8687	24596	5678	44156	8015
2	4958	22965	19037	15600	32371	13199	7026	20064	4527	36011
3	26054	3701	16887	12233	9827	17544	7289	4574	10615	2510
4	9233	14190	2075	8623	6100	4553	8154	2889	1544	4564
5	3302	5472	7255	1258	4806	2652	1841	3710	1136	537
6	1167	1957	3431	3845	820	2183	1145	758	1332	492
7	1435	841	1193	1824	1894	430	954	445	244	517
8	138	865	620	572	1123	930	202	357	167	120
9	275	70	478	426	360	732	458	123	107	71
10+	40	191	56	236	233	228	466	215	81	45
1+	74654	73542	70186	84187	74023	51139	52131	38813	63911	52882
3+	41644	27286	31996	29018	25164	29252	20509	13071	15288	8857

(b) Mean mid-year population biomass (t)

1	16678	18751	14476	31671	11284	7640	23433	4608	37089	5208
2	5515	29909	22509	18651	33841	14873	9339	20971	5041	42586
3	46360	5971	30354	20730	17759	29653	11652	5807	17577	3585
4	24352	43529	6013	22237	15871	10209	20431	7277	3489	12651
5	10918	21521	30440	5278	17978	8664	6319	11794	4319	1970
6	5451	11061	17052	19849	3970	9587	4913	2903	6204	2394
7	8221	6690	7088	12337	12695	2494	5394	2295	1561	2922
8	829	6744	4766	4499	9121	6882	1603	2123	1121	752
9	2685	653	2915	4552	3640	6750	3637	1144	914	508
10+	433	2241	651	2750	2355	2371	5457	2161	861	430
1+	121441	147068	136263	142554	128514	99124	92178	61083	78176	73007
3+	99248	98408	99278	92232	83389	76611	59406	35504	36046	25213

(c) Fishing mortality

1	0.000	0.002	0.005	0.001	0.023	0.012	0.004	0.026	0.004	0.004
2	0.092	0.107	0.242	0.262	0.413	0.394	0.229	0.437	0.390	0.267
3	0.408	0.378	0.472	0.496	0.569	0.566	0.726	0.886	0.644	1.011
4	0.323	0.471	0.300	0.385	0.633	0.705	0.588	0.733	0.856	0.686
5	0.323	0.267	0.435	0.228	0.589	0.640	0.687	0.824	0.638	0.802
6	0.127	0.295	0.432	0.508	0.446	0.628	0.744	0.932	0.746	0.802
7	0.307	0.105	0.535	0.285	0.511	0.556	0.784	0.778	0.508	0.802
8	0.473	0.392	0.175	0.264	0.228	0.510	0.297	1.000	0.657	0.802
9	0.165	0.032	0.507	0.404	0.258	0.253	0.554	0.221	0.661	0.802
10+	0.485	0.315	0.323	0.327	0.650	0.582	0.316	0.666	0.523	0.802
3+	0.370	0.389	0.445	0.432	0.561	0.589	0.654	0.827	0.671	0.801

Table 16. Summary of catches by the USA for NAFO unit areas 5Zeh,j,m and n for 1981-87. (pers. comm. from Dr. Frederic Serchuk, NMFS).

Year	5Zeh	5Zej	5Zem	5Zen
1981	5300 t	5041	3233	2127
1982	5268	4946	3725	1200
1983	6532	5365	3322	790
1984	4274	5557	5142	1902
1985	3820	2247	4510	1225
1986	1967	1926	3771	617
1987	3664	2095	2746	600

Table 17. Canadian partial F's (total F times ratio of Canadian to total catch at age, 1978-87).

Age	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
1	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.000	0.002
2	0.015	0.025	0.046	0.016	0.085	0.035	0.004	0.146	0.068	0.097
3	0.112	0.173	0.086	0.082	0.206	0.108	0.021	0.325	0.179	0.458
4	0.094	0.070	0.124	0.082	0.222	0.285	0.057	0.201	0.396	0.230
5	0.078	0.057	0.080	0.129	0.206	0.158	0.272	0.217	0.195	0.248
6	0.074	0.032	0.055	0.132	0.250	0.136	0.207	0.321	0.261	0.245
7	0.049	0.024	0.041	0.055	0.174	0.271	0.139	0.161	0.173	0.334
8	0.121	0.015	0.027	0.105	0.100	0.179	0.139	0.191	0.180	0.263
9	0.044	0.032	0.056	0.060	0.084	0.102	0.072	0.100	0.127	0.290
10+	0.208	0.013	0.323	0.076	0.287	0.190	0.091	0.069	0.070	0.174
3+	0.102	0.075	0.081	0.089	0.203	0.147	0.077	0.251	0.208	0.303

Table 18. Summary of input parameters used for catch projection

Age	1988 beginning of year population numbers	Partial Recruitment	Mean Weight (kg)
1	18090	0.014	0.851
2	7002	0.479	1.456
3	22574	1	2.332
4	748	1	3.904
5	1882	1	5.500
6	197	1	7.104
7	180	1	8.644
8	190	1	10.030
9	44	1	11.810
10+	26	1	15.000

Summary	1988	1989
Population numbers	50871	46758
Population biomass	68220	73796
Catch	37500	15129

Table 19. Proportion of total abundance (numbers) in NAFO Subdivision 5Ze taken in the Canadian zone, 1970-87, for USA spring and fall surveys and Canadian spring survey.

(a) USA fall survey

	Age										
Year	1	2	3	4	5	6	7	8	9+	Total	3+
1970	0.15	0.06	0.05	0.05	0.07	1.00	0.00	0.06	0.03	0.09	0.05
1971	0.17	0.13	0.09	0.08	0.12	0.10	0.07	0.08	0.00	0.13	0.10
1972	0.16	0.19	0.13	0.07	0.02	0.02	0.00	0.00	0.00	0.16	0.11
1973	0.37	0.14	0.09	0.05	0.04	0.02	0.03	0.05	0.03	0.14	0.11
1974	0.12	0.20	0.17	0.14	0.06	0.03	1.00	0.02	1.00	0.14	0.16
1975	0.19	0.17	0.23	0.13	0.12	0.03	1.00	1.00	1.00	0.11	0.15
1976	0.42	0.10	0.08	0.04	0.05	0.00	0.05	0.00	0.00	0.28	0.08
1977	0.13	0.24	0.16	0.12	0.14	0.09	0.05	0.05	1.00	0.20	0.21
1978	0.27	0.20	0.21	0.13	0.08	0.07	0.05	0.04	0.03	0.19	0.17
1979	0.33	0.34	0.28	0.23	0.18	0.19	0.14	0.07	0.10	0.29	0.27
1980	0.29	0.30	0.23	0.14	0.17	0.08	0.09	0.26	1.00	0.26	0.23
1982	0.15	0.11	0.17	0.13	0.02	1.00	0.00	1.00	1.00	0.11	0.11
1983	0.01	0.07	0.12	0.09	0.02	0.12	1.00	0.49	1.00	0.08	0.09
1984	0.25	0.39	0.33	0.32	0.35	0.23	0.07	0.17	0.03	0.27	0.32
1985	0.44	0.36	0.28	0.10	0.07	1.00	1.00	1.00	1.00	0.31	0.28
1986	0.45	0.16	0.19	0.03	0.02	0.02	0.00	1.00	0.00	0.38	0.14

(b) USA spring survey

	Age										
Year	1	2	3	4	5	6	7	8	9+	Total	3+
1970	0.30	0.45	0.24	0.15	0.11	0.13	0.11	0.02	0.43	0.21	0.21
1971	0.13	0.25	0.21	0.22	0.17	0.23	0.18	0.09	0.20	0.20	0.20
1972	0.10	0.25	0.19	0.20	0.20	0.17	0.14	0.11	0.19	0.17	0.20
1973	0.36	0.06	0.08	0.11	0.19	0.22	0.38	0.42	0.34	0.08	0.07
1974	0.32	0.38	0.19	0.20	0.27	0.26	0.24	0.29	0.19	0.27	0.27
1975	0.00	0.04	0.08	0.08	0.09	0.09	0.12	0.07	0.19	0.08	0.08
1976	0.15	0.08	0.11	0.12	0.10	0.12	0.14	0.31	1.00	0.11	0.10
1977	1.00	0.05	0.16	0.21	0.21	0.18	0.13	0.05	1.00	0.11	0.11
1978	0.04	0.10	0.11	0.20	0.25	0.34	0.30	0.22	0.25	0.12	0.15
1979	0.29	0.26	0.24	0.24	0.23	0.26	0.29	0.25	0.23	0.25	0.25
1980	0.10	0.33	0.25	0.34	0.33	0.34	0.36	0.30	0.26	0.30	0.30
1982	0.19	0.29	0.48	0.48	0.47	0.48	0.47	0.51	0.49	0.44	0.44
1983	0.12	0.08	0.13	0.12	0.15	0.23	0.41	0.10	0.53	0.13	0.13
1984	0.10	0.13	0.21	0.09	0.08	0.07	0.11	1.00	0.18	0.12	0.12
1985	0.13	0.20	0.24	0.28	0.22	0.18	0.27	0.29	0.32	0.22	0.23
1986	0.07	0.13	0.16	0.15	0.17	0.18	0.19	0.26	0.34	0.15	0.17

(c) Canadian spring survey

	Age										
Year	1	2	3	4	5	6	7	8	9+	Total	3+
1987	0.04	0.48	0.44	0.36	0.33	0.58	0.47	0.47	0.33	0.42	0.41
1988	0.10	0.20	0.64	0.53	0.45	0.43	0.47	0.44	0.33	0.52	0.58

