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ASSESSMENT AND STATUS OF THE GEORGES BANK AND GULF OF MAINE ATLANTIC COD STOCKS - 1986

by

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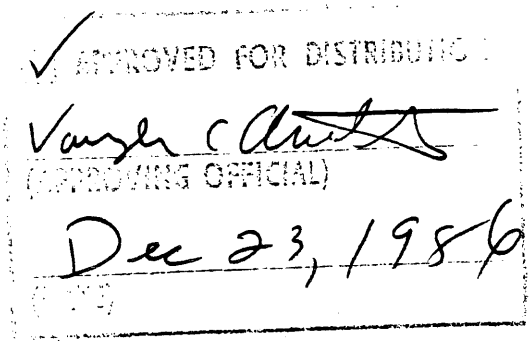

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SUMMARY

Annual commercial landings of Atlantic cod from the Georges Bank (NAFO Division 5Z and Statistical Area 6) and Gulf of Maine (NAFO Division 5Y) stocks, after steadily increasing from 30,100 metric tons (mt) in 1976 to 71,150 mt in 1982, sequentially declined to 49,400 mt in 1985. USA commercial landings in 1985 were 37,500 mt, the lowest since 1977. Canadian landings, which declined from 19,200 mt to 7,200 mt between 1982 and 1984, increased to 11,900 mt in 1985. Cod was the dominant species landed in the 1985 USA Atlantic coast groundfish fishery, accounting for more catch, by weight, than any other single species. Estimated USA recreational landings of cod in 1985 were 9,000 mt, 67% higher than in 1984, but similar to the 1981-1983 average of 8,300 mt.

Commercial 1985 landings from the Georges Bank cod stock was 37,269 mt, 4% less than in 1984. USA and Canada accounted for 72% and 28%, respectively, of the 1985 total. The USA catch was the lowest since 1978; the 1985 Canadian catch, 81% greater than in 1984, was the third highest since 1967. Total fishing effort in 1985 increased to a record-high level. Commercial CPUE, however, declined to a record-low. USA research vessel survey catch-per-tow indices in 1985 showed disparate patterns. The autumn indices were among the lowest ever (the autumn 1985 weight per tow value was a record-low) while the spring indices were relatively high. The elevated spring survey values, however, are believed to reflect an increase in catchability rather than abundance since virtually all of the 1985 catch-at-age indices were higher than in 1984.

The strong 1980 and 1983 year classes were predominant in the 1985 Georges Bank landings. The 1983 cohort accounted for 51% of the total catch in numbers and 26% in weight. The 1980 year class accounted for 13%, by number, and 25%, by weight, of the 1985 yield. Both year classes were similarly dominant in the 1985 research vessel surveys.

Virtual population analysis of commercial catch-at-age data indicated that fishing mortality (F) on the Georges Bank stock doubled between 1978 and 1985 (0.40 to 0.82). During this same period, spawning stock biomass declined by half (95,500 mt in 1978 to 46,200 mt in 1985), with the 1985 biomass level the lowest in the time series. Parallel trends in F and biomass were also produced from analyses of spring and autumn survey data. Yield per recruit calculations indicate that F in 1985 was far above $F_{0.1}$ (0.155) and F_{max} (0.280). Although VPA-survey relationships indicate that the 1985 year class is above average in strength, continued fishing in 1986 at the 1985 F level will result in further declines in both total and spawning stock biomass. If the 1986 catch approximates 30,000 mt (F=0.58) (likely based on Jan-Aug 1986 landings patterns), spawning stock biomass in 1987 will still be lower than in 1986, although total biomass will increase slightly (+3%) due to growth in weight of the 1985 year class. No rebuilding of total biomass can be expected during 1987 unless F in 1987 is reduced below F=0.58 and towards F_{max}.

Commercial Gulf of Maine cod landings in 1985 totaled 12,150 mt, 1% less than in 1984, and the lowest annual catch since 1979. USA landings (10,700 mt) were the lowest since 1976 while Canadian landings (1,450 mt), essentially unchanged from 1984, were half the 1983 level. Since substantial

misreporting of Canadian Scotian Shelf (NAFO Division 4X) cod landings as Gulf of Maine catch is believed to have occurred since 1982, recent total and Canadian (but not USA) landings trends are suspect. USA commercial fishery effort in 1985 increased to a record-high level while commercial CPUE remained at the historically low 1984 level. USA spring and autumn research survey indices in 1985 indicated an increase in stock abundance from 1984 although this increase may have been artifact caused by change in survey trawl doors used in the 1985 (and subsequent) surveys. The spring 1986 survey indices were significantly lower than 1985 spring values and about equal to the near-record low 1984 values.

The 1985 USA commercial catch was dominated by the 1980-1982 year classes. Together these cohorts accounted for 82% of the 1985 USA landings by number and 76% by weight. The same year classes were predominant in the 1985 research vessel surveys. Both the autumn 1985 and spring 1986 surveys indicated that the 1985 Gulf of Maine cod year class may be a strong one.

Estimates of fishing mortality derived from analyses of USA research vessel survey data indicate that F during 1982-1985 was 0.62, about twice the 1977-1981 F level (0.32) and well above F_{max} (0.30). Given the current record-high effort, low commercial CPUE values, and low survey abundance indicators, short-term annual yields at the 1985 level (12,000 mt) do not appear to be sustainable. Presently, potential yield and stock reproductive potential can be enhanced by reducing F towards F_{max}.

INTRODUCTION

The Georges Bank and Gulf of Maine Atlantic cod (Gadus morhua) stocks are significant components of the demersal finfish resource off the northeast coast of the United States. Combined commercial landings (nominal catches) from these stocks have fluctuated fivefold during the past 25 years, from a low of 14,400 metric tons (mt) in 1960 to a peak of 72,150 mt in 1982 (Table 1). Aggregate annual landings doubled between 1976 and 1982 (30,100 mt to 72,150 mt) but subsequently have sequentially declined. Total commercial landings in 1985 were 49,400 mt, the lowest annual catch since 1978. Since 1978, only the USA and Canada have been permitted (under extended fisheries jurisdiction legislation in both countries) and harvested cod from the two stocks. Between 1978 and 1984, the average catch from the two stocks was 57,900 mt, with the USA accounting for 82% of the total. In 1985, the USA catch (37,500 mt), the lowest since 1977, comprised only 76% of the total. Canadian landings, which declined from 19,200 mt to 7,200 mt during 1982-1984, increased in 1985 to 11,900 mt (24% of the 1985 total). Despite the decline in total USA cod catches in recent years, cod has remained the predominant species landed in the USA Atlantic coast groundfish fishery. In 1985, cod accounted for more catch, by weight, than any other species in this fishery and was so dominant that cod landings exceeded the 1985 USA landings of haddock, pollock, and yellowtail flounder combined (United States Department of Commerce 1986a). Additionally, important recreational fisheries for cod occur along the northeast coast from Maine to New Jersey. In 1985, an estimated 9,000 mt of cod were taken by marine recreational anglers (United States Department of Commerce 1986b).

Three major groups of cod have generally been identified in USA Atlantic coast waters: (1) Georges Bank; (2) Gulf of Maine; and (3) Southern New England-Middle Atlantic (Serchuk et al. 1982). Although the Gulf of Maine population is generally distinct from either of the two more southerly groups (based on tagging studies, parasite infestation studies, growth rate analyses, and recruitment patterns), strong affinities exist between Georges Bank and Southern New England-Middle Atlantic cod (Serchuk and Wood 1979). These similarities are so pronounced that, since 1977, the two groups have been managed as a single stock unit (i.e., Georges Bank and South; herein referred to as Georges Bank stock).

This report presents current assessments of the Georges Bank (NAFO [Northwest Atlantic Fisheries Organization] Division 5Z and Statistical Area 6) and Gulf of Maine (NAFO Division 5Y) cod stocks based on examination of commercial and recreational fisheries data and research vessel survey results. The status of each stock is reviewed and quantitative (Georges Bank) and quali tative (Gulf of Maine) stock and catch projections provided for 1986-1987.

MANAGEMENT

Prior to March 1977, when a Fishery Management Plan (FMP) for Atlantic Groundfish (Atlantic cod, haddock, and yellowtail flounder) was implemented to manage cod under authority of the Magnuson Fishery Conservation and Management Act, Subarea 5 cod fisheries were managed by the International Commission for the Northwest Atlantic Fisheries (ICNAF). Regulatory measures enacted by ICNAF included minimum cod-end mesh sizes, by-catch restrictions on cod in

small mesh fisheries, closed seasons and areas (as part of the haddock spawning closure areas) and annual quotas (see Serchuk and Wood 1981 for a detailed account of ICNAF management regulations). Since 1977, USA Atlantic cod fisheries have been regulated under three different management plans (the initial FMP from 15 March 1977 to 30 March 1982; the Interim Plan for Atlantic Groundfish from 31 March 1982 to 18 September 1986; and the FMP for the Northeast Multispecies Fishery from 19 September 1986 to the present). Management measures implemented under each of these plans have varied but have included annual and quarterly catch quotas, weekly and/or trip landings restrictions by vessel size class and gear type, minimum mesh sizes, closed seasons and areas, incidental catch restrictions, fishery closures, licensing and record keeping/reporting requirements, minimum landings sizes of fish, and small mesh/large mesh fishing areas and seasons (see Serchuk et al. 1982, and Serchuk and Wood 1979, 1981 for a more complete account of regulatory actions). The Northeast Multispecies Plan established a 5 1/2" (140 mm) minimum cod end mesh size; regulated and exempted mesh areas; a minimum landings size [total length of 17 inches (43 cm) for cod taken by commercial vessels and 15 inches (38 cm) for cod taken by recreational fishermen]; closed seasons and areas (principally for haddock and yellowtail flounder but prohibiting all trawl fishing); and administrative and reporting procedures. Operationally, the Plan makes no formal distinction among the various stocks of individual species (including the two cod stocks) within the management region (Eastern Maine through Southern New England). Currently, the Northeast Multispecies Plan regulations will regulate cod and other groundfish fishing activity until 30 September 1987.

After withdrawal from ICNAF at the end of 1977, Canada established a management program for cod (and haddock) on Georges Bank (NAFO Division 5Z) based on annual catch allocations for the Canadian fishery. For Georges Bank cod, Canadian catch allocations in 1985 and 1986 were set at 25,000 mt and 11,000 mt, respectively (Joe Hunt, DFO, Canada: pers. comm.). Additional management measures include minimum cod-end mesh sizes, a haddock spawning closure area, limited entry of vessels in the Canadian offshore groundfish fleet, and catch reporting requirements (logbook system).

In October 1984, the International Court of Justice in the Hague delimited a maritime boundary between the USA and Canada in the Gulf of Maine-Georges Bank area. Subsequently, fishing activity by each country has been restricted to its own waters. This has effectively partitioned the extant fishery resources (often across generally accepted stock boundaries) between the two nations. As a result, a portion of the Georges Bank cod stock is managed separately and independently by each country.

RECREATIONAL FISHERY LANDINGS

Estimates of recreational cod landings by USA marine anglers are available from the national saltwater angling surveys conducted in 1960, 1965 and 1970 (Clark 1962; Deuel and Clark 1968; Deuel 1973), a 1974 northeastern coast regional marine recreational survey (Ridgely and Deuel 1975; Deuel, pers. comm.), and annual National Marine Fisheries Service (NMFS) Marine Recreational Fishery Statistics Surveys (MRFSS) conducted since 1979 (United States Department of Commerce 1984; 1985a, b; 1986b). The latter series of surveys are considered the most reliable relative to catch data since they

employed a standardized statistical design involving a combination household telephone survey and an intercept (on-site creel census) survey to obtain landings data at the species level.

Recreational cod catch estimates during 1960-1985 range between 3,800 mt (1979) and 16,300 mt (1970) (Table 2). The highest estimates were derived prior to 1979 but must be considered tentative due to methodological weaknesses and differences in survey procedures in these years (United States Department of Commerce 1979: p. 21). Since 1981, annual recreational cod landings have exhibited little variability. Apart from 1984, recent annual catches have been between 8,000-9,000 mt, and averaged 8,500 mt per year. The 1985 catch estimate (8,982 mt) is the highest in the MRFSS series.

In addition to annual catch estimates, the MRFSS surveys provide summary data on the distribution of recreational catches by geographical region, state, area of fishing, and mode of fishing. For cod, these data are presented in Appendix Tables 1-4, respectively. The data indicate that most of the recreational cod landings are taken in the North Atlantic region (Maine to Connecticut), in Federal Conservation Zone waters (>3 mi from shore) using party/charter and private/rental boats. Massachusetts landings exceed those of any other state.

The MRFSS surveys do not provide data on the distribution of landings by stock area, precluding apportionment of cod catches between the Georges Bank and Gulf of Maine stocks. Efforts are underway to modify the MRFSS geographical reporting system to facilitate assignment of catches in future surveys to standard NMFS statistical areas. Due to the lack of stock information for the completed 1979-1985 surveys, recreational cod catches have not been included in any of the present assessment analyses.