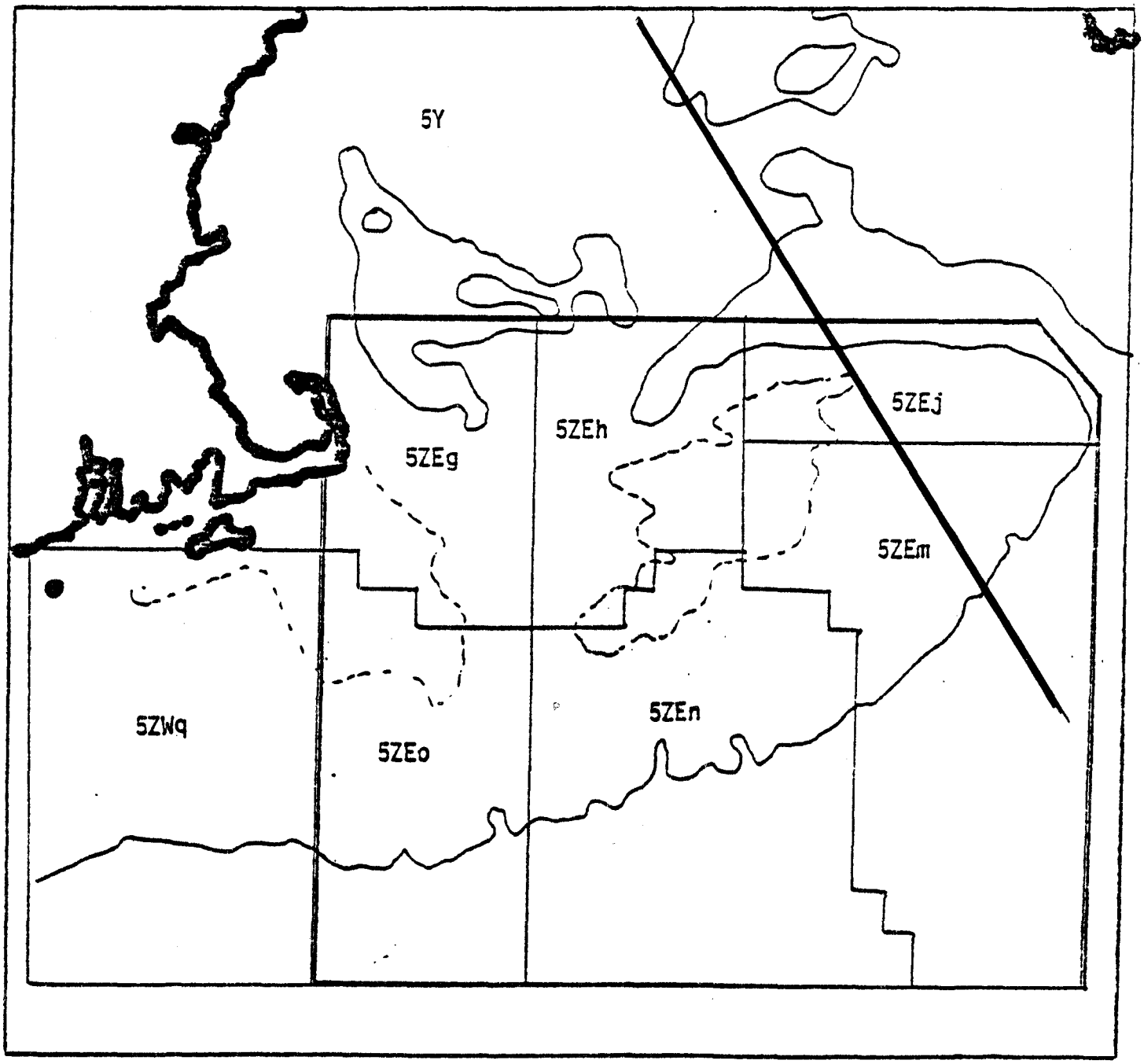


Figure 1. NAFO statistical areas for Georges Bank

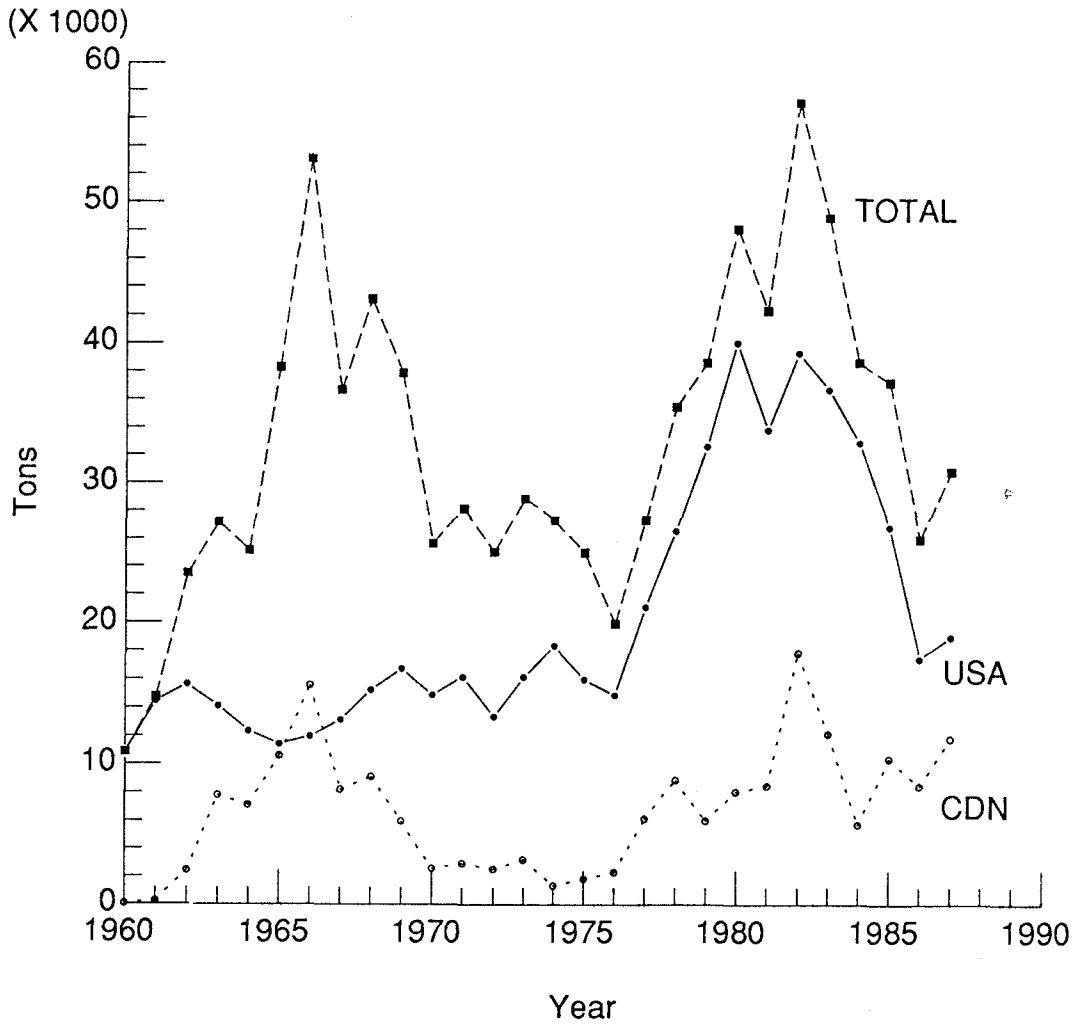


Figure 2. Reported landings of cod from NAFO Division 5Z and Subarea 6, 1960-87.

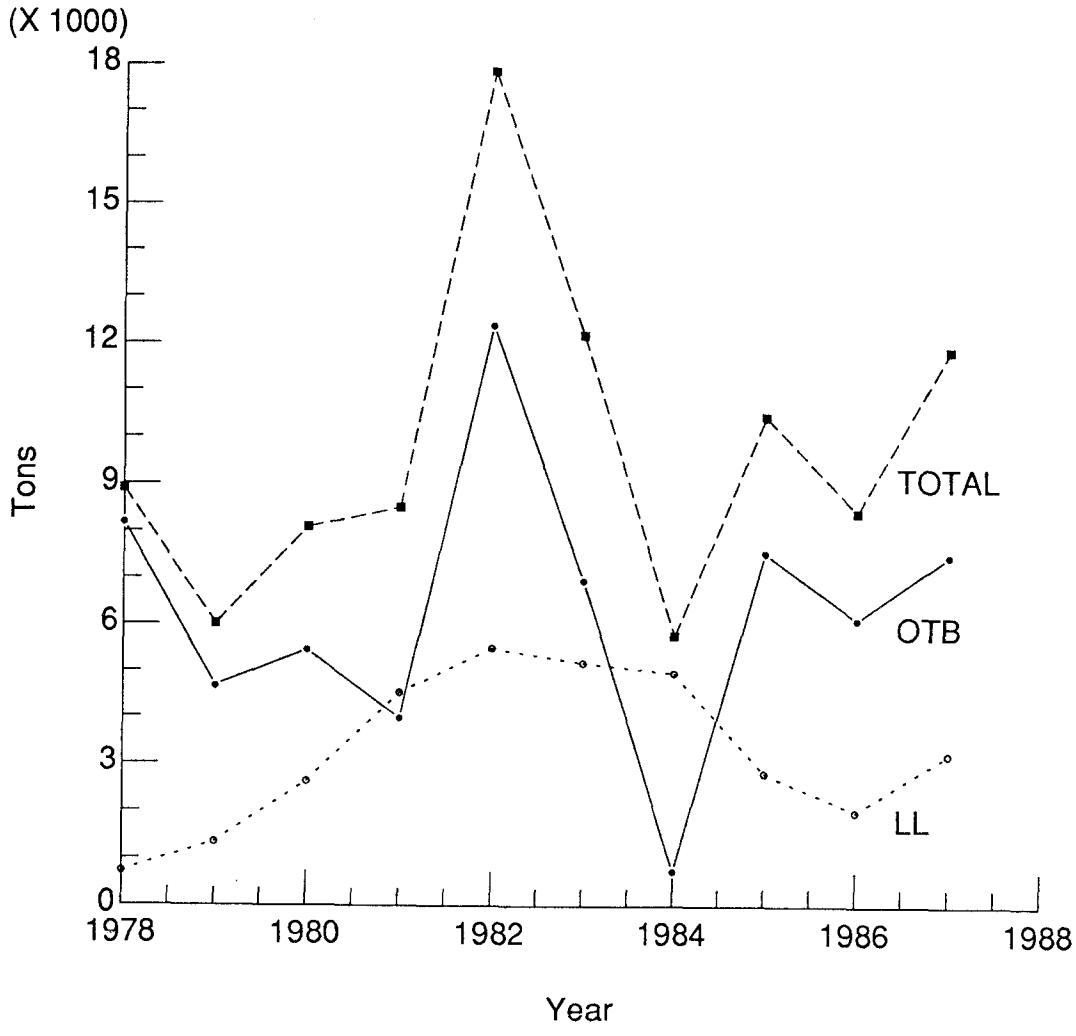


Figure 3. Reported Canadian landings of cod by gear type, 1978-87.

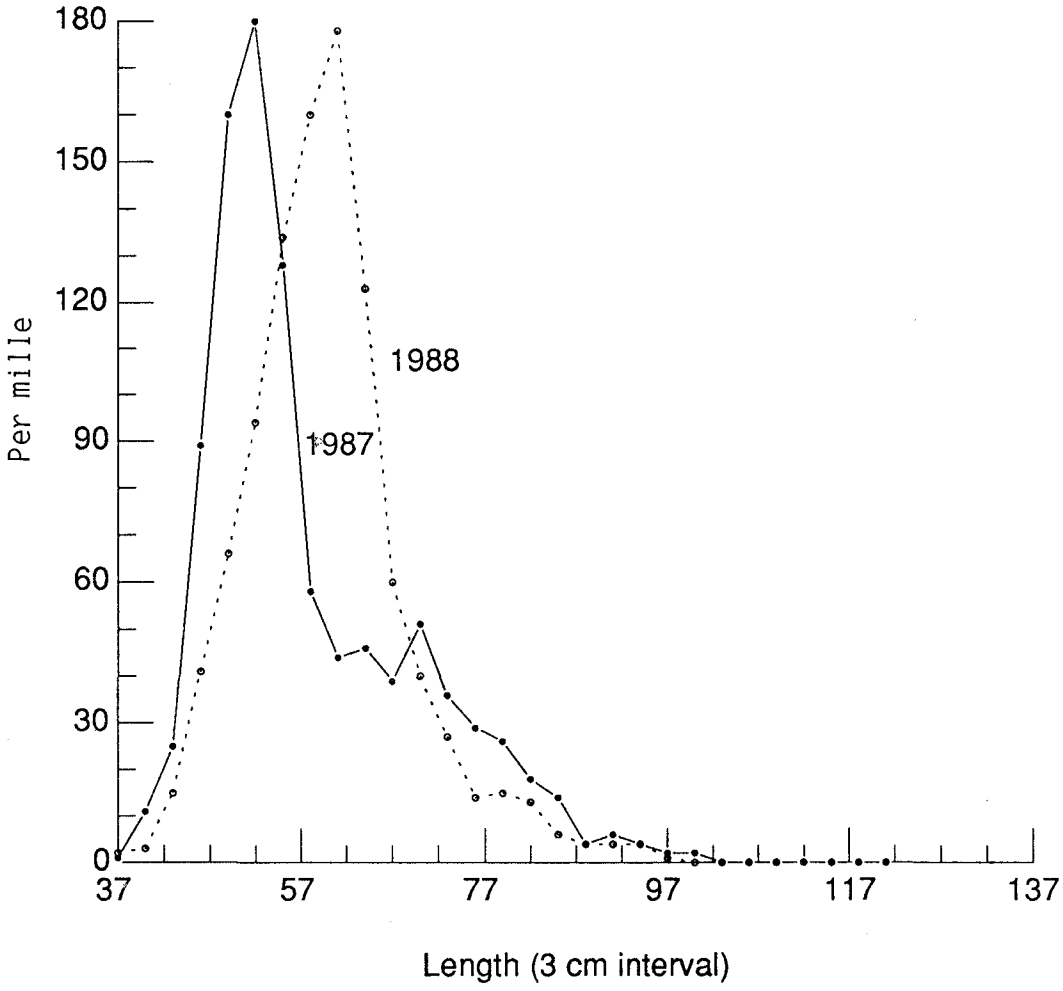


Figure 4. Comparison of 1987 and 1988 (preliminary) length frequencies taken by Canadian otter trawlers.

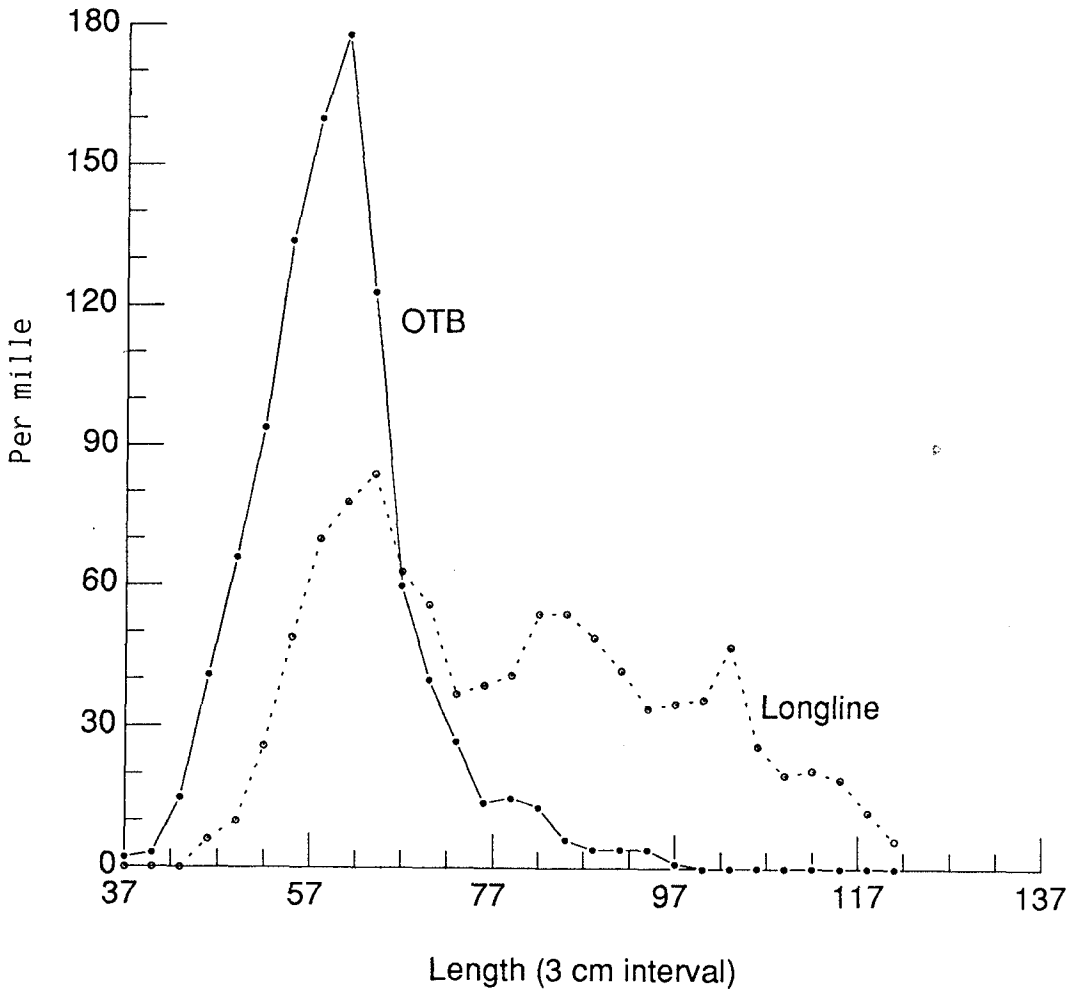


Figure 5. Estimated length composition of 1988 (preliminary) Canadian landings for otter trawl and longline.