GEORGES BANK STOCK

COMMERCIAL LANDINGS

Landings of Georges Bank cod have ranged between 10,900 mt (1960) and 57,200 mt (1982) since 1960 (Table 1; Figure 1). In the mid- and late-1960s, landings sharply increased due to increased exploitation by Canada and distant-water fleets. Annual catch during 1965-1969 averaged 41,900 mt, at the time the highest five-year average since the early 1900s. Landings declined after 1968 but stabilized between 25,000 and 29,000 mt during 1970-1975. From 1976 to 1982 landings steadily increased reaching their highest level in the century in 1982. Subsequently, annual landings have consecutively declined.

Total catch in 1985 was 37,300 mt, 4% lower than in 1984, and the lowest annual yield in seven years. The USA and Canada, sole participants in the fishery since 1978, accounted for 72% and 28%, respectively, of the 1985 total. The 1985 USA catch (26,800 mt) was the lowest since 1978 while Canadian landings (10,500 mt), nearly twice (+81%) the 1984 level, were the third highest since 1967.

As in the past, otter trawl catches accounted for most (82%) of the total 1985 catch. The otter trawl fishery accounted for 86% of the 1985 USA landings (Table 3) and 72% of the Canadian catch (Stratis Gavaris, DFO,

Canada; pers. comm.). During 1978-1985, 87% of the USA catch (Table 3) and 63% of the Canadian catch (Hunt and Waiwood 1985) was attributable to otter trawl gear.

CATCH COMPOSITION

Sampling Intensity - A summary of USA and Canadian length frequency and age sampling of Georges Bank cod landings during 1978-1985 is presented in Table 4. USA length frequency sampling averaged one sample per 339 mt landed over the eight year period but, since 1982, has improved to one sample per 273 mt landed. Virtually all of the USA samples have been taken from otter trawl catches but sampling is proportionally stratified by market category (scrod, market, and large). Of the 100 USA samples collected in 1985, 34 were scrod samples, 42 were market, and 27 were large. This distribution of samples was nearly identical to the 1985 USA market category catch distribution (Table 5). Comparison of market and large cod length frequency samples from otter trawl catches with those obtained from fixed gear (a few samples from gill nets and longlines) revealed no obvious differences in size composition of fish, within market category, by gear.

Canadian sampling intensity has been much lower than that in the USA fishery. During 1978-1985, Canadian sampling coverage averaged one length frequency sample per 571 mt landed. Between 1982 and 1984, sampling was less intense averaging one sample per 917 mt landed, but significantly improved in 1985 (one sample per 360 mt). Canadian samples are biased towards otter trawl catches (Hunt and Waiwood 1985) except for 1984 when all seven samples were obtained from longline gear (unlike recent years, however, the 1984 Canadian fishery was dominated by longline landings which accounted for 86% of the Canadian Georges Bank cod catch). Canadian sampling is not done by market category but representative samples of the catch are taken.

Construction of the Catch-at-Age Matrix - Age composition of USA landings during 1978-1985 was estimated, by market category, from monthly length frequency and age samples, pooled by calendar quarter. Quarterly mean weights, by market category, were obtained from applying the USA cod length-weight equation ($\ln \text{Weight}_{(kg,live)} = -11.7231 + 3.0521 \ln \text{Length}_{(cm)}$) to the quarterly market category sample length frequencies. Mean weight values were then divided into quarterly market category landings to derive estimated numbers landed by quarter, by market category. Quarterly age/length keys were then applied to the quarterly market category numbers at length distributions to provide numbers at age. These values were summed over market categories and quarters to attain the annual USA catch-at-age matrix (Table 6). Derivation of catch by quarter, rather than by month, was performed since not all months had at least two length frequency samples per market category (i.e., minimum desired for monthly catch estimates).

For many of the length frequency samples, sample weights were also available. These were converted (x1.17) to live weights and compared to the calculated weights fromthe length-weight equation. In most cases, the differences were small (<5%) implying that use of the length-weight equation to derive catch numbers imparted little, if any, bias to the catch calculations.

Canadian catch-at-age data for 1978-1984 (Hunt and Waiwood 1985) differed noticeably in most years from USA age composition data. These differences seem related to interpretation of otolith age markings with a tendency for Canadian-aged fish to be older than USA-aged fish at the same length. A two-day aging workshop was held in Woods Hole in May 1986 to address the apparent disparity in age determination between the two countries. Discussions at the workshop indicated that Canadian age readers were consistently over-aging Georges Bank cod by one year relative to USA age readers (a large settling check inside the first annulus was being counted as an annulus).

Canada is currently in the process of re-evaluating and revising its Georges Bank cod catch-at-age matrix. Pending completion of these revisions, USA age/length keys and age composition data were used to calculate Canadian and total catch-at-age values for 1978-1985. Three different procedures were used:

1) For 1978-1983, annual Canadian catches (in weight) were distributed, by age, using the USA catch in weight at age compositions for each year. The derived Canadian weight landed at age values were subsequently divided by the USA catch mean weight at age values to obtain Canadian catch numbers at age. The Canadian catch values (both numbers and weight) were then added to the corresponding USA values to provide total fishery removals at age (This procedure essentially "raises" the USA data to the total catch).

2) In 1984, almost all of the Canadian catch (86%) was taken by longlines. It was deemed inappropriate to use the 1978-1983 method to derive the Canadian catch at age since 87% of the 1984 USA catch was taken by otter trawls (Table 3). Analysis of USA 1984 longline catch, by market category, indicated that 56% of the USA Georges Bank longline catch was "large" cod and 44% was "market" cod. Accordingly, the 1984 Canadian catch was considered to be comprised of 3,226 mt (56%) of large cod and 2,535 mt (44%) of market cod. These estimates were divided by the mean weight of large and market cod in the 1984 USA fishery (8.7231 kg and 3.3919 kg, respectively) to obtain Canadian catch numbers at age in the two market categories (370,000 large fish; 747,000 market fish). These values were then apportioned to age based on the 1984 USA age compositions for each market category. The estimated numbers at age were subsequently summed over both market categories to produce the 1984 Canadian catch-at-age vector, and finally added to the USA 1984 values to generate the 1984 fishery age composition.

3) In 1985, Canadian catch data were available by month and gear type (otter trawl; longline; and "other"). "Other" gear landings (92 mt) were combined with the Canadian otter trawl catch to delimit only two catch categories (7,636 mt, otter trawls, 2,805 mt, longlines). For each category, landings were totaled by calendar quarter. Estimated quarterly Canadian catches (in weight) by market category, gear type, and quarter were then derived using 1985 USA market category composition data (% by weight) for each gear type, within each calendar quarter. Catch weights were summed for each market category, within each quarter, over the two gear types (i.e., producing quarterly catch estimates, by weight, of large, market, and scrod cod). Catch estimates (by number of fish in each market category in each quarter) were obtained by dividing the quarterly market category catch in weight values by the corresponding USA 1985 mean weight per fish values for each market category and quarter. The estimated total number of fish caught

in each market category and quarter were then apportioned to length groups using the quarterly USA market category sample distributions. The 1985 USA quarterly age/length keys were subsequently applied to the length frequencies to determine numbers-at-age. Finally, the numbers-at-age were summed over market categories and quarters to give the annual Canadian catch by age group, and combined with the USA data to produce the overall 1985 catch matrix (Table 7).

Total numbers-at-age catch data from the Georges Bank stock are presented in Table 8.

Both USA and Canadian catches in 1985 were dominated by the 1980 and 1983 year classes (Table 7). The 1983 cohort at age 2 accounted for 51% of the total catch in numbers and 26% by weight. The 1980 year class accounted for 13% by number and 25% by weight of the 1985 yield. The 1980 year class has been dominant in the fishery since 1982, accounting for 31% of the total tonnage landed from the stock in the past four years (Table 8).

Other year classes which have been principal components of the landings since 1978 include the 1975 cohort and the 1977 and 1978 year classes.

Mean Weights at Age - Mean weights at age for ages 1-11+ in the total catch from Georges Bank during 1978-1985 are given in Table 8 and, based on landings patterns, are considered mid-year values. Only slight variations are apparent among years indicating no discernible change in growth rate. Mean weights at age for calculating stock biomass as of 1 January in each year are provided in Table 9. These values were derived from the catch mean weight at age data (Table 8) using the procedures described by Rivard (1982).

STOCK ABUNDANCE AND BIOMASS INDICES

Commercial Catch Rates - USA commercial CPUE indices (catch per unit effort, expressed in metric tons landed per day fished) were calculated, by tonnage class (Class 2: 5-50 GRT; Class 3: 51-150 GRT; Class 4: 151-500 GRT), from otter trawl trips landing cod from Georges Bank (Subdivision 5Ze) (see Serchuk and Wood 1981 for details). Indices were derived based on all trips landing cod, and for "directed" trips in which cod comprised 50% or more of the total trip catch by weight (Table 10). "Directed trips" have accounted for greater than 50% (and as high as 71%) of USA Georges Bank otter trawl landings of cod since 1973 (Table 11).

Since 1970, both total and directed USA CPUE indices have exhibited similar fluctuations (Table 10; Figure 2). CPUE values for Class 3 and 4 vessels (which generally account for more than 95% of the USA Georges Bank otter trawl landings of cod: Appendix Table 5) increased during 1972 and 1973, leveled off at slightly lower levels between 1974 and 1976, and then sharply increased attaining peak levels in the late 1970s. Subsequently, the CPUE indices have trended downward. The 1985 directed CPUE indices were the lowest in the 21-year time series. Apart fromthe 1985 directed CPUE index for Class 2 vessels (which was marginally higher than in 1984), all 1985 indices (total and directed for each vessel class) were the lowest in at least 10 years.

Seasonal USA CPUE indices were also calculated for the July-September time period for comparison with Canadian indices, for both all of Georges Bank

(Table 12; Figure 3) and for the Northern Edge and Peak region alone (Table 13). Nearly identical patterns to those obtained from evaluating the annual indices were apparent. The seasonal USA indices exhibit sharp declines in recent years, both on the Peak and throughout the Bank, with the 1985 values being the lowest or near the lowest in the time series. Canadian CPUE indices peaked in 1977, declined through 1980 but, unlike the USA patterns, increased and remained high throughout 1983 (Figure 3). The sharp drop in the 1984 Canadian index, although reflective of the USA trend, has been attributed to the low level of Canadian otter trawl effort exerted on Georges Bank in that year (Hunt and Waiwood 1985).

Research Vessel Survey Indices - Indices of cod abundance (stratified mean catch per tow in numbers) and biomass (stratified mean weight per tow in kilograms), developed from Northeast Fisheries Center (NEFC) and State of Massachusetts (MASS) research vessel bottom trawl surveys, have been used to monitor changes and assess trends in population size and recruitment of USA cod populations since 1963. Offshore ($\geq$27 m) stratified random NEFC surveys on Georges Bank (Sampling strata 13-25: Appendix Figure 1) have been conducted annually in the autumn since 1963, and in the spring since 1968. Inshore areas (<27 m) have been sampled since 1978 during spring and autumn NEFC inshore surveys (Inshore sampling strata 45-46 and 55-56 shoalward of Georges Bank: Appendix Figure 2), and since 1978 during MASS spring and autumn inshore bottom trawl surveys (MASS sampling strata 11-21 in Regions 1-3 shoalward of Georges Bank: Appendix Figure 3). For the NEFC surveys, a "36 Yankee" trawl has been the standard sampling gear except for spring 1973-1981 when a modified "41 Yankee" trawl was used. Prior to 1985, BMV oval doors (550 kg) were used in all NEFC surveys; since 1985, Portuguese polyvalent doors (450 kg) have been used. No adjustments in the survey catch per tow data for cod have been made for any of the gear differences. Details on NEFC survey sampling design and procedures are provided in Azarovitz (1981) and Clark (1981). The MASS bottom trawl sampling program is described in Howe et al. (1981).

NEFC spring and autumn offshore catch per tow indices for Georges Bank cod have exhibited similar trends, both in abundance and biomass, during the survey time series (Table 14; Figure 4). The survey indices were relatively low and stable during 1963-1971, fluctuated at a generally higher level between 1972 and 1981, but subsequently have trended downward. Large increases in the number per tow indices in 1967, 1972-73, 1976, 1978, 1981 and 1985 reflect above average recruitment of the 1966, 1971, 1975, 1977, 1978, 1980, 1983 and 1985 year classes at ages 0 and 1 (Figures 4 and 5; Appendix Table 6). The sequential dominance of these cohorts at older ages in the surveys is revealed in the offshore spring and autumn number and weight per tow at age values (Appendix Tables 6 and 7, respectively). The 1978 cohort also appeared strong in the MASS spring and autumn inshore surveys (Appendix Table 8), while the 1983 cohort showed above average strength in spring inshore NEFC surveys (Appendix Table 9). Data from the inshore surveys, however, are more difficult to interpret than offshore data because of relatively large inter-annual variability in cohort catch at age indices between ages 0 and 2. This probably reflects out-migration of juveniles, as they grow, to deeper waters as well as large catchability differences between age 0 and 2 cod.