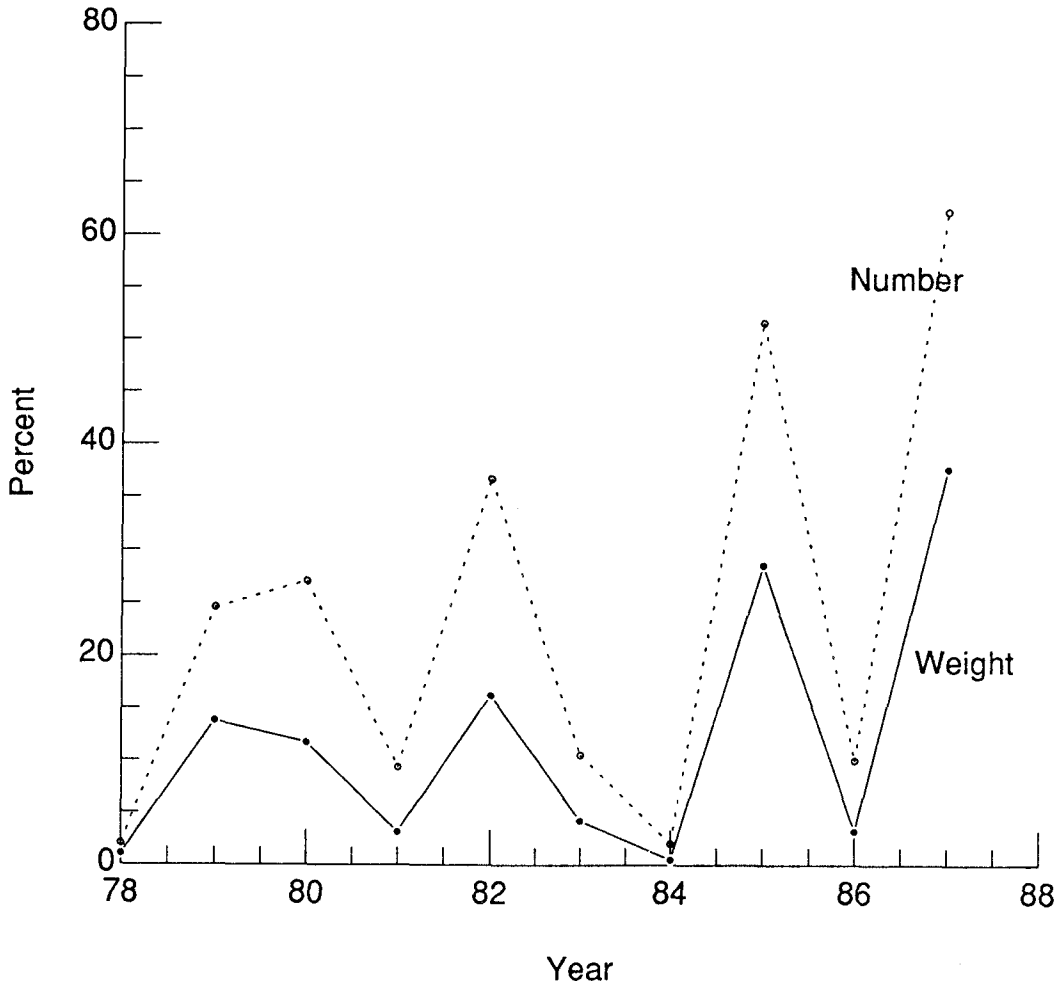


Figure 6. Percent composition in number and weight for agegroup 2 in Canadian landings.

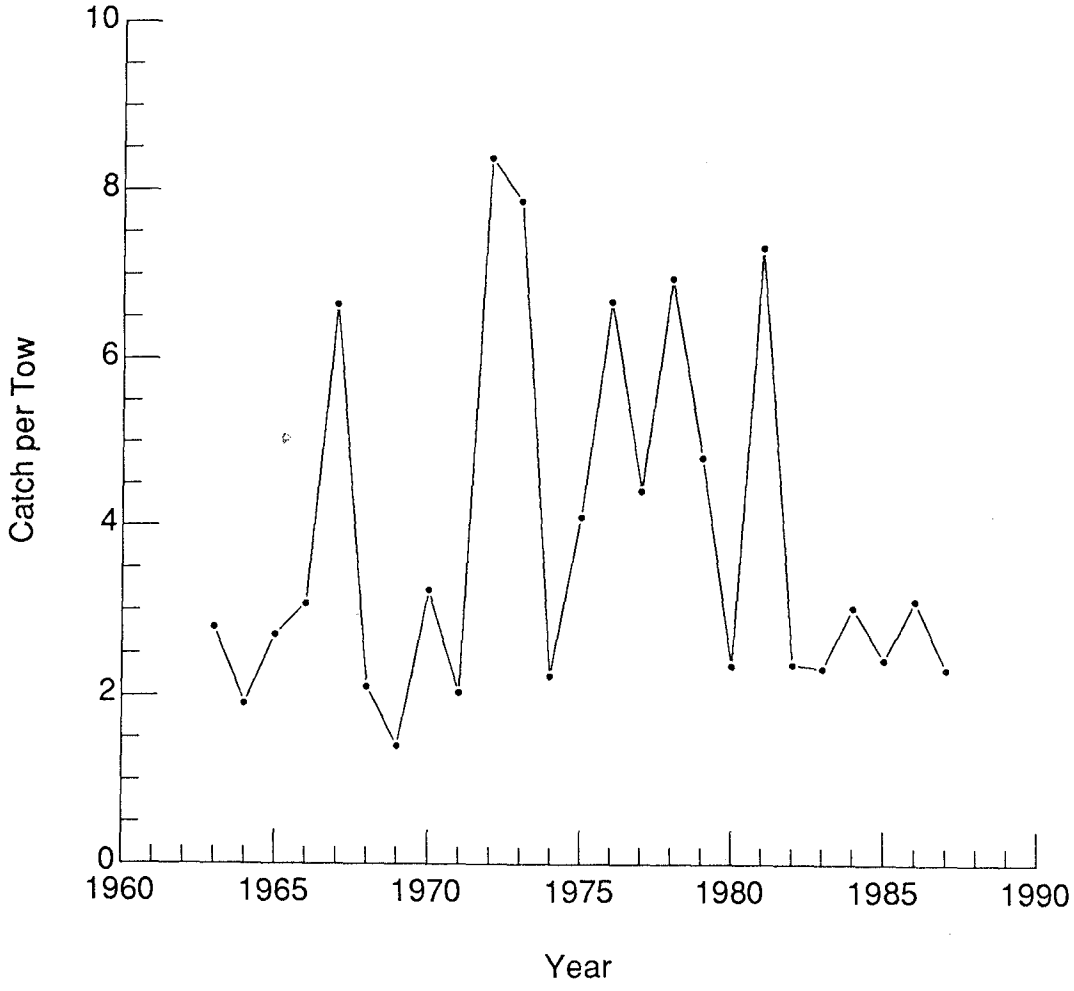


Figure 7. Stratified mean catch per tow for USA autumn survey.

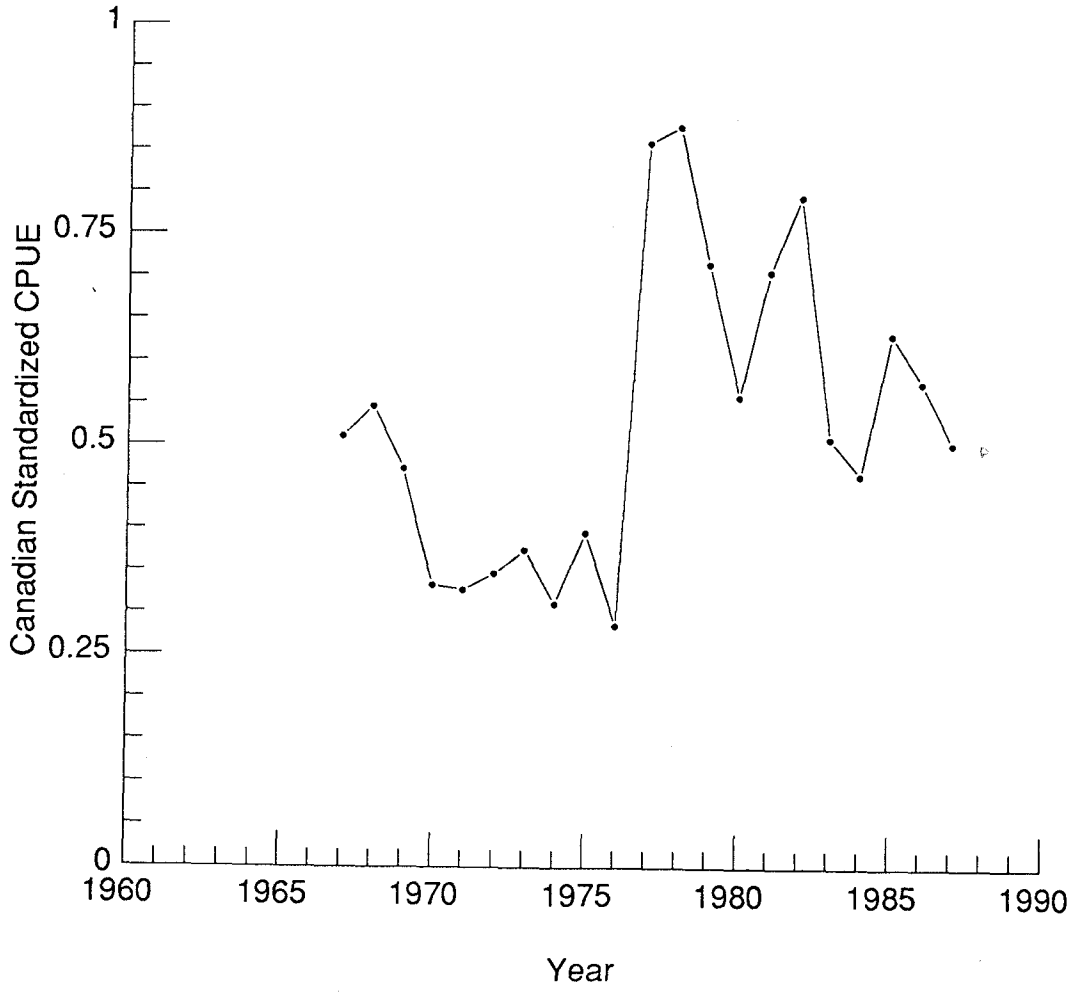


Figure 8. Standardized CPUE (t/hr) for Canadian otter trawlers.