For the offshore surveys, survey indices were also calculated using ln (x+1) transformed values and retransformed values (see Clark 1981 for statistical details). Trends in the time series of these indices parallel those of the linear number and weight per tow values (Appendix Tables 10-13). Examination of the survey coefficients of variation (relative standard errors) indicated that precision of both the linear and ln (x+1) catch per tow indices is greater in the spring surveys (both for numbers and weight) than in the autumn surveys. Since 1980, the coefficients of variation associated with the mean number and mean weight per tow indices in the autumn surveys have averaged 31% on the linear scale and 17% on the ln (x+1) scale, while corresponding spring survey CVs have averaged 20% (linear) and 9% (ln transformed) (Appendix Tables 10-13). These results indicate that proportional changes in abundance and biomass of less than about $\pm$60% in the autumn and $\pm$40% in the spring would normally not be detected with high probability (i.e., P=0.05). Although the transformed survey estimates have coefficients of variation one-third to one-half of their respective linear values, on an absolute basis little improvement in precision is gained in detecting proportional population changes since retransformed confidence limits are about as large as the linear intervals.

The 1985 spring and autumn catch per tow indices (Table 14) showed disparate patterns. Both the number and weight per tow indices in the autumn survey were among the lowest on record (the autumn 1985 weight per tow value was the lowest ever), while the spring value was relatively high and more than double the previous spring's values. The elevated spring 1985 values, however, are believed to reflect an increase in catchability rather than abundance since virtually all of the 1985 catch at age values were higher than in 1984 (Appendix Table 6). Spring 1986 survey indices declined from 1985 but were still higher than low 1984 values (Table 14; Figure 4). Comparison of the 1986 and 1985 indices with those in 1984, however, is confounded by the change in survey trawl doors that commenced with the spring 1985 survey.

The 1980 and 1983 year classes, which were dominant in the 1985 commercial fishery, were similarly dominant in the 1985 spring and autumn surveys (Appendix Table 6). There has been a remarkable consistency between the percentage age composition of cod in the spring survey (both in terms of numbers and weight) and that observed in the USA Georges Bank fishery (Table 15; Figures 6 and 7). Based on this correspondence, the spring 1986 survey age composition data suggest that the 1980 and 1983 cohorts will dominate the 1986 catch, as they did in 1985.

The 1985 NEFC spring and autumn surveys, as well as the spring 1986 survey, indicate that recruitment from the 1985 year class may be very good. The 1985 age 0 catch per tow indices were among the highest observed; the 1986 spring age 1 index was the third highest in the spring series. Should above average recruitment of the 1985 cohort be realized, the pattern of good recruitment noted every 3-5 years in the Georges Bank stock (Figure 5) would be maintained.

MORTALITY

Natural Mortality - Instantaneous natural mortality (M) for Georges Bank cod was assumed to be 0.20, the conventional value of M used for all Northwest Atlantic cod stocks (Paloheimo and Koehler 1968; Pinhorn 1975; Minet 1978).

Total Mortality Estimates - Pooled estimates of instantaneous total mortality (Z) were calculated for five time periods encompassed by the NEFC autumn and spring offshore surveys: 1964-1967, 1968-1972, 1973-1976, 1977-1981, and 1982-1985 (Table 16). Total mortality was calculated from survey catch per tow at age data (Appendix Table 6) for fully recruited age groups (age 3+) by the $\log_e$ ratio of the pooled age 3+/age 4+ indices in the autumn surveys, and the pooled age 4+/age 5+ indices in the spring surveys. For example, the 1982-1985 values were derived from:

Autumn: $\ln$ (Σ age 3+ for 1981-84/ Σ age 4+ for 1982-85)

Spring: $\ln$ (Σ age 4+ for 1982-85/ Σ age 5+ for 1983-86)

Different age groups were used in the autumn and spring analyses so that Z could be evaluated over identical year classes within each time period.

The pooled estimates indicate that total mortality was high (0.73) during 1964-1967, declined significantly during 1968-1972 (0.41), increased afterwards to between 0.53 and 0.63 (1973-1981), and increased to its highest level (0.79) in the period since 1982. Values of Z derived from the spring surveys are generally lower than those calculated from the autumn data. Moreover, while the autumn estimates have sequentially increased during the three most recent time periods, the spring estimates have declined and remained stable. Rather than selecting one survey series over the other, total mortality was calculated by taking a geometric mean of the spring and autumn estimates in each time period. From the only survey data currently available to estimate Z in 1985 (spring 1985/spring 1986), a value of $Z_{(1985)} = 0.78$ was obtained [Appendix Table 6: $\ln(3.206/1.470)$].

Estimates of Z for individual cohorts were also derived from the survey data using catch curve analysis of successive annual number per tow at age indices (Figure 8). The results suggest that Z has been higher on more recent year classes (1978-1981 cohorts) than on preceding cohorts. In general, the catch curve results tend to corroborate the mortality estimates and trends ascertained from the pooled data, although these analyses are not mutually independent.

ESTIMATION OF STOCK SIZE

Virtual Population Analysis - Based on the Z values estimated from the pooled and catch curve survey analyses, virtual population analysis (VPA) runs were made with terminal fishing mortality (F) in 1985 ranging between 0.50 and 0.85 (in 0.05 and 0.02 increments) using the 1978-1985 commercial catch at age matrix (Table 8) with age groups 9 and older combined into a plus group (i.e., 9+). To estimate the partial recruitment vector in 1985 for the VPA, a separable virtual population analysis (SVPA) was first performed using catches in ages 2-8 during 1978-1985 (see Shepherd and Stevens 1983 and Anonymous 1983 for SVPA details). Reference age for the terminal F was set at 3 years with S (F on the oldest age relative to that on the reference age, on average) = 1.0 at age 8. Virtually identical age-specific exploitation patterns were obtained irrespective of the input F (0.50-0.85). Coefficients of variation of the catch data were all 24% resulting in very low log catch ratio residuals, and satisfying the assumption of a relatively constant exploitation

pattern for the 1978-1985 period. The resultant SVPA partial recruitment vector was:

	Age						
	2	3	4	5	6	7	8
S(j)	0.484	1.000	0.918	0.782	0.934	1.106	1.000

The decline in partial recruitment at age 5 given by the SVPA could not be explained relative to known fishing practices and behavior. Accordingly, considering the small differences in the age 4-7 S(j) values from 1.0 (full recruitment relative to age 3), the 1985 exploitation pattern used in the VPA considered all ages 3 and older to be fully recruited.

Given the 1985 exploitation pattern, tuning of the VPA (i.e., calibration of terminal F in 1985) was accomplished using annual fishing effort data and autumn survey 3+ biomass data. Annual fishing effort was derived by dividing the total commercial catch by the annual weighted mean USA CPUE values for (1) all otter trawl trips catching cod, and (2) for trips in which cod comprised 50% or more of the trip catch (Table 10). Autumn survey 3+ biomass (mean weight per tow in kilograms) values were available directly from the survey weight-at-age data (Appendix Table 7).

Estimates of mean annual F for age groups 3-7 (i.e., $\bar{F}_{(3-7)}$) in 1978-85, determined from the VPA runs using terminal Fs from 0.50 to 0.85, were regressed against fishing effort in those years. Similarly, VPA 4+ biomass values from the calibration runs were regressed on autumn survey 3+ biomass indices lagged by one year (i.e., 1978 VPA 4+ biomass against 1977 autumn 3+ weight per tow index). The effort and survey values used in the calibration runs are presented in Table 17.

Calibration criteria for selecting the terminal F in 1985 from the regression relationships were: maximization of the correlation coefficient (r), minimization of sum of the residuals of the last three years, minimization of the sum of the squared residuals for the last three years, and the nearness of the most recent data point to the regression line (minimization of absolute value of the residual in the last year).

A summary of the VPA tuning results is provided in Table 18. For $\bar{F}_{(3-7)}$ on fishing effort (derived from all cod trips), F_{85} = 0.82 exhibited the lowest sum of residuals and the closest 1985 residual. Maximum r was obtained at F_{85} = 0.84 but was only 0.0001 higher than at F_{85} = 0.82. The sum of the squared residuals kept decreasing as the terminal F increased; after F_{85} = 0.82, however, the differences became wuite small. For $F_{(3-7)}$ on fishing effort (derived from 50% trips), F_{85} = 0.82 exhibited the highest r and lowest residuals of any of the starting F values used in the regressions.

Tuning results from the VPA/survey biomass regressions were slightly different than those from the F vs effort relationships. The correlation coefficient continued to increase slightly as F_{85} increased above 0.82. Contrariwise, the sum of the residuals and the last year's residual decreased as F_{85} increased. Only the sum of the squared residuals exhibited a minimum value in the range tested (at F_{85} = 0.78). All of the VPA/survey biomass

regressions, however, exhibit lower r values and very high intercept (a) values compared with the F/effort regressions. Accordingly, terminal F was estimated with greater emphasis on the commercial data and $F_{(3-7)}$ in 1985 of 0.82 was adopted for the final VPA run. Based on simulation analyses, Mohn (1983) suggested that VPA tuning using fishing mortality versus f is the preferred basis for calibration of terminal F.

Estimates of age-specific F, stock size, stock biomass, and spawning stock biomass (considering all fish age 3+ as spawners) obtained from the final VPA are presented in Table 19. Stock sizes for age 1 and 2 fish in 1985 (1984 and 1983 cohorts, respectively) were predicted from VPA/survey functional linear regressions using both spring and autumn NEFC offshore survey age 1 catch per tow indices (Table 20). Based on the 1985 catch data and predicted stock sizes for the 1983 and 1984 cohorts in 1985, corresponding F values were determined (F = 0.013 for the 1984 cohort; F = 0.321 for the 1983 cohort).

VPA results indicate that F sharply increased during the last eight years, doubling between 1978 (F=0.40) and 1985 (F=0.82) (Table 19; Figure 9). Spawning stock biomass (age 3+), in the same period, declined by half (95,500 mt in 1978 to 46,200 mt in 1985), despite strong recruitment from the 1980 year class. Spawning stock biomass at the beginning of 1986 is estimated to be slightly higher than in 1985 although it will still be the second lowest in the time series (Figure 9). An increase in 1986 spawning stock biomass was expected due to good recruitment from the 1983 cohort; the 1986 increase, however, is much less than anticipated based on the size of the 1983 year class prior to exploitation (stock size at age 1 was 34 million fish).

VPA trends in F, stock biomass, and patterns in recruitment agree closely with those derived from survey analyses (Figures 2, 4, and 5) and CPUE data (Figures 2-3).

YIELD PER RECRUIT

Yield-per-recruit, total stock biomass per recruit, and spawning stock biomass per recruit analyses were performed using the Thompson and Bell (1934) method. Data used in these analyses are listed in Table 21.

The results (Table 22) indicate that $F_{0.1}$ = 0.155 and F_{max} = 0.280. The estimated 1985 F (0.82) is 5X higher than $F_{0.1}$ and 3X higher than F_{max} (Figure 10). Relative to F_{max}, the 1985 F generates 70% less stock biomass per recruit and 73% less spawning stock biomass per recruit under equilibrium conditions (Table 22, Figure 10).

Assuming constant recruitment at age 1 of 20 million fish (the geometric mean of VPA age 1 stock size estimates during 1978-1985), equilibrium yields would be 33,000 mt at $F_{0.1}$ and 35,000 mt at F_{max}. Corresponding equilibrium total stock and spawning stock biomass levels at the F reference points would be 230,000 mt and 201,000 mt, respectively, at $F_{0.1}$, and 170,000 mt and 128,000 mt, respectively at F_{max}.

CATCH AND STOCK SIZE PROJECTIONS

Catches and stock biomasses (total and spawning) were projected through 1987 (i.e., to the beginning of 1988) based on the estimated 1986 stock size (89,000 mt total biomass; 54,000 mt spawning stock biomass), a predicted recruitment of the 1985 year class at age 1 of 27.5 millioni fish, and assuming average recruitment (20 million fish) at age 1 in 1987 and 1988. Average 1984-1985 catch and stock mean weights at age were used in the forecast. Partial recruitment (PR) at ages 1 and 2 were set at geometric mean of the PR values during 1982-1985 (age 1 PR = 0.0165; age 2 PR = 0.5173). The age 2 PR value used in the projections was virtually identical to that derived from SVPA (0.484). All data used in the projections are summarized in Table 21.

Two options for F in 1986 were considered: (1) $F_{86} = F_{85} = 0.82$; and (2) $F_{86} = 0.58$, corresponding to a 1986 commercial catch of 30,000 mt. Preliminary analysis of USA and Canadian January-August 1986 landings data suggests that catch will decline in 1986 to about the 30,000 mt level.

Under either of the 1986 F options, spawning stock biomass at the beginning of 1987 will be lower than in 1986 (Table 23). At $F_{86} = 0.82$, spawning stock biomass in 1987 would be 40,000 mt, the lowest in the recent time series (since 1978). At $F_{86} = 0.58$, the 1987 spawning stock biomass would decline to 49,000, the second lowest in recent years. Total stock biomass in 1987 would be marginally higher (+3%) than in 1986 if $F_{86} = 0.58$ due to growth in weight of the above average 1985 year class. However, total biomass in 1987 (92,000 mt) would still be lower than any day of the 1978-1984 values.

Assuming $F_{86} = 0.58$, continued fishing at this rate in 1987 will produce a catch of 32,000 mt and result in no change (<1%) in the 1988 total stock biomass from that in 1987. Spawning stock biomass would increase 17% between 1987 and 1988 (49,000 mt to 57,000 mt) due to recruitment of the 1985 year class into the spawning population, and would be slightly above the 1985 level. If $F_{87} = F_{max} = 0.28$, an estimated 17,000 mt catch would ensue resulting in significant rebuilding of total and spawning stock biomass by 1988. Stock sizes in 1988 (109,000 mt total biomass; 72,000 mt spawning stock biomass) would be higher than at any time since 1982-1983.

Given the status quo projection for total stock biomass between 1987 and 1988 if $F_{86} = 0.58$, no increase in total stock size can be expected during 1987 unless fishing mortality is reduced below F=0.58 and towards F_{max}.

DISCUSSION

Results of this assessment indicate that the Georges Bank cod stock has markedly declined in recent years. Total stock biomass (age 1 and older) declined 20% between 1978 and 1985, while spawning stock biomass (3+ biomass) dropped by 52%. These declines have occurred despite strong recruitment from the 1980 and 1983 year classes. Fishing mortality has doubled in the past eight years; F in 1985 is probably a record or near-record high for the fishery. As a consequence, spawning stock biomass has been reduced to its lowest level since at least 1978. Even if fishing mortality is reduced in 1986 by 30% (to F= 0.58), spawning stock biomass will still decline. It is not known whether

the current levels of spawning stock biomass will result in lowered recruitment but there is certainly an increased risk of this.

Fishing effort has sharply increased in recent years and attained a record-high in 1985. Effort has undoubtedly been redirected towards cod from other groundfish resources (i.e., haddock and yellowtail flounder) which are in relatively much poorer shape. This seems tobe apparent for both the USA Subarea 5 fisheries and the Canadian Division 4X fisheries. The loss of access to traditional fishing grounds resulting from the 1984 World Court Gulf of Maine - Georges Bank Maritime Boundary decision has exacurbated these problems further, since fishing effort has effectively been concentrated into smaller geographical regions than was previously the case.

Since the Georges Bank cod stock has declined to a level well below its apparent normal historical range and because cod is a major component in the USA northeast multispecies fishery, the present state of the Georges Bank stock gives cause for concern.

GULF OF MAINE STOCK

COMMERCIAL LANDINGS

Since 1960, annual landings of cod from the Gulf of Maine (NAFO Division 5Y) have varied six-fold, from a low of 2,700 mt in 1963 to a record-high of 16,700 mt in 1983 (Table 1; Figure 1). After averaging about 3,300 mt during 1960-1965, annual landings doubled between 1966 and 1969 (4,500 to 8,500 mt) and then sequentially declined to 6,150 mt in 1973. Subsequently, landings steadily increased peaking in 1983. Although landings have declined since, annual yields have exceeded 12,000 mt during each of the past nine years. Prior to 1976, catches of more than 10,000 mt were only achieved during 1934, 1944, and 1945.

In 1985, Gulf of Maine cod landings totaled 12,150 mt, 1% less than in 1984, and the lowest annual catch since 1979. USA landings (10,700 mt) were the lowest since 1976 while Canadian landings (1,450 mt), essentially unchanged from 1984, were half the 1983 level. Canadian landings since 1982, however, are believed to reflect substantial misreporting of Scotian Shelf (NAFO Division 4X) cod landings as Gulf of Maine catch (Campana and Simon 1985) as a result of the enactment of catch quotas in the Canadian 4X cod fishery. Hence, recent total and Canadian (but not USA) landings values must be considered suspect. However, since the USA fishery has traditionally accounted for more than 95% of the total harvest (97% during 1960-1981), resource evaluations based on USA data alone should be extremely robust.

USA Fishery Landings by Gear Type and Tonnage Class - The USA Gulf of Maine cod fishery is dominated by otter trawlers. Otter trawl landings accounted for 67% of the 1985 catch (Table 24), about the same percentage as during 1978-1984 (68%). Gill net landings, which accounted for 37% of the USA harvest in 1984, comprised 29% of the 1985 catch. The decline in gill net landings between 1984 and 1985 (-900 mt) was responsible for the decline in total fishery yield in 1985.

Before 1982, the bulk of the USA otter trawl catch of cod from the Gulf of Maine was taken by tonnage class 2 vessels (5-50 GRT). Between 1965 and 1981, Class 2 vessels accounted for 51% of the otter trawl landings; in some years (1970-1973), nearly 60% of the trawl catch was harvested by these smaller vessels (Appendix Table 5). However, since 1982, Class 3 vessels (51-150 GRT) have been dominant in the USA fishery accounting for over half of the otter trawl landings. Recently, Class 4 vessels (151-500 GRT) have also become more important in the fishery. Otter trawl catches by Class 4 vessels nearly doubled between 1984 and 1985 (Table 25) and, in 1985, accounted for 22% of the cod landed by trawlers from the Gulf of Maine, the highest annual percentage for this vessel class in the 1965-1985 time series.

CATCH COMPOSITION

Sampling and Sampling Intensity - USA length frequency and age sampling of Gulf of Maine commercial cod landings was relatively poor prior to 1982 but has subsequently markedly improved (Table 26). The number of samples collected tripled between 1981 and 1982 and has since varied between 55 and 71 samples per year. Length frequency sampling coverage, which averaged one sample per 1,086 mt landed in 1980-1981, has progressively become more intensive in recent years. Since 1982, sampling has averaged one sample per 200 mt landed, with the 1985 sampling intensity the highest in 25 years (one sample per 155 mt).

Coupled with the improvement in overall sampling levels has been a significant improvement in the distribution of samples by market category relative to market category catch patterns (Table 26). Of the 69 samples collected in 1985, 33% were scrod samples, 36% were market, and 31% were large. This distribution is in general accord with the 1985 Gulf of Maine catch composition (20% scrod, 51% market, and 25% large: Table 5). Although none of the recent sampling distributions have been completely concordant with annual market category catch patterns, they are much more representative than were sampling distributions in earlier years (i.e., no market or large samples were collected in 1980; only 2 large samples were obtained in 1981). However, the sampling still reflects a tendency to "oversample" scrod on a proportional basis relative to the two other market categories of cod.

As for Georges Bank cod, virtually all of the Gulf of Maine size frequency and age samples have been taken from otter trawl landings.

Age Composition of USA Landings - Age composition of USA cod landings from the Gulf of Maine fishery during 1982-1985 was derived by applying quarterly age/length keys to quarterly market category catch length frequency distributions and summing over market categories and quarters (i.e., the identical procedure described on page 4 for estimating age composition of the USA Georges Bank cod landings). Because of the limited sampling data for 1980 and 1981, catch-at-age matrices were not calculated for these years. Due to a lack of Canadian sampling data and large uncertainty about Canadian catch levels since 1982, no attempt was made to estimate total fishery removals at age in the 1982-1985 period. Virtual population analysis (VPA) was not performed in light of these constraints and the short time series of available USA catch-at-age data.

Numbers at age and catch weights at age of cod in the USA Gulf of Maine fishery are presented in Table 27.

Landings during 1982-1985 were dominated by three age groups of cod. Age groups 2-4 accounted for 79% of the total catch in numbers while age groups 3-5 accounted for 69% of the total tonnage landed (Table 27). In 1985, the USA catch was dominated by the 1980-1982 year classes; together these cohorts comprised 82% of the landings by number and 76% by weight. The 1980 year class has been the most important in sustaining fishery yields during the past four years. Over 25% of the tonnage landed since 1982 has been from the 1980 cohort.

Mean Weight and Length at Age - Estimated mean weights and mean lengths of cod in the Gulf of Maine catch are provided in Table 27. No trends in size at age are apparent although the 1985 values for age groups 2-4 are the highest in the short time series.

STOCK ABUNDANCE AND BIOMASS INDICES

Commercial Catch Rates - Annual USA commercial CPUE indices (metric tons of cod landed per day fished) were calculated, by vessel tonnage class, from otter trawl trips landing cod from the Gulf of Maine during 1965-1985 (Table 25). As for the Georges Bank cod fishery, CPUE indices for the Gulf of Maine fishery were determined for (1) all trips landing cod, and (2) for "directed" trips in which cod accounted for $\geq$50% of the trip catch in weight. Both indices were derived by dividing annual vessel class cod landings by annual vessel class effort (days fished).

Throughout the 21-year time series, total and directed CPUE indices have shown nearly identical trends (Table 25; Figure 11). CPUE values for Class 2 and 3 vessels (the two dominant vessel classes in the fishery: Appendix Table 5) sharply increased in the mid-1960's, remained at relatively high levels until 1969, and then declined reaching record and near-record lows in 1973. Afterward, the indices again increased (markedly for vessel class 3) stabilizing during 1974-1978 near the high levels observed in 1967-1971. Since the late 1970's-early 1980's, catch rates have trended downward, declining to historically low levels in 1984 and 1985.

Recent declines in CPUE have been accompanied by significant increases in fishing effort. USA trawl effort on Gulf of Maine cod (days fished, all trips) doubled between 1976-1985, with effort in 1985 a record-high (Table 28). Both the number of trips and days fished per trip in 1985 for Class 3 and 4 vessels were the highest in the time series. These increases more than offset reductions in effort by Class 2 vessels.

The Gulf of Maine cod fishery became increasingly more directed during 1980 to 1983 (Table 29). The percentage of total landings accounted for by 50% trips rose from 31% to 44%. In 1984 and 1985, however, directed landings accounted for less than 25% of the total catch, the lowest percentage since 1974. Directed effort (both trips and days fished) in 1984 and 1985 was 60% lower than in 1983 (Table 28). The reduced importance of the directed fishery suggests that the Gulf of Maine trawl fleet has become more opportunistic in terms of major species sought, and that cod is proportionally less abundant (or less desirable) relative to other demersal resources in the Gulf

of Maine. However, since landings and abundance of most other Gulf of Maine groundfish species have also declined in recent years (US Department of Commerce 1986c), the decline in directed cod landings (coupled with the record-low CPUE indices for both all cod trips and directed trips) also reflects a reduction in the cod stock itself.

Research Vessel Survey Indices - As for Georges Bank cod, abundance and recruitment patterns in the Gulf of Maine stock have been monitored since 1963 using research vessel bottom trawl survey data. NEFC offshore (≥27 m) bottom trawl surveys in the Gulf of Maine (sampling strata 26-30 and 36-40: Appendix Figure 1) have been performed annually during autumn (1963 and onward) and spring (1968 and onward). Inshore waters (<27 m) have been sampled annually since 1979 during spring and autumn NEFC inshore surveys (Inshore sampling strata 58-66: Appendix Figure 2), and since 1978 during MASS spring and autumn bottom trawl surveys (MASS sampling strata 25-36 in sampling regions 4-5: Appendix Figure 3). In all surveys, indices of relative abundance and biomass have been calculated in terms of stratified mean number and weight per tow, respectively.

Catch per tow indices from the NEFC offshore surveys are presented in Table 14 and Figure 12. Number per tow values declined during the mid- and late 1960's but since 1971 have fluctuated as a result of a series of recruitment pulses. Peaks in the number per tow indices (Figure 12) during 1972-73, 1975, 1977-78, 1980-82, and 1985 reflect recruitment of the above average 1971, 1973, 1977-1980, and 1983 year classes at ages 1 and 2 (Figure 13; Appendix Table 14). The 1978, 1979, and 1980 cohorts also appeared strong in both the MASS and NEFC inshore surveys during 1978-1982 (Appendix Tables 8 and 9).

Weight per tow indices from the NEFC spring and autumn offshore surveys show generally similar trends. Biomass values trended downward between 1968 and 1975, increased during the late 1970's-early 1980's, but have subsequently again declined (Figure 12). The 1984 spring and autumn indices were among the lowest in the time series. Although the 1985 survey results indicated an increase in stock biomass, this increase appears to be an artifact caused by the change in survey trawl doors used in the 1985 (and subsequent) surveys. The spring 1986 weight per tow index declined to the record-low 1984 level, suggesting that the 1985 increase was more apparent than real.

The 1980-1982 year classes, which were dominant in the 1985 commercial fishery landings, were likewise dominant in the 1985 NEFC offshore surveys, accounting for 78% of the spring survey number per tow index and 73% of the spring weight per tow index (Figure 13; Appendix Tables 14 and 15). This correspondence is not surprising since generally there has been good agreement (although not as striking as for Georges Bank cod) between spring survey age composition data and that in the USA Gulf of Maine fishery (Table 30; Figure 14). Based on this similarity, the spring 1986 survey data indicate that the 1982 and 1983 year classes will jointly account for more than 50% (in numbers and weight) of the 1986 commercial catch (Table 30).

Both the autumn 1985 and spring 1986 catch per tow results indicate that the 1985 Gulf of Maine cod year class may be quite strong. The autumn 1985 age 0 abundance index was the fourth highest in the 23-year time series, while the spring 1986 age 1 index was the second highest recorded (Appendix Table 14).