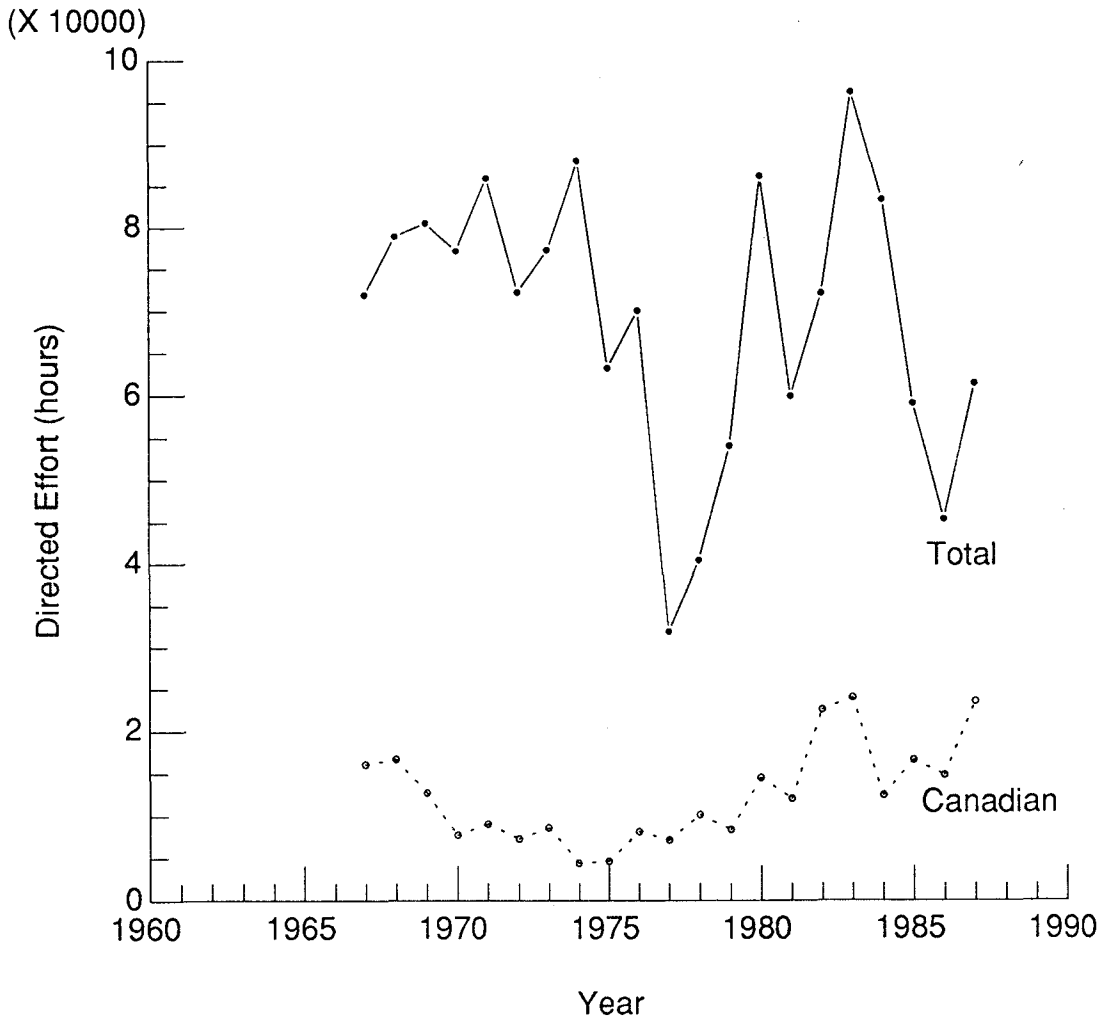


Figure 9. Directed effort derived from Canadian CPUE for Canadian and and total landings.

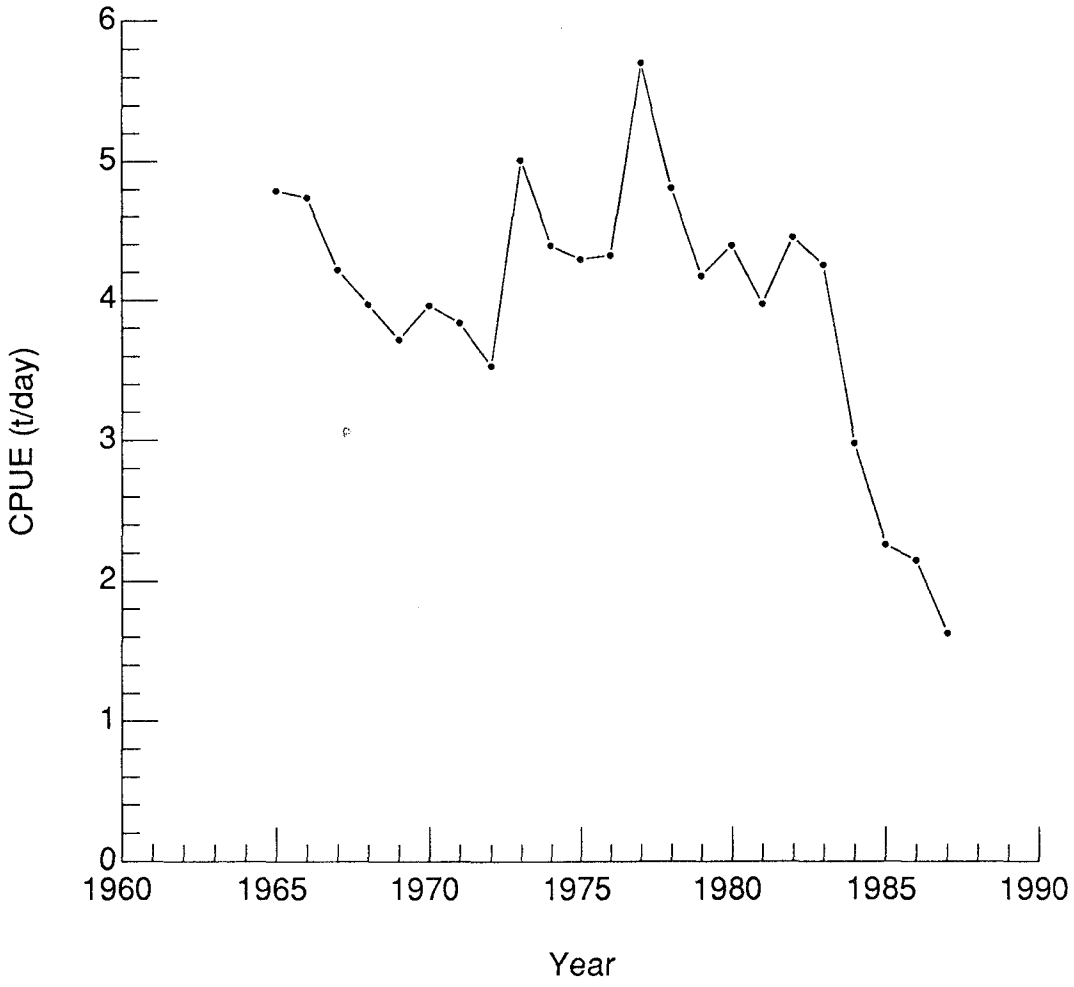


Figure 10. Catch rate (t/day) for USA otter trawlers directing on cod (>50% catch).