MORTALITY

Total Mortality Estimates - Estimates of instantaneous total mortality (Z) for Gulf of Maine cod were derived by pooling NEFC offshore survey catch at age data (Appendix Table 14) for fully recruited age groups (age 3+) over five time periods (1964-1967, 1968-1972, 1973-1976, 1977-1981, and 1982-1985) (Table 16). Separate estimates of total mortality were calculated from the spring and autumn surveys, but mortality was evaluated over identical year classes within each time period by taking the $\log_e$ ratio of the pooled age 3+/age 4+ indices in the autumn surveys and the pooled age 4+/age 5+ indices in the spring surveys lagged by one year. The Z values for the 1982-1985 period, for example, were derived from:

Autumn: $\ln$ (Σ age 3+ for 1981-84/Σ age 4+ for 1982-1985)

Spring: $\ln$ (Σ age 4+ for 1982-85/Σ age 5+ for 1983-1986)

For each time period, average instantaneous fishing mortality (F) was estimated by assuming natural mortality (M) = 0.20 and subtracting this value from Z. A geometric mean of the spring and autumn mortality estimates was also calculated for each time period to integrate the results from both survey series.

Average Z values for the five time periods varied between 0.39 and 0.82 (Table 16). Total mortality was relatively low and stable during 1964-1976 (~0.40), but significantly increased afterwards. Both the spring and autumn survey show similar trends, with Z and F values for 1982-1985 the highest on record. Mean F during 1982-1985 was 0.62, nearly double the 1977-1981 level (F=0.32), and well above F_{max} (F_{max} = 0.30, Serchuk et al. 1982).

Estimates of Z were also derived, by cohort, from catch curve analysis of sequential annual NEFC survey catch per tow at age indices (Appendix Table 14) for the 1973 and 1977-1982 year classes (Figure 15). For almost all year classes, Z values exceed 0.50 implying that average fishing mortality on these cohorts has been higher than F_{max}. Since the Z values reflect mortality during 1977-1986, the curve catch results are consistent with the pooled mortality analyses in indicating that F in recent years has been relatively high.

That F has increased since the late 1970's relative to early time periods can also be inferred from survey age composition data (Appendix Table 14). During 1963-1971, age groups 5 and older were well represented in autumn survey catches accounting for between 26% and 61% of the total number per tow of cod caught. Over the nine-year period, age 5+ cod comprised 41% of the Gulf of Maine population. During the most recent nine-year period (1977-1985), however, age groups 5 and older have only accounted for between 13% and 44% of the total autumn survey abundance indices, and comprised just 20% of the 1977-1985 survey average. Since there has been a succession of good Gulf of Maine cod year classes since 1977, an increase in the abundance of older

cod in the population would normally be expected as time progressed. However, this has not occurred. The catch per tow indices for age 5+ cod in the 1981-1985 autumn Gulf of Maine surveys were the lowest in the time series (Appendix Table 14). This suggests that F has significantly increased during the past several years resulting in no restoration in abundance of older age groups in the stock. The virtual absence of older age groups of cod in recent surveys is evident in Figure 13. Since most of the fishery yield since 1982 has come from age groups 2-5 (Table 27), high exploitation of young fish has apparently precluded any increase in the abundance of older fish from the recent series of good year classes.

DISCUSSION

The present assessment results indicate that the Gulf of Maine cod stock has declined to historically low levels. Commercial CPUE values in 1984/1985 were the lowest on record while fishing effort increased to record highs. Although survey and fishery data show that recent recruitment has been good, stock biomass has continued to decline. Spring 1984 and 1986 survey biomass values were the lowest in the time series.

Fishing mortality doubled between 1977-1981 and 1982-1985 (0.32 vs 0.62). F in the most recent time period is the highest on record and well in excess of the level producing maximum yield per recruit (F_{max} = 0.30).

Although a virtual population analysis could not be performed due to the short time series of catch at age data (1982-1985), all of the existing biological, survey, and commercial indicators of stock status suggest that a significant decline in resource abundance has occurred.

Given the depressed condition of the Gulf of Maine cod population, continued declines in stock biomass and landings are expected if fishing mortality is not reduced. Both long-term yield and stock reproductive potential would be enhanced by reducing F towards F_{max}.

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Table 1. Commercial landings (metric tons, live) of Atlantic cod from Georges Bank and southward (NAFO Division 5Z and Statistical Area 6), and the Gulf of Maine (NAFO Division 5Y), 1960-1985.

	Georges Bank and South[1]					Gulf of Maine					Total				
Year	USA	Canada	USSR	Other[2]	Total	USA	Canada	USSR	Other[2]	Total	USA	Canada	USSR	Other[2]	Total
1960	10,834	19	-	-	10,853	3,448	129	-	-	3,577	14,282	148	-	-	14,430
1961	14,453	223	55	-	14,731	3,216	18	-	-	3,234	17,669	241	55	-	17,965
1962	15,637	2,404	5,302	143	23,486	2,989	83	-	-	3,072	18,626	2,487	5,302	143	26,558
1963	14,139	7,832	5,217	1	27,189	2,595	3	133	-	2,731	16,734	7,835	5,350	1	29,920
1964	12,325	7,108	5,428	304	25,165	3,226	25	-	-	3,251	15,551	7,133	5,428	304	28,416
1965	11,410	10,598	14,415	1,910	38,333	3,780	148	-	-	3,928	15,190	10,746	14,415	1,910	42,261
1966	11,990	15,601	16,830	8,713	53,134	4,008	384	-	-	4,392	15,998	15,985	16,830	8,713	57,526
1967	13,157	8,232	511	14,852	36,752	5,676	297	-	-	5,973	18,833	8,529	511	14,852	42,725
1968	15,279	9,127	1,459	17,271	43,136	6,360	61	-	-	6,421	21,639	9,188	1,459	17,271	49,557
1969	16,782	5,997	646	14,514	37,939	8,157	59	-	268	8,484	24,939	6,056	646	14,782	46,423
1970	14,899	2,583	364	7,806	25,652	7,812	26	-	423	8,261	22,711	2,609	364	8,229	33,913
1971	16,178	2,979	1,270	7,752	28,179	7,380	119	-	163	7,662	23,558	3,098	1,270	7,915	35,841
1972	13,406	2,545	1,878	7,230	25,059	6,776	53	11	77	6,917	20,182	2,598	1,889	7,307	31,976
1973	16,202	3,220	2,977	6,524	28,923	6,069	68	-	9	6,146	22,271	3,288	2,977	6,533	35,069
1974	18,377	1,374	476	7,104	27,331	7,639	120	-	5	7,764	26,016	1,494	476	7,109	35,095
1975	16,017	1,847	2,403	4,741	25,008	8,903	86	-	26	9,015	24,920	1,933	2,403	4,767	34,023
1976	14,906	2,328	933	1,759	19,926	10,172	16	-	-	10,188	25,078	2,344	933	1,759	30,114
1977	21,138	6,173	54	2	27,367	12,426	106	-	-	12,532	33,564	6,279	54	2	39,899
1978	26,579	8,904	-	-	35,483	12,426	384	-	-	12,810	39,005	9,288	-	-	48,293
1979	32,645	6,011	-	-	38,656	11,680	379	-	-	12,059	44,325	6,390	-	-	50,715
1980	40,053	8,094	-	-	48,147	13,528	161	-	-	13,689	53,581	8,255	-	-	61,836
1981	33,849	8,508	-	-	42,357	12,534	599	-	-	13,133	46,383	9,107	-	-	55,490
1982	39,333	17,862	-	-	57,195	13,582	1,369	-	-	14,951	52,915	19,231	-	-	72,146
1983[3]	36,756	12,132	-	-	48,888	13,981	2,752	-	-	16,733	50,737	14,884	-	-	65,621
1984[3]	32,915	5,761	-	-	38,676	10,806	1,404	-	-	12,210	43,721	7,165	-	-	50,886
1985	26,828	10,441	-	-	37,269	10,693	1,445	-	-	12,138	37,521	11,886	-	-	49,407

[1] 5NK landings have been assigned to the Georges Bank and southward region.

[2] Primarily Spain and Poland.

[3] Provisional.

Table 2. Estimated number (000's of fish) and weight (metric tons, live) of Atlantic cod caught by marine recreational fishermen, by region, in 1960, 1965, 1970, 1974, and 1979-1985.

	North Atlantic[1]		Mid-Atlantic		All Regions	
Year	Number (000's)	Metric tons	Number (000's)	Metric tons	Number (000's)	Metric tons
1960	3998	11426	793	2590	4791	14016
1965	4970	13144	62	421	5032	13565
1970	3690	16188	154	204	3844	16292
1974	2155	8566	717	3753	2901	12368
1979[2]	3083	3763	8	55	3091	3818
1980[2]	2403	6376	36	9	2439	6385
1981[2]	4440	7281	482	1368	4922	8649
1982[2]	2663	4378	586	3633	3249	8011
1983[2]	3511	7438	244	852	3755	8290
1984[2]	2463	5062	102	330	2565	5392
1985[2]	3611	8644	62	338	3673	8982

[1]During 1960, 1965, and 1970 surveys, North Atlantic included Maine to New York; during 1974, 1979, and afterward, North Atlantic only included Maine to Connecticut.

[2]For 1979-1985 surveys, total weight caught was derived by multiplying the total number of cod caught in each region by the mean weight of cod landed in whole form in each region obtained from intercept (creel) surveys.

Table 3. Distribution of USA commercial landings (metric tons, live) of Atlantic cod from Georges Bank (Area 5Ze), by gear type, 1965-1985. The percentage of total USA commercial landings of Atlantic cod from Georges Bank, by gear type, for each year, is also presented. Data only reflect Georges Bank cod landings that could be identified by gear type.

	Landings (metric tons, live)						Percentage of Annual Landings					
Year	Otter Trawl	Sinking Gill Net	Line Trawl	Handline	Other Gear	Total Landings	Otter Trawl	Sinking Gill Net	Line Trawl	Handline	Other Gear	Total
1965	10251	0	582	505	9	11347	90.3	-	5.1	4.5	0.1	100.0
1966	10206	0	787	757	19	11769	86.7	-	6.7	6.4	0.2	100.0
1967	10915	0	894	704	9	12522	87.2	-	7.1	5.6	0.1	100.0
1968	12084	0	936	524	<1	13544	89.2	-	6.9	3.9	-	100.0
1969	13194	0	1371	387	<1	14952	88.2	-	9.2	2.6	-	100.0
1970	11270	0	1676	404	<1	13350	84.4	-	12.6	3.0	-	100.0
1971	12436	0	2334	230	2	15002	82.9	-	15.6	1.5	-	100.0
1972	10179	0	2071	217	10	12477	81.6	-	16.6	1.7	0.1	100.0
1973	12431	3	2185	206	21	14846	83.7	-	14.7	1.4	0.2	100.0
1974	14078	3	2548	11	9	16649	84.6	-	15.3	0.1	-	100.0
1975	12069	0	2435	84	4	14592	82.7	-	16.7	0.6	-	100.0
1976	12257	4	1519	153	5	13938	88.0	-	10.9	1.1	-	100.0
1977	18529	30	912	83	22	19576	94.6	0.2	4.7	0.4	0.1	100.0
1978	20862	81	1569	1180	59	23751	87.8	0.3	6.6	5.0	0.3	100.0
1979	26562	620	2707	860	159	30908	85.9	2.0	8.8	2.8	0.5	100.0
1980	32479	4491	1102	0	273	38345	84.7	11.7	2.9	-	0.7	100.0
1981	27694	3515	120	584	197	32110	86.3	10.9	0.4	1.8	0.6	100.0
1982	33371	2935	385	624	210	37525	88.9	7.8	1.0	1.7	0.6	100.0
1983	30981	1812	831	441	81	34146	90.7	5.3	2.4	1.3	0.3	100.0
1984	26161	2573	366	753	197	30050	87.1	8.6	1.2	2.5	0.6	100.0
1985	21444	2482	436	284	163	24809	86.4	10.0	1.8	1.1	0.7	100.0

Table 4. USA and Canadian sampling of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Statistical Area 6), 1978-1985.

	USA				Canada			
	Length Samples		Age Samples		Length Samples		Age Samples	
Year	No.	Measured	No.	Aged	No.	Measured	No.	Aged
1978	88	6841	76	1463	29	8027	28	1364
1979	80	6973	79	1647	12	3363	12	591
1980	69	4990	67	1119	10	2784	10	536
1981	59	4304	59	1231	17	4147	16	791
1982	151	11970	147	2579	17	4948	8	341
1983	146	12544	138	2945	15	3822	14	601
1984	100	8721	100	2431	7	1889	7	412
1985	100	8366	100	2321	29	7654	20	732

Source: USA data from NEFC files; Canadian data from NAFO SCS Doc. 80/VI/8 (1978), NAFO SCS Doc. 85/18 (1979-83), NAFO SCS Doc. 85/19 (1984), NAFO SCS Doc. 86/20(1985), and from Hunt and Waiwood 1985 (CAFSAC Res. Doc. 85/87).

Table 5. Percentage of USA commercial Atlantic cod landings (by weight) from Georges Bank and South (NAFO Subdivision 5Ze and Statistical Area 6) and the Gulf of Maine (NAFO Division 5Y), by market category, 1964-1985.

	Georges Bank and South				Gulf of Maine			
Year	Large	Market	Scrod	Total[1]	Large	Market	Scrod	Total[1]
1964	45	47	8	100	29	59	12	100
1965	56	40	3	100	39	54	7	100
1966	53	37	10	100	42	48	10	100
1967	41	42	16	100	41	41	17	100
1968	34	46	19	100	47	43	9	100
1969	27	57	16	100	35	55	9	100
1970	30	62	8	100	43	52	6	100
1971	40	51	9	100	52	42	6	100
1972	37	53	10	100	58	35	7	100
1973	24	40	36	100	52	36	11	100
1974	24	59	17	100	39	33	28	100
1975	28	62	10	100	32	42	26	100
1976	34	48	18	100	29	45	20	100
1977	26	39	34	100	33	42	22	100
1978	29	60	11	100	38	44	17	100
1979	37	55	8	100	37	49	14	100
1980	41	47	12	100	36	45	19	100
1981	36	49	12	100	29	45	22	100
1982	31	47	22	100	29	45	24	100
1983	25	53	21	100	25	45	28	100
1984	31	56	12	100	26	51	19	100
1985	27	46	25	100	25	51	20	100

[1]Includes landings of "mixed" cod.

Table 6. Catch at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of USA commercial Atlantic cod landings from Georges Bank and South (NAFO Division 5Z and Statistical Area 6), 1978-1985.

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Total
USA Commercial Catch in Numbers (000's) at Age												
1978	-	331	5731	1636	625	53	288	35	28	8	-	8735
1979	34	1618	572	4107	910	403	59	244	-	31	14	7992
1980	88	3002	4707	286	1888	951	413	76	153	-	-	11564
1981	25	3060	3613	1960	101	1026	330	72	109	46	-	10342
1982	325	7855	2466	1682	1258	117	452	116	50	23	34	14378
1983	81	3542	5557	1244	854	722	85	218	88	26	36	12453
1984	81	1281	3305	2961	500	393	386	25	153	39	43	9167
1985	130	4280	1539	985	1388	273	173	165	12	68	18	9031
USA Commercial Catch in Weight (Tons) at Age												
1978	-	430	14159	6041	2794	276	2168	274	356	81	-	26579
1979	30	2462	1411	17622	4525	2943	541	2507	-	417	147	32645
1980	74	4475	11663	1141	10937	6375	3504	657	1227	-	-	40053
1981	22	4592	8528	6644	524	7532	2773	716	1628	890	-	33849
1982	249	10960	7032	6465	6856	755	4281	1200	624	363	548	39333
1983	80	5303	13647	4271	4015	4628	679	2244	975	331	583	36756
1984	85	2099	8096	10650	2655	2655	3456	246	1739	508	726	32915
1985	118	6094	3320	3930	7219	1746	1397	1707	148	852	297	26828
USA Commercial Catch Mean Weight (kg) at Age												
1978	-	1.298	2.470	3.692	4.473	5.199	7.522	7.924	12.794	10.620	-	3.043[1]
1979	0.889	1.522	2.464	4.301	4.974	7.309	9.127	10.264	-	13.435	10.620	4.085
1980	0.839	1.490	2.478	3.992	5.792	6.703	8.489	8.648	8.046	-	-	3.464
1981	0.885	1.501	2.360	3.389	5.209	7.339	8.397	9.988	14.884	19.527	-	3.274
1982	0.767	1.395	2.852	3.845	5.449	6.457	9.473	10.297	12.434	15.917	16.257	2.736
1983	0.993	1.497	2.456	3.434	4.703	6.407	7.955	10.280	11.091	12.970	16.213	2.952
1984	1.053	1.638	2.450	3.597	5.308	6.751	8.960	9.710	11.361	13.214	16.842	3.590
1985	0.914	1.424	2.157	3.989	5.201	6.398	8.075	10.355	12.107	12.431	16.877	2.971
USA Commercial Catch Mean Length (cm) at Age												
1978	-	50.2	61.5	69.8	73.7	79.3	89.3	91.3	107.1	101.0	-	64.9[2]
1979	44.7	52.9	61.0	73.9	77.5	88.2	95.3	99.4	-	108.4	101.0	70.9
1980	43.9	52.6	61.6	72.4	81.9	86.3	92.9	92.2	91.2	-	-	66.5
1981	44.6	52.3	60.4	68.5	78.4	88.7	93.1	98.2	112.8	123.2	-	64.6
1982	42.3	51.4	64.4	70.8	79.9	84.1	96.5	99.2	105.5	114.8	115.0	60.7
1983	46.3	52.7	61.5	68.1	75.9	84.5	90.7	99.1	101.5	107.4	114.8	63.3
1984	47.2	54.1	61.5	69.8	79.3	86.5	94.8	97.5	102.5	107.5	116.1	67.7
1985	45.1	51.8	58.6	72.4	79.0	84.5	91.4	99.4	104.7	105.5	117.0	62.5

[1]Mean weight.

[2]Mean length.

Table 7. Summary of USA and Canada 1985 landings of Atlantic cod from Georges Bank and South (NAFO Division 5Z and Statistical Area 6).

	USA Catch at Age				Canada Catch at Age				Total Catch at Age			
Age	Catch in Numbers (000's)	% of USA Total	Catch in Weight (mt)	% of USA Total	Catch in Number (000's)	% of Canada Total	Catch in Weight (mt)	% of Canada Total	Catch in Numbers (000's)	% of Total	Catch in Weight (mt)	% of Total
1	130	1.5	118	0.4	30	0.7	29	0.3	160	1.2	147	0.4
2	4280	47.4	6094	22.7	2599	59.8	3434	32.9	6879	51.4	9528	25.5
3	1539	17.0	3320	12.4	789	18.2	1675	16.0	2328	17.4	4995	13.4
4	985	10.9	3930	14.7	379	8.7	1589	15.2	1364	10.2	5519	14.8
5	1388	15.4	7219	26.9	383	8.8	2130	20.4	1771	13.3	9349	25.1
6	273	3.0	1746	6.5	65	1.5	488	4.7	338	2.5	2234	6.0
7	173	1.9	1397	5.2	40	0.9	348	3.3	213	1.6	1745	4.7
8	165	1.8	1707	6.4	36	0.8	414	4.0	201	1.5	2121	5.7
9+	100	1.1	1297	4.8	24	0.6	334	3.2	124	0.9	1631	4.4
Total	9033	100.0	26828	100.0	4345	100.0	10441	100.0	13378	100.0	37269	100.0
Mean Age	3.25				2.81				3.11			
Mean weight Per Fish (kg)			2.97				2.40				2.79	

Table 8. Catch at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of total commercial Atlantic cod landings from Georges Bank and South (NAFO Division 5Z and Statistical Areas 6), 1978 - 1985.

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Total
						Total Commercial Catch in Numbers (000's) at Age						
1978	-	442	7651	2185	834	71	385	46	37	10	-	11661
1979	41	1916	678	4863	1077	477	70	289	-	37	16	9464
1980	106	3609	5658	344	2270	1143	496	91	183	-	-	13900
1981	31	3829	4522	2453	126	1284	413	90	137	57	-	12942
1982	473	11422	3586	2445	1830	170	657	169	73	33	49	20907
1983	108	4711	7391	1654	1135	961	114	290	117	34	38	16563
1984	81	1328	3604	3356	593	487	496	32	200	51	56	10284
1985	160	6879	2328	1364	1771	338	213	201	15	84	22	13378
						Total Commercial Catch in Weight (Tons) at age						
1978	-	570	18904	8066	3730	369	2895	365	475	109	-	35483
1979	36	2916	1670	20914	5359	3485	640	2969	-	493	174	38656
1980	89	5379	14020	1372	13146	7664	4212	790	1475	-	-	48147
1981	27	5746	10671	8314	656	9426	3470	896	2037	1114	-	42357
1982	363	15937	10226	9401	9969	1098	6225	1744	908	528	796	57195
1983	107	7053	18152	5681	5339	6156	904	2984	1296	441	775	48888
1984	85	2203	8961	12220	3209	3324	4468	315	2276	668	947	38676
1985	147	9528	4995	5519	9349	2234	1745	2121	194	1069	368	37269
						Total Commercial Catch Mean Weight (kg) at Age						
1978	-	1.290	2.471	3.692	4.472	5.197	7.519	7.935	12.838	10.900	-	3.043[1]
1979	0.878	1.522	2.463	4.301	4.976	7.306	9.413	10.273	-	13.324	10.875	4.045
1980	0.840	1.490	2.478	3.988	5.791	6.705	8.492	8.681	8.060	-	-	3.464
1981	0.871	1.501	2.360	3.389	5.206	7.341	8.402	9.956	14.869	19.544	-	3.273
1982	0.767	1.395	2.852	3.845	5.448	6.459	9.475	10.320	12.438	16.000	16.245	2.736
1983	0.991	1.497	2.456	3.435	4.704	6.406	7.930	10.290	11.077	12.971	16.146	2.952
1984	1.049	1.659	2.486	3.641	5.411	6.825	9.008	9.844	11.380	13.098	16.911	3.761
1985	0.919	1.385	2.146	4.046	5.279	6.609	8.192	10.552	12.933	12.726	16.727	2.786
						Total Commercial Catch Mean Length (cm) at Age						
1978	-	50.20	61.54	68.92	73.73	79.26	89.31	91.28	107.12	101.00	-	64.85[2]
1979	44.66	52.93	61.03	73.91	77.54	88.20	95.30	99.45	-	108.38	101.00	70.87
1980	43.87	52.64	61.57	72.41	81.90	86.32	92.94	92.18	91.19	-	-	66.45
1981	44.64	52.25	60.42	68.45	78.44	88.73	93.05	98.15	112.75	123.20	-	64.61
1982	42.29	51.44	64.44	70.81	79.91	84.08	96.48	99.19	105.49	114.76	114.97	60.73
1983	46.34	52.72	61.48	68.11	75.89	84.51	90.74	99.07	101.50	107.40	114.80	63.27
1984	47.23	52.30	61.83	70.12	79.77	86.84	95.04	97.63	102.57	107.55	116.20	68.69
1985	45.30	51.36	58.44	72.66	79.33	85.41	91.85	100.08	105.61	106.07	117.55	61.15

1 Mean length
2 Mean weight

Table 9. Mean weight at age (kg) of the Georges Bank and South (NAFO Division 5Z and Statistical Area 6) Atlantic cod stock on January 1. Values derived from catch mean weight at age values (mid-year) using procedures described by Rivard (1982).

Year	Age 1	2	3	4	5	6	7	8	9+[1]
1978	0.699	0.934	1.873	3.180	3.852[2]	4.477[2]	6.433	7.620[2]	12.426
1979	0.674	1.157	1.783	3.260	4.286	5.716	6.994	8.789	12.585
1980	0.628	1.144	1.942	3.134	4.991	5.776	7.877	9.040	8.060
1981	0.688	1.123	1.875	2.898	4.557	6.520	7.506	9.195	16.242
1982	0.549	1.102	2.069	3.012	4.297	5.799	8.340	9.312	14.400
1983	0.766	1.072	1.851	3.130	4.253	5.908	7.157	9.874	13.291
1984	0.913	1.282	1.929	2.990	4.311	5.666	7.596	8.835	12.674
1985	0.800[2]	1.205	1.887	3.172	4.384	5.980	7.477	9.750	13.479

[1]Mean weight-at-age values for 9+ were set equal to catch (mid-year) mean weight-at age values.

[2]Modified values from Rivard (1982) calculated values.

Table 10. USA commercial landings (L)[1], days fished (DF)[2], and landings per day fished (L/DF), by vessel tonnage class (Class 2: 5-50 GRT; Class 3: 51-150 GRT; Class 4: 151-500 GRT), of Atlantic cod for otter trawl trips catching cod from Georges Bank (Area 5Ze), 1965-1985. Data are also provided for otter trawl trips in which cod comprised 50% or more of the total trip catch, by weight (directed trip).