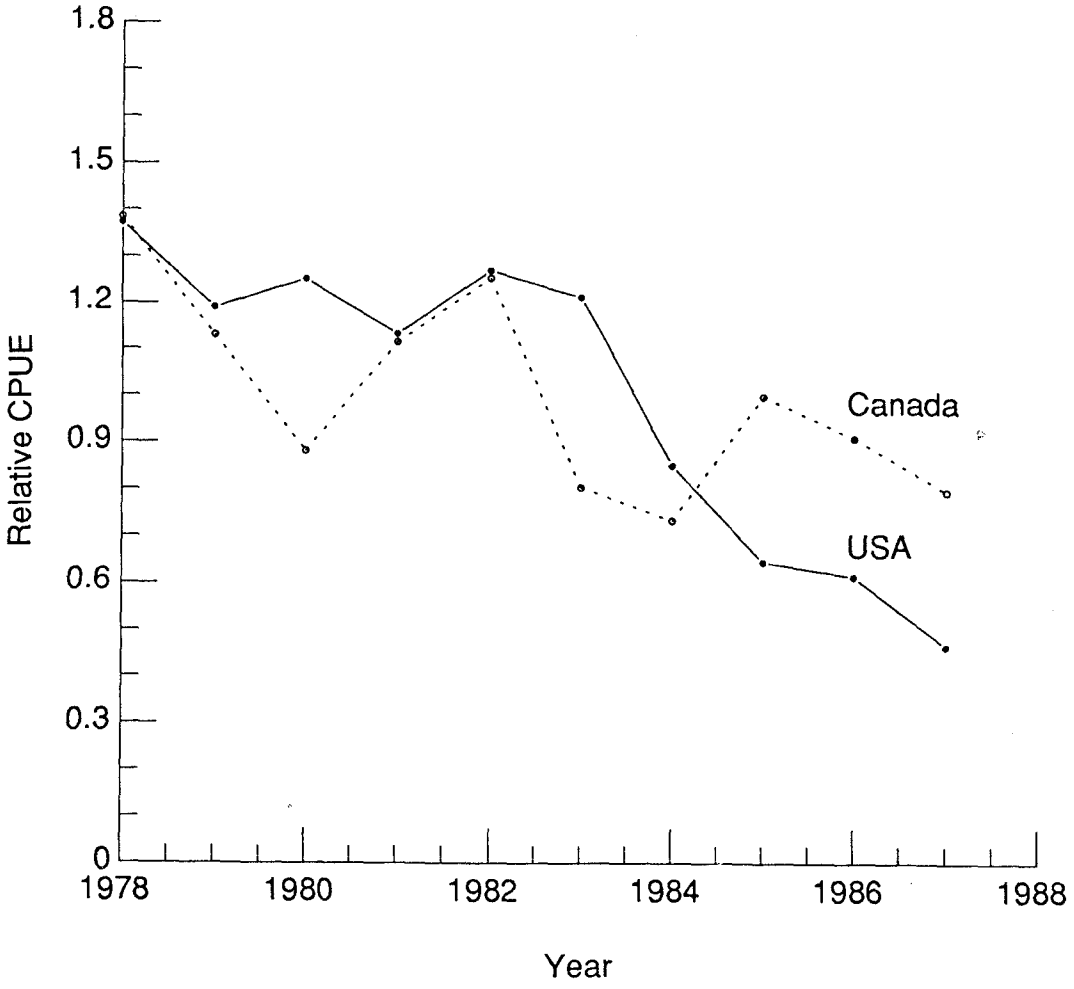
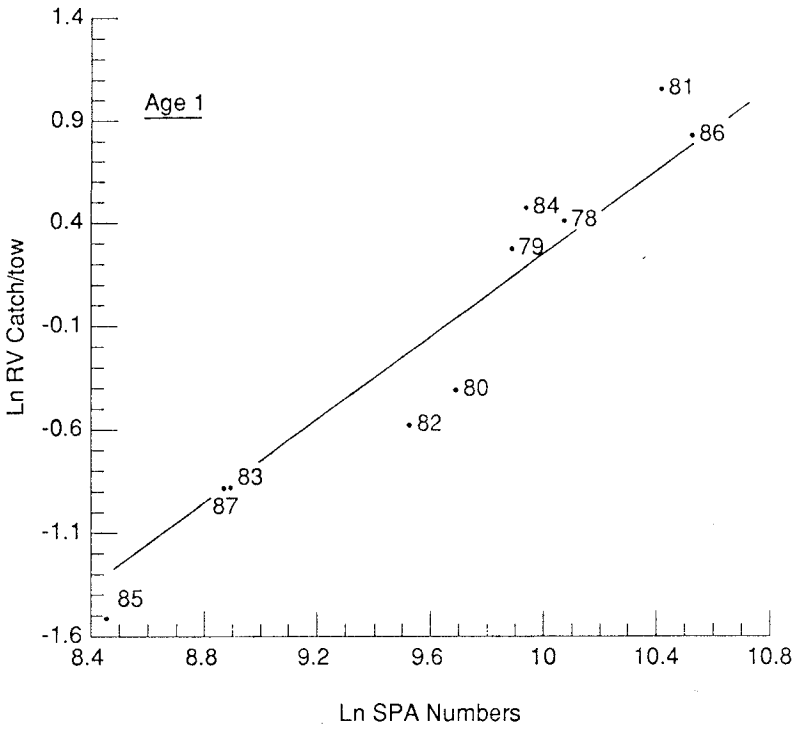


Figure 11. Comparison of relative CPUE (standardized to 1978-87 mean) for Canadian and USA otter trawlers.



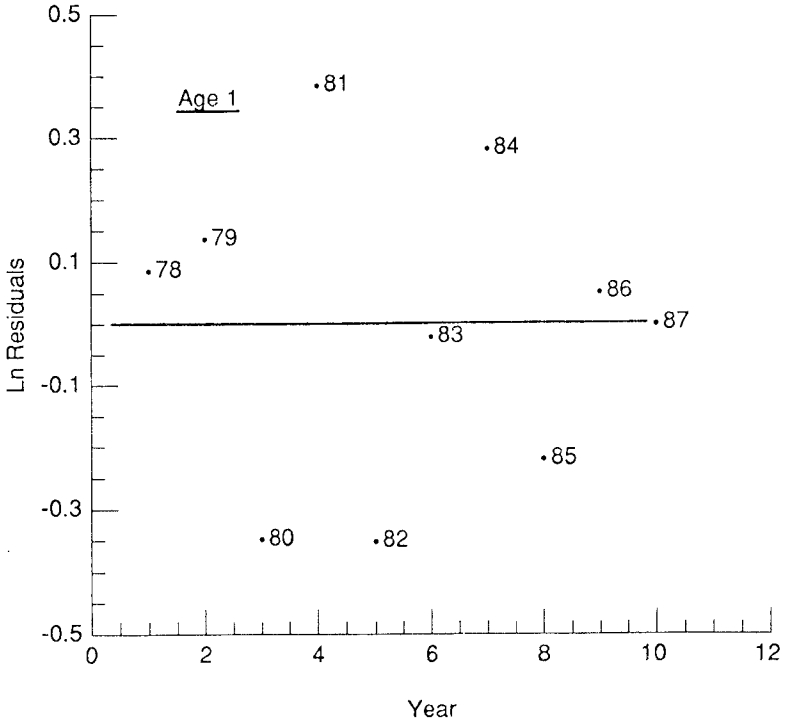
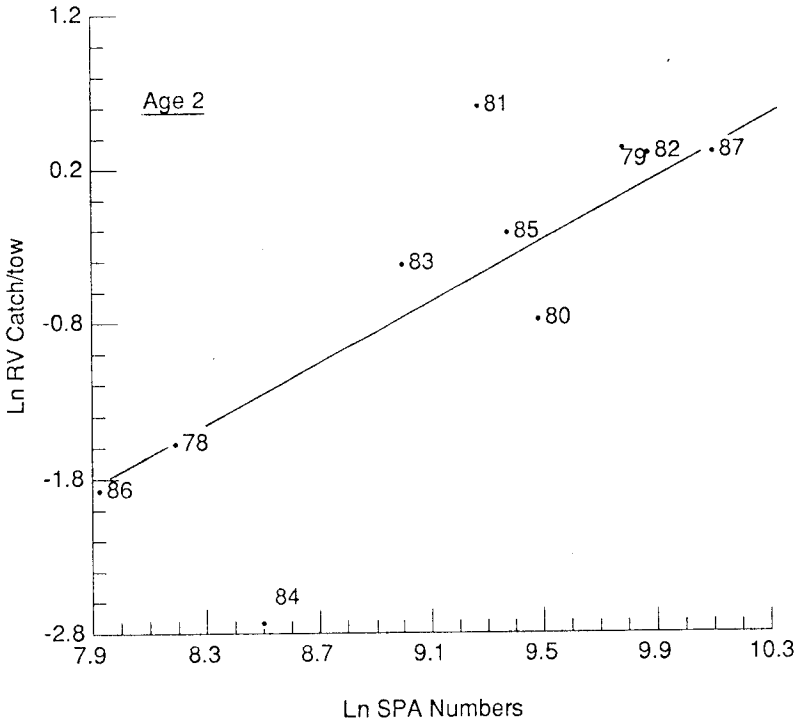
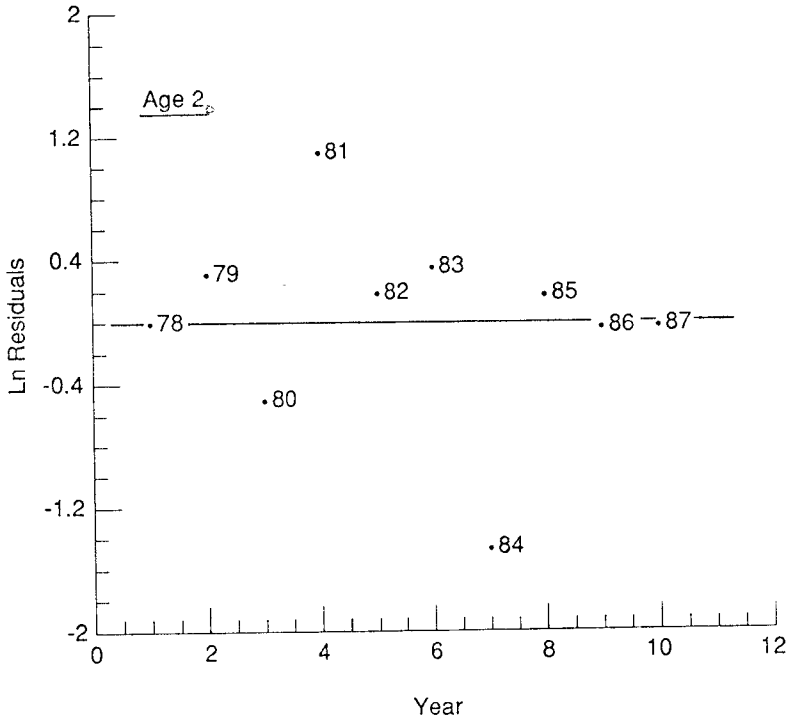
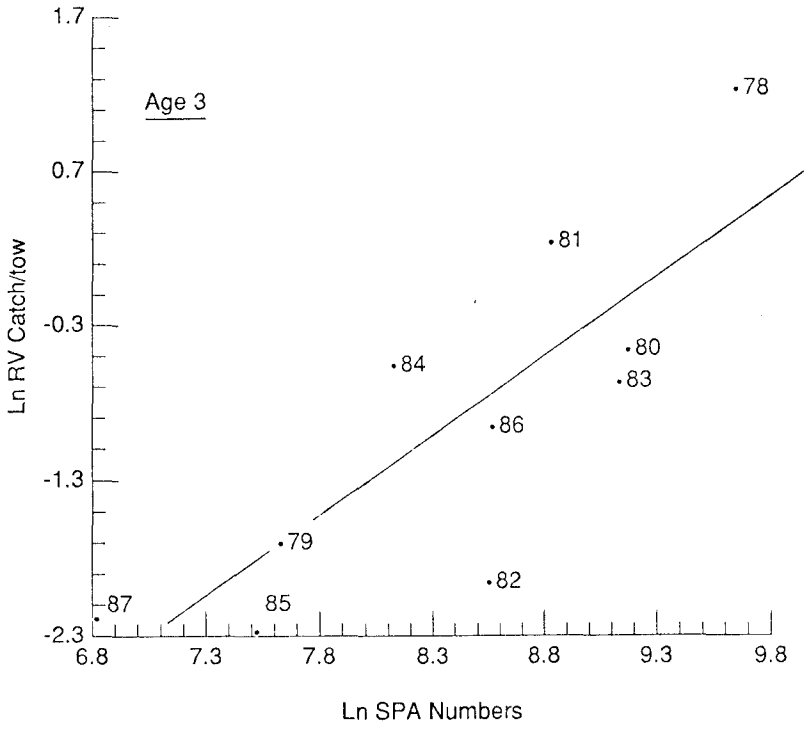
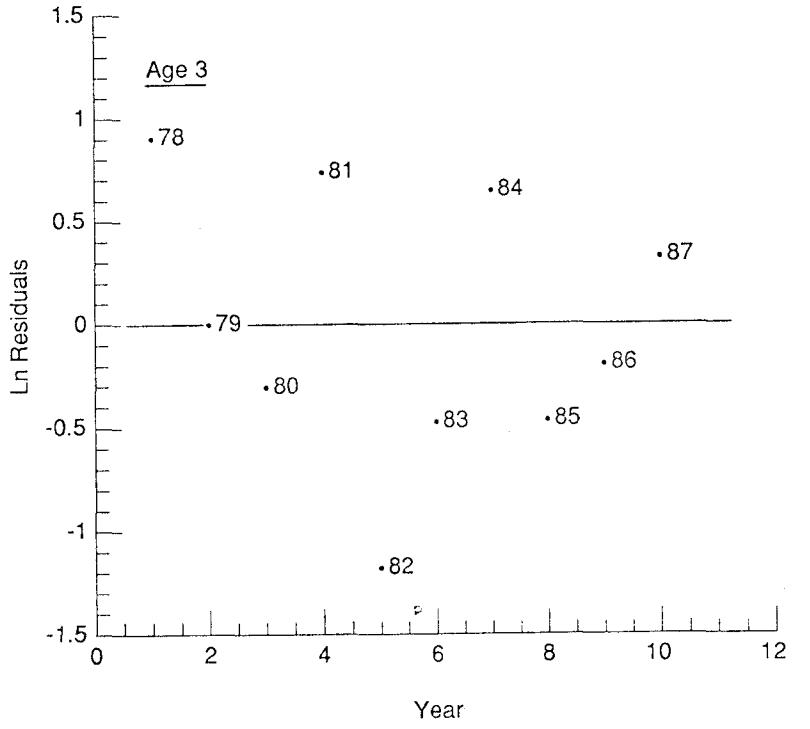