	Vessel Tonnage Class									Total	
	Class 2			Class 3			Class 4				
Year	L	DF	L/DF	L	DF	L/DF	L	DF	L/DF	L	L/DF[3]
					All Trips						
1965	487	1661	0.29	5201	9719	0.54	4351	4175	1.04	10039	0.74
1966	386	1555	0.25	4754	10505	0.45	4731	4510	1.05	9871	0.73
1967	437	1069	0.41	5292	8570	0.62	4519	3789	1.19	10248	0.86
1968	321	570	0.56	6861	8534	0.80	4903	3397	1.44	12085	1.05
1969	433	500	0.87	7942	7953	1.00	4819	2783	1.73	13194	1.26
1970	508	535	0.95	6729	8296	0.81	4033	2218	1.82	11270	1.18
1971	563	681	0.83	7652	8808	0.87	4215	2195	1.92	12430	1.22
1972	524	721	0.73	6382	9257	0.69	3274	1766	1.85	10180	1.07
1973	322	550	0.59	7814	8668	0.90	4295	1701	2.52	12431	1.45
1974	585	617	0.95	8222	9438	0.87	5266	2097	2.51	14073	1.49
1975	509	534	0.95	7029	8684	0.81	4527	2085	2.17	12065	1.33
1976	421	474	0.89	7861	7791	1.01	3969	1469	2.70	12251	1.55
1977	850	607	1.40	13250	9492	1.40	4423	1472	3.00	18523	1.78
1978	1165	715	1.63	14853	9411	1.58	4829	1551	3.11	20847	1.94
1979	956	658	1.45	18377	9924	1.85	7116	2507	2.84	26449	2.10
1980	1062	882	1.20	21331	10961	1.95	10053	3726	2.70	32446	2.16
1981	1184	845	1.40	17025	10615	1.60	9404	3797	2.48	27613	1.89
1982	1406	695	2.02	20468	10717	1.91	11450	4296	2.67	33314	2.18
1983	835	429	1.95	17112	10694	1.60	13011	5116	2.54	30958	2.00
1984	375	427	0.88	14883	13605	1.09	10899	5746	1.90	26157	1.42
1985	370	453	0.82	12852	13629	0.94	8215	5501	1.49	21437	1.15
					≥50% Trips						
1965	18	8	2.27	353	86	4.10	819	159	5.15	1190	4.79
1966	7	<1	-	370	88	4.20	991	199	4.98	1368	4.74
1967	33	17	1.94	874	238	3.67	1464	318	4.60	2371	4.22
1968	16	3	5.33	1665	464	3.59	1442	328	4.40	3123	3.97
1969	73	9	8.11	2612	773	3.38	1475	359	4.11	4160	3.72
1970	164	25	6.56	1695	534	3.17	1739	388	4.48	3598	3.96
1971	117	15	7.80	2232	721	3.10	2163	494	4.38	4512	3.84
1972	152	54	2.81	2137	716	2.98	1879	445	4.22	4168	3.53
1973	52	16	3.25	3242	820	3.95	3010	486	6.19	6304	5.01
1974	259	119	2.18	3707	1115	3.32	3899	703	5.55	7865	4.39
1975	246	85	2.89	2678	842	3.18	3128	585	5.35	6052	4.29
1976	159	66	2.41	3665	1089	3.37	2664	464	5.74	6488	4.32
1977	502	120	4.18	6595	1342	4.91	2899	373	7.77	9996	5.70
1978	846	215	3.93	6554	1644	3.99	2427	330	7.35	9827	4.81
1979	612	168	3.64	9714	2558	3.80	4270	840	5.08	14596	4.17
1980	644	196	3.29	11727	2909	4.03	5616	1067	5.26	17987	4.39
1981	766	153	5.01	9414	2591	3.63	4312	953	4.52	14492	3.97
1982	1046	212	4.93	14724	3631	4.06	7791	1521	5.12	23561	4.45
1983	566	130	4.35	11884	3033	3.92	8795	1872	4.70	21245	4.25
1984	140	55	2.55	9156	3454	2.65	6620	1918	3.45	15916	2.98
1985	184	65	2.83	8725	4346	2.01	6053	2330	2.60	14962	2.26

[1]Metric tons, live weight.

[2]Days fished with trawl on bottom was derived by dividing hours fished with trawl on bottom by 24.0.

[3]Total landings per day fished was derived by weighting individual tonnage class landings rates by the percentage of total landings in each vessel class and summing the weighted landings rates over the three vessel class categories.

Table 11. Percentage, within vessel tonnage class[1], of the vessel class Atlantic cod landings (L)[2], vessel trips (T), and effort (DF)[3] of otter trawlers landing cod from Georges Bank (Area 5Ze) in which cod comprised 50% or more of trip catch weight (directed trip).

	Vessel Tonnage Class											
	Class 2			Class 3			Class 4			Total		
Year	L	T	DF	L	T	DF	L	T	DF	L	T	DF
1965	3.7	1.0	0.5	6.8	1.9	0.9	18.8	5.4	3.8	11.9	3.4	1.6
1966	1.8	0.1	<0.1	7.8	1.4	0.8	20.9	6.5	4.4	13.9	2.2	1.7
1967	7.6	1.3	1.6	16.5	4.0	2.8	32.4	11.5	8.4	23.1	4.9	4.3
1968	5.0	1.0	0.5	24.3	5.9	5.4	29.4	12.3	9.7	25.8	6.5	6.4
1969	16.9	5.2	1.8	32.9	10.0	9.7	30.6	13.8	12.9	31.5	10.3	10.2
1970	32.3	10.4	4.7	25.2	7.3	6.4	43.1	19.5	17.5	31.9	9.7	8.6
1971	20.8	6.9	2.2	29.2	8.3	8.2	51.3	24.2	22.5	36.3	10.3	10.5
1972	29.0	8.8	7.5	33.5	9.7	7.7	57.4	25.2	25.2	40.9	11.5	10.3
1973	16.1	3.4	2.9	41.5	10.7	9.5	70.1	31.4	28.6	50.7	12.9	12.1
1974	44.3	11.1	19.3	45.1	13.9	11.8	74.0	37.8	33.5	55.9	17.3	15.9
1975	48.3	10.6	15.9	38.1	12.3	9.7	69.1	32.8	28.1	50.2	15.7	13.4
1976	37.8	11.1	13.9	46.6	16.9	14.0	67.1	35.1	31.6	53.0	19.1	16.6
1977	59.1	15.5	19.8	49.8	18.9	14.1	65.5	29.2	25.3	54.0	19.8	15.9
1978	72.6	22.0	30.1	44.1	22.6	17.5	50.3	28.1	21.3	47.1	23.2	18.7
1979	64.0	21.0	25.5	52.9	28.0	25.8	60.0	35.4	33.5	55.2	28.7	27.2
1980	60.6	21.1	22.2	55.0	26.9	26.5	55.9	34.5	28.6	55.4	27.7	26.8
1981	64.7	21.1	18.1	55.3	26.0	24.4	45.9	27.3	25.1	52.5	25.6	24.2
1982	74.4	23.9	30.5	72.0	34.1	33.9	68.0	38.8	35.4	70.7	33.7	34.2
1983	67.8	19.5	30.3	69.4	29.1	28.4	67.6	38.9	36.6	68.6	30.6	31.0
1984	37.3	7.0	12.9	61.5	25.9	25.4	60.7	35.2	33.4	60.8	26.4	27.4
1985	49.7	8.7	14.3	67.9	29.8	31.9	73.7	41.9	42.4	69.8	30.9	34.4

[1]Class 2: 5-50 GRT; Class 3: 51-150 GRT; Class 4: 151-500 GRT.

[2]Metric tons, live weight.

[3]Effort is expressed as days fished with trawl on bottom and derived from hours fished with trawl on bottom divided by 24.0.

Table 12. Commercial July-September catch rates of Atlantic cod, by vessel tonnage class, for USA and Canadian otter trawlers fishing on Georges Bank (Area 5Ze), 1965-1985. USA data are provided for all trips landing cod and for trips in which cod comprised 50% or more of trip catch, by weight.

	USA[1]						Canada[2,3]	
	Class 2[4]		Class 3		Class 4		Class 4	Class 5
Year	All Trips	50% Trips	All Trips	50% Trips	All Trips	50% Trips	Side Trawlers	Stern Trawlers
1965	0.413	8.568	0.628	4.277	0.661	1.814	-	-
1966	0.394	24.192	0.528	2.955	0.839	4.046	-	-
1967	0.459	1.396	0.764	3.694	1.379	4.282	-	-
1968	0.446	-	0.812	2.945	1.521	3.344	0.315	0.353
1969	0.867	11.146	1.105	3.050	2.150	4.483	0.328	0.424
1970	0.831	11.016	0.806	3.003	1.781	4.271	0.194	0.260
1971	0.883	10.034	0.672	2.452	1.603	3.928	0.222	0.220
1972	0.815	2.291	0.572	2.390	1.576	3.561	0.220	0.357
1973	0.655	4.536	0.972	4.025	3.035	6.941	0.219	0.300
1974	0.736	1.665	0.690	3.122	2.600	6.175	-	0.241
1975	1.294	3.645	0.833	3.985	2.399	6.141	0.139	0.280
1976	1.041	2.555	1.066	3.786	3.385	5.850	0.147	0.245
1977	1.613	3.874	1.284	4.980	3.524	9.795	0.526	0.865
1978	1.990	3.381	1.278	4.382	2.446	5.718	0.521	0.688
1979	1.411	2.805	1.842	3.767	3.209	4.891	0.384	0.487
1980	1.177	3.146	1.887	3.960	2.914	5.139	0.200	0.504
1981	1.314	5.003	1.424	3.227	2.277	3.816	0.331	0.862
1982	2.756	5.711	2.143	4.312	2.790	5.189	0.371	0.761
1983	2.334	4.879	1.609	3.887	2.390	4.463	-	0.827
1984	0.928	2.679	0.875	2.608	1.489	3.091	-	0.284
1985	0.432	5.425	0.739	1.837	1.083	2.624		

[1]USA commercial catch rates are expressed as metric tons per day fished with trawl on bottom.

[2]Canadian commercial catch rates are expressed as metric tons per hour fished with trawl on bottom.

[3]Canadian data from Hunt and Waiwood (CAFSAC Res. Doc. 85/87).

[4]Class 2: 5-50 GRT; Class 3: 51-150 GRT; Class 4: 151-500 GRT; Class 5: 500-1000 GRT.

Table 13. Commercial July-September catch rates of Atlantic cod, by vessel tonnage class, for USA and Canadian otter trawlers fishing on the Northern Edge and Northeast Peak of Georges Bank, 1965-1984. USA data represent trips landing cod from Statistical Areas 523 and 524. USA data are provided for all trips landing cod and for trips in which cod comprised 50% or more of trip catch, by weight.

	USA[1]				Canada[2,3]	
	Class 3[4]		Class 4[4]		Class 4[4]	Class 5[4]
Year	All Trips	50% Trips	All Trips	50% Trips	Side Trawlers	Stern Trawlers
1965	0.277	2.722*	0.630	-	-	-
1966	0.281	-	0.909	4.672*	-	-
1967	0.402	4.536*	1.443	7.146	-	-
1968	0.316	0.907*	1.216	2.098*	0.315	0.353
1969	0.312	3.233*	1.181	3.724*	0.328	0.424
1970	0.445	3.670	1.272	3.284	0.194	0.260
1971	0.293	2.060*	1.005	2.815	0.222	0.220
1972	0.248	2.197*	0.870	1.986*	0.220	0.357
1973	0.577	4.009	2.194	6.910	0.219	0.300
1974	0.230	2.268*	2.231	7.014	-	0.241
1975	0.222	2.156*	1.526	4.436	0.139	0.280
1976	0.150	2.378*	1.337	9.792*	0.147	0.245
1977	0.448	4.469*	2.474	10.855*	0.526	0.865
1978	0.682	5.508*	1.529	15.701*	0.521	0.688
1979	1.543	3.312	2.686	4.916	0.384	0.487
1980	1.233	3.801	2.720	5.665	0.200	0.504
1981	1.186	3.580	2.341	5.260	0.331	0.862
1982	1.696	5.290	3.088	5.766	0.371	0.761
1983	1.163	3.762	2.448	4.691	-	0.827
1984	0.732	2.546	1.734	2.711	-	-

[1]USA commercial catch rates are expressed as metric tons per day fished with trawl on bottom.

[2]Canadian commercial catch rates are expressed as metric tons per hour fished with trawl on bottom.

[3]Canadian data from Hunt and Waiwood (CAFSAC Res. Doc. 84/65).

[4]Class 3: 51-150 GRT; Class 4: 151-500 GRT; Class 5: 501-1000 GRT.

*Based on less than 10 trips.

Table 14. Stratified mean catch per tow in numbers and weight (kgs) for Atlantic cod from USA offshore spring and autumn bottom trawl surveys on Georges Bank (Strata 13-25) and in the Gulf of Maine (Strata 26-30 and 36-40), 1963-1986.