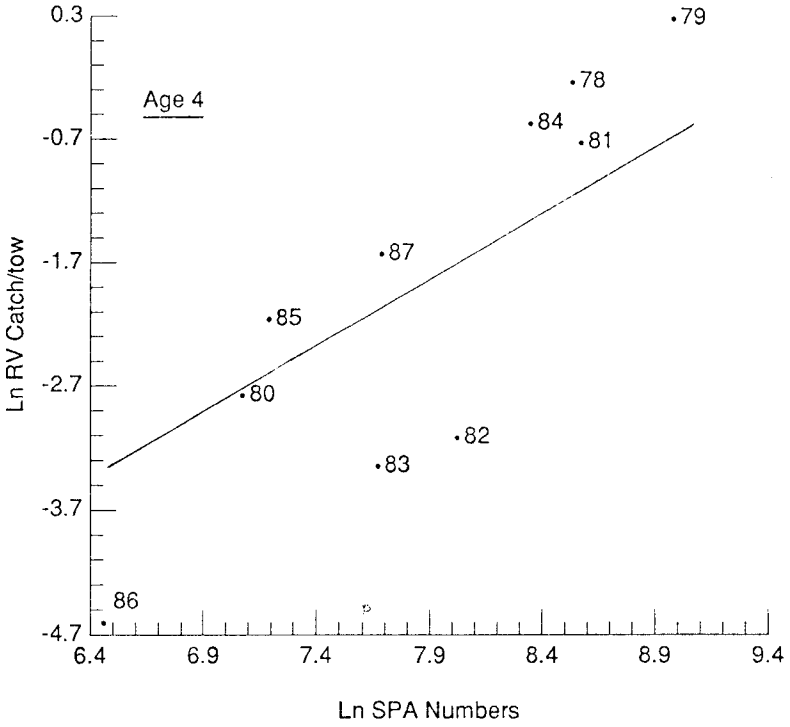
Figure 12. Relationship between USA fall survey and population numbers derived from ADAPT for ages 1-4 and trend in residuals over time.

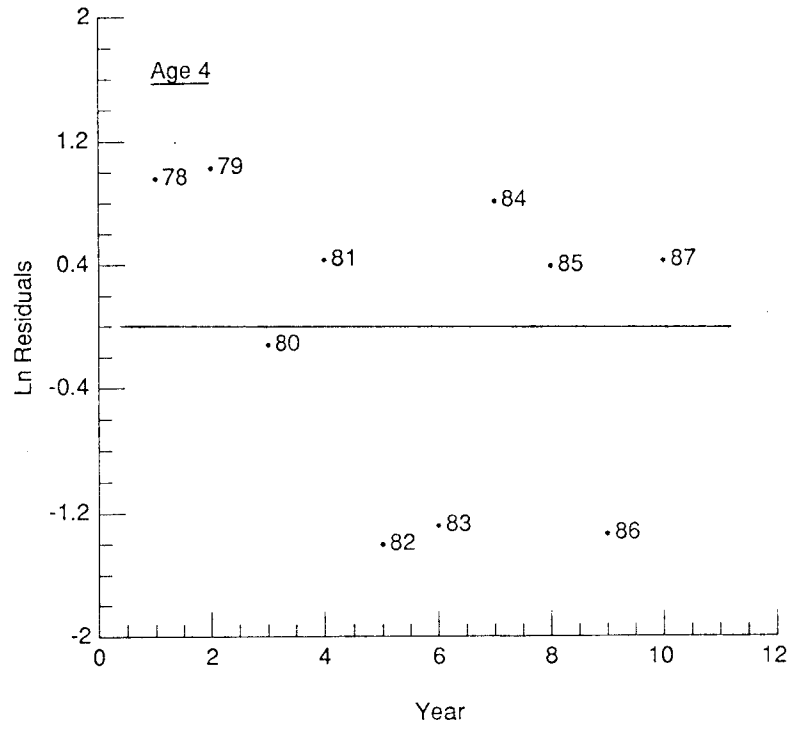

Age 2
1.2
0.2
-0.8
-1.8
-2.8
Ln RV Catch/tow
7.9
8.3
8.7
9.1
9.5
9.9
10.3
Ln SPA Numbers
81
79
82
87
85
83
80
78
86
84


Age 2
2
1.2
0.4
-0.4
-1.2
-2
Ln Residuals
0
2
4
6
8
10
12
Year
81
79
83
82
85
78
86
87
80
84


Age 3
Ln RV Catch/tow
Ln SPA Numbers
1.7
0.7
-0.3
-1.3
-2.3
6.8
7.3
7.8
8.3
8.8
9.3
9.8
78
81
80
83
84
86
79
82
87
85


Age 3
Ln Residuals
Year
1.5
1
0.5
0
-0.5
-1
-1.5
0
2
4
6
8
10
12
78
81
84
87
79
86
80
83
85
82


Age 4
Ln RV Catch/tow
Ln SPA Numbers
0.3
-0.7
-1.7
-2.7
-3.7
-4.7
6.4
6.9
7.4
7.9
8.4
8.9
9.4
79
78
84
81
87
85
80
82
83
86


Age 4
Ln Residuals
Year
2
1.2
0.4
-0.4
-1.2
-2
0
2
4
6
8
10
12
78
79
84
81
85
87
80
82
83
86

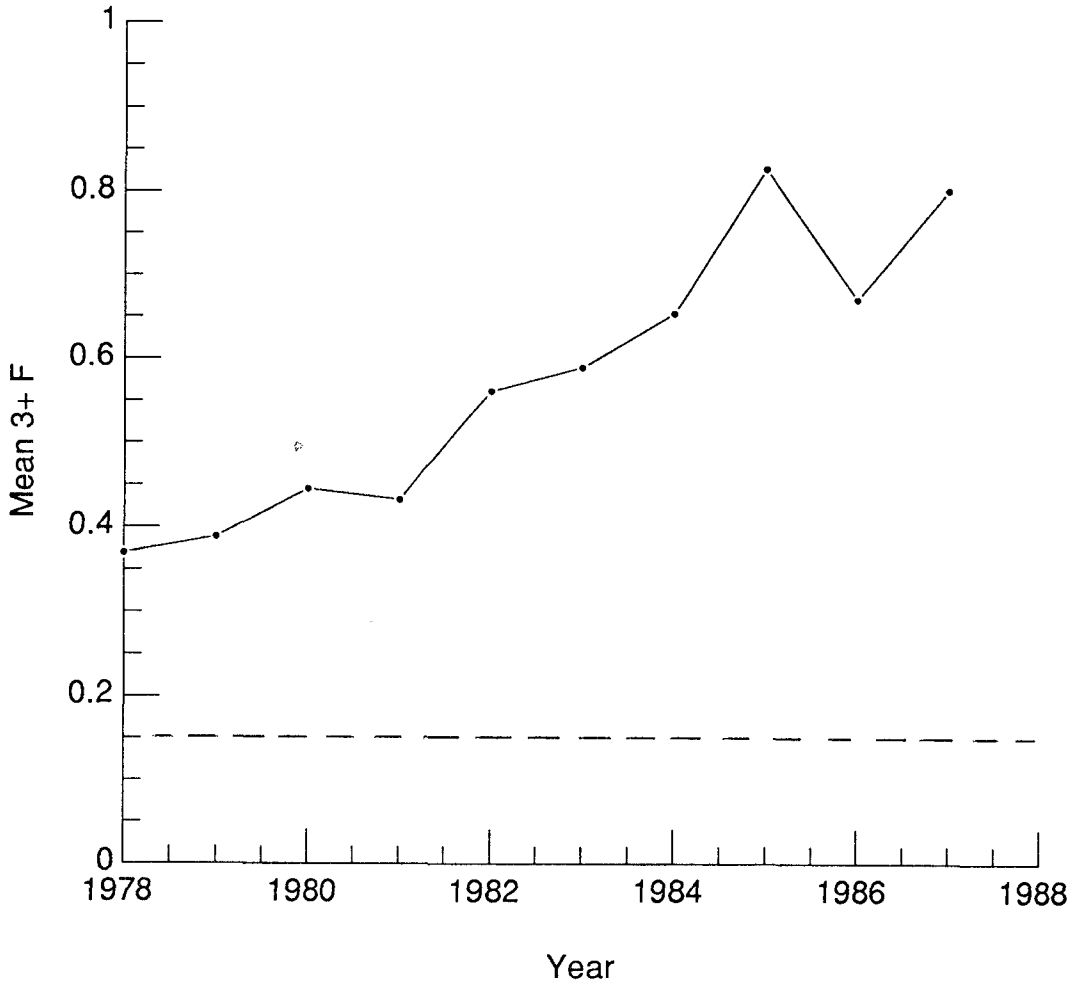


Figure 13. Trend in mean 3+ fishing mortality for 1978-87.

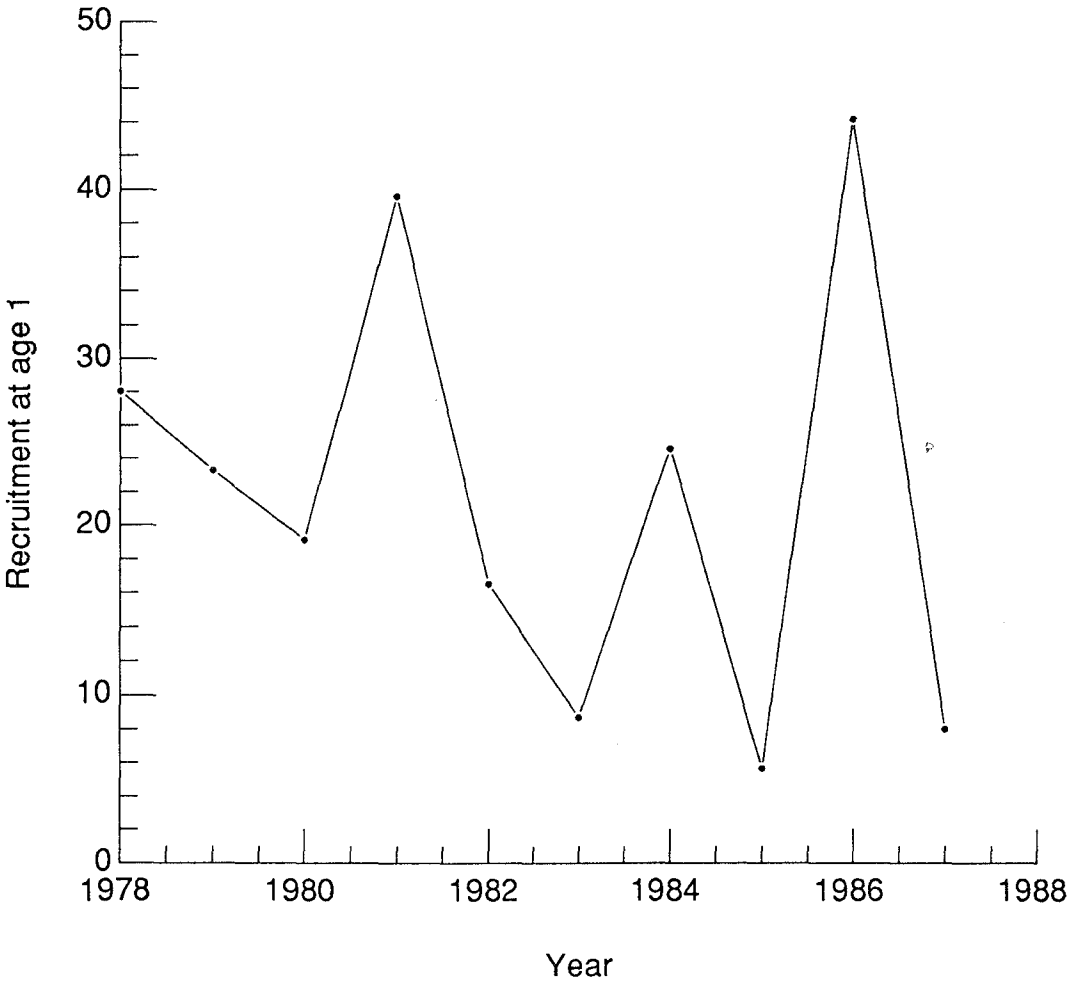


Figure 14. Estimated recruitment (millions of fish) at age 1 derived from sequential population analysis.

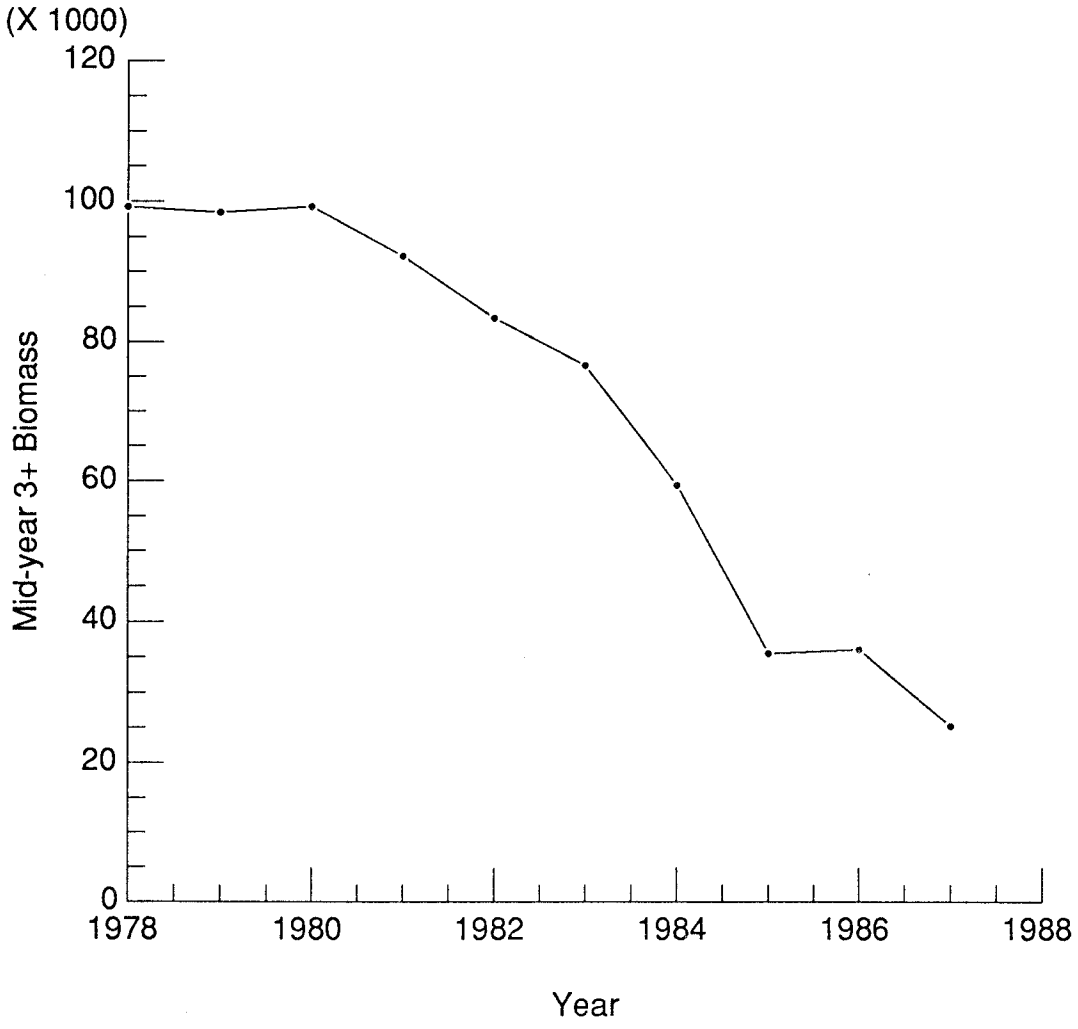


Figure 15. Estimated 3+ population biomass derived from sequential population analysis.