	Georges Bank				Gulf of Maine			
	Spring[1]		Autumn		Spring[1]		Autumn	
Year	Nos	Wt(kgs)	Nos	Wt(kgs)	Nos	Wt(kgs)	Nos	Wt(kgs)
1963	-	-	2.80	11.0	-	-	3.79	11.1
1964	-	-	1.91	7.1	-	-	2.57	14.1
1965	-	-	2.72	7.2	-	-	2.88	7.4
1966	-	-	3.09	5.0	-	-	2.43	8.0
1967	-	-	6.66	8.4	-	-	1.64	5.7
1968	3.03	7.8	2.12	5.3	3.48	11.1	2.80	12.0
1969	2.97	11.0	1.41	5.0	2.08	8.2	1.77	9.5
1970	2.78	9.7	3.25	7.7	1.41	6.8	3.14	10.1
1971	2.17	8.8	2.04	6.1	0.92	4.3	2.80	10.2
1972	5.74[2]	11.7[2]	8.39	14.2	1.32	5.0	5.96	8.0
1973	11.98[2]	24.5[2]	7.87	19.0	4.82	11.6	2.85	5.4
1974	9.45	22.5	2.24	5.1	1.86	4.6	2.77	5.5
1975	4.42	16.1	4.11	8.7	1.61	3.7	3.94	5.3
1976	4.52	11.5	6.68	10.9	1.78	4.7	1.38	4.2
1977	4.04	9.5	4.42	11.5	2.48	5.3	2.49	9.4
1978	7.89	19.3	6.97	21.5	1.31	4.8	4.68	11.9
1979	3.30	10.5	4.82	15.2	2.74	5.9	2.23	10.8
1980	4.96	15.3	2.36	6.2	1.74	5.7	5.71	13.1
1981	8.47[3]	24.0[3]	7.33	17.5	3.94	9.9	1.55	5.0
1982	6.65[3]	14.2[3]	2.38	4.3	3.04	7.9	4.98	9.9
1983	4.94	14.8	2.33	4.0	2.51	6.5	2.71	5.4
1984	2.61	9.5	3.04	6.3	2.18	3.6	1.55	5.4
1985	6.94	21.5	2.43	3.5	2.52	7.7	2.92	8.5
1986	5.04	16.7			1.96	3.6		

[1]Spring surveys, 1973-1981, were accomplished with "41 Yankee" trawl; spring surveys in other years were accomplished with "36 Yankee" trawl. No adjustments have been made to the catch per tow data for these gear differences.

[2]Excludes unusually high catch of 1894 cod (2558 kg) at station 230 (strata tow 20-4).

[3]Excludes unusually high catch of 1032 cod (4096 kg) at station 323 (strata tow 16-7).

Table 15. Percentage age composition, by number and weight, of Atlantic cod in USA commercial landings from Georges Bank and South (NAFO Division 5Z and Statistical Area 6) and in NEFC offshore spring research vessel bottom trawl surveys on Georges Bank (Strata 13-25), 1978-1986. Age 0 and age 1 cod caught in the surveys have been excluded from the analyses to facilitate comparison with the commercial data.

Year / Data Source	Age 1	2	3	4	5	6	7	8	9	10	11+	Total
Percentage Age Composition by Number												
1978												
USA Catch	-	3.8	65.6	18.7	7.2	0.6	3.3	0.4	0.3	0.1	-	100.0
Spring Survey	-	*2.2*	*64.1*	*11.2*	*9.0*	*1.7*	*8.3*	*0.6*	*1.6*	*0.7*	*0.6*	*100.0*
1979												
USA Catch	0.4	20.2	7.2	51.4	11.4	5.0	0.7	3.1	-	0.4	0.2	100.0
Spring Survey	-	*29.5*	*6.4*	*41.5*	*11.7*	*5.1*	*1.9*	*3.1*	*0.3*	-	*0.5*	*100.0*
1980												
USA Catch	0.8	26.0	40.7	2.5	16.3	8.2	3.5	0.7	1 3	-	-	100.0
Spring Survey	-	*29.8*	*35.4*	*2.7*	*19.5*	*7.9*	*2.5*	*0.4*	*0.4*	-	*1.4*	*100.0*
1981												
USA Catch	0.2	29.6	34.9	19.0	1.0	9.9	3.2	0.7	1.1	0.4	-	100.0
Spring Survey	-	*24.5*	*35.5*	*21.3*	*1.3*	*11.1*	*3.4*	*1.8*	-	*1.1*	-	*100.0*
1982												
USA Catch	2.3	54.6	17.2	11.7	8.7	0.8	3.1	0.8	0.3	0.2	0.2	100.0
Spring Survey	-	*44.9*	*18.6*	*17.1*	*13.7*	*0.2*	*3.9*	*0.8*	*0.2*	-	*0.5*	*100.0*
1983												
USA Catch	0.7	28.4	44.6	10.0	6.9	5.8	0.7	1.7	0.7	0.2	0.3	100.0
Spring Survey	-	*27.0*	*41.8*	*10.5*	*9.6*	*5.9*	*0.7*	*2.6*	-	*1.1*	*0.8*	*100.0*
1984												
USA Catch	0.9	14.0	36.0	32.3	5.4	4.3	4.2	0.3	1.7	0.4	0.5	100.0
Spring Survey	-	*12.6*	*21.7*	*31.6*	*12.1*	*11.5*	*6.1*	-	*4.2*	*0.2*	-	*100.0*
1985												
USA Catch	1.4	47.4	17.1	10.9	15.4	3.0	1.9	1.8	0.1	0.8	0.2	100.0
Spring Survey	-	*39.9*	*11.5*	*16.0*	*20.1*	*4.1*	*3.1*	*2.6*	*0.4*	*1.0*	*1.3*	*100.0*
1986												
USA Catch												
Spring Survey	-	*10.4*	*44.7*	*8.8*	*13.4*	*15.5*	*1.6*	*2.9*	*2.3*	-	*0.4*	*100.0*
Percentage Age Composition by Weight												
1978												
USA Catch	-	1.6	53.3	22.7	10.5	1.0	8.2	1.0	1.4	0.3	-	100.0
Spring Survey	-	*0.5*	*37.1*	*12.2*	*12.8*	*3.2*	*21.4*	*1.6*	*5.7*	*3.0*	*2.5*	*100.0*
1979												
USA Catch	0.1	7.5	4.3	54.1	13.9	9.0	1.7	7.7	-	1.3	0.4	100.0
Spring Survey	-	*3.1*	*3.6*	*42.4*	*17.2*	*9.8*	*5.7*	*9.8*	*1.1*	-	*3.3*	*100.0*
1980												
USA Catch	0.2	11.2	29.1	2.9	27.3	15.9	8.8	1.6	3.0	-	-	100.0
Spring Survey	-	*8.4*	*24.1*	*2.9*	*32.0*	*16.2*	*5.7*	*1.2*	*1.4*	-	*8.1*	*100.0*
1981												
USA Catch	0.1	13.6	25.2	19.6	1.5	22.3	8.2	2.1	4.8	2.6	-	100.0
Spring Survey	-	*7.8*	*23.7*	*23.3*	*1.4*	*23.7*	*9.1*	*5.5*	-	*5.6*	-	*100.0*
1982												
USA Catch	0.6	27.9	17.9	16.4	17.4	1.9	10.9	3.1	1.6	0.9	1.4	100.0
Spring Survey	-	*14.4*	*17.4*	*21.7*	*23.9*	*0.4*	*13.7*	*3.3*	*0.9*	-	*4.2*	*100.0*
1983												
USA Catch	0.2	14.4	37.1	11.6	10.9	12.6	1.8	6.1	2.6	0.9	1.6	100.0
Spring Survey	-	*9.6*	*32.1*	*11.4*	*13.3*	*11.9*	*2.1*	*10.8*	-	*5.3*	*3.6*	*100.0*
1984												
USA Catch	0.3	6.4	24.6	32.3	8.1	8.1	10.5	0.7	5.3	1.5	2.2	100.0
Spring Survey	-	*2.1*	*12.3*	*28.6*	*15.6*	*17.3*	*12.5*	-	*11.1*	*0.5*	-	*100.0*
1985												
USA Catch	0.4	22.7	12.4	14.6	26.9	6.5	5.2	6.4	0.6	3.2	1.1	100.0
Spring Survey	-	*9.3*	*7.6*	*17.0*	*28.1*	*8.1*	*8.7*	*9.7*	*1.5*	*4.9*	*6.1*	*100.0*
1986												
USA Catch												
Spring Survey	-	*2.2*	*23.6*	*7.9*	*19.4*	*25.8*	*3.8*	*8.5*	*8.1*	-	*0.7*	*100.0*

Table 16. Estimates of instantaneous total mortality (Z) and fishing mortality (F)[1] for Georges Bank and Gulf of Maine Atlantic cod for five time periods, 1964-1985, derived from NEFC offshore spring and autumn bottom trawl survey data[2].

Time Period	Georges Bank						Gulf of Maine					
	Spring		Autumn		Geometric Mean		Spring		Autumn		Geometric Mean	
	Z	F	Z	F	Z	F	Z	F	Z	F	Z	F
1964-1967	-	-	0.73	0.53	0.73	0.53	-	-	0.39	0.19	0.39	0.19
1968-1972	0.34	0.14	0.49[3]	0.29	0.41	0.21	0.37[4]	0.17	0.43	0.23	0.40	0.20
1973-1976	0.70	0.50	0.56	0.36	0.63	0.43	0.35[5]	0.15	0.45	0.25	0.40	0.20
1977-1981	0.44	0.24	0.63	0.43	0.53	0.33	0.47	0.27	0.57[6]	0.37	0.52	0.32
1982-1985	0.45	0.25	1.40	1.20	0.79	0.59	0.93	0.73	0.72	0.52	0.82	0.62

[1]Instantaneous natural mortality (M) assumed to be 0.20.

[2]Estimates derived from:

Georges Bank spring: ln (Σ age 4+ for years i to j/Σ age 5+ for years i+1 to j+1).
Georges Bank autumn: ln (Σ age 3+ for years i-1 to J-1/Σ age 4+ for years i to j).

Gulf of Maine spring: ln (Σ age 4+ for years i to j/Σ age 5+ for years i+1 to j+1).
Gulf of Maine autumn: ln (Σ age 3+ for years i-1 to j-1/Σ age 4+ for years i to j).

[3]Excludes autumn 1971-1972 data (3+/4+) since these gave negative Z value.
[4]Excludes spring 1972-1973 data (4+/5+) since these gave large negative Z value.
[5]Excludes spring 1973-1974 data (4+/5+) since these gave unreasonably high Z value.
[6]Excludes autumn 1976-1977 data (3+/4+) since these gave large negative Z value.

Table 17. Independent variables used in tuning Georges Bank cod VPA for terminal fishing mortality (F) in 1985. For terminal F values between 0.50 and 0.85, VPA $\bar{F}_{(3-7)}$ was regressed upon effort values, and VPA 4+ biomass was regressed on USA autumn survey age 3+ weight per tow values.

	Relative Total Effort[1]		USA Autumn Survey Index
	"All	"50%	Mean Weight Per Tow (Age 3+)(kg)
Year (i)	Trips"	Trips"	For Year i-1
1978	18290	7377	7.52
1979	18408	9270	20.40
1980	22290	10967	11.98
1981	22411	10669	5.06
1982	26236	12853	12.94
1983	24444	11503	1.56
1984	27237	12979	2.62
1985	32408	16491	

[1]Days fished. "All Trips" effort was derived by dividing total annual landings by annual weighted mean CPUE calculated from all USA otter trawl trips in which cod from Georges Bank was landed.

"50% Trips" effort was derived by dividing total annual landings by annual weighted mean CPUE calculated from USA otter trawl trips in which cod from Georges Bank comprised 50% or more of the total trip catch, by weight (i.e., directed trip).

Table 18. Summary of Georges Bank cod VPA tuning results. Values presented are from regression equations (Y = a + bX) where a = Y intercept and b = slope. Tuning measures include the correlation coefficient (r), the sum of residuals for the last three years ($\Sigma|R_i|$), the sum of the squared residuals for the last three years (ΣR_i^2), and the absolute value of the residual in the last year. *Denotes best fit (either maximization of correlation coefficient or minimization of residuals).

	Terminal F Value											
	0.50	0.55	0.60	0.65	0.70	0.75	0.76	0.78	0.80	0.82	0.84	0.85
Fishing Mortality ($\bar{F}$3-7) on Fishing Effort (Total Landings/CPUE from all USA Cod Otter Trawl Trips)												
a	0.3016	0.2362	0.1712	0.1059	0.0400	-0.0247	-0.0381	-0.0631	-0.0897	-0.1142	-0.1340	-0.1534
b	7.93E-6	1.13E-5	1.46E-5	1.79E-5	2.12E-5	2.44E-5	2.51E-5	2.63E-5	2.76E-5	2.88E-5	3.01E-5	3.07E-5
r	0.6757	0.8171	0.8929	0.9330	0.9541	0.9640	0.9653	0.9669	0.9683	0.9688	0.9689*	0.9687
$\Sigma\|R_i\|$	0.1235	0.1240	0.1220	0.1141	0.1047	0.0928	0.0904	0.0845	0.0789	0.0730*	0.0765	0.0783
ΣR_i^2 (x10^3)	5.89	5.59	5.21	4.53	3.89	3.32	3.22	3.03	2.85	2.69	2.61	2.59*
1985 Residual (Absolute Value)	0.0588	0.0524	0.0449	0.0361	0.0265	0.0157	0.0135	0.0088	0.0046	0.0005*	0.0055	0.0079
Fishing Mortality ($\bar{F}$3-7) on Fishing Effort (Total Landings/CPUE from USA Otter Trawl Trips with ≥50% of Cod)												
a	0.3323	0.2827	0.2331	0.1827	0.1316	0.0813	0.0709	0.0511	0.0303	0.0112	-0.0091	-0.0196
b	1.38E-5	1.95E-5	2.51E-5	3.06E-5	3.61E-5	4.16E-5	4.27E-5	4.48E-5	4.70E-5	4.91E-5	5.12E-5	5.23E-5
r	0.6807	0.8132	0.8835	0.9202	0.9395	0.9482	0.9493	0.9510	0.9523	0.9526*	0.9526*	0.9524
$\Sigma\|R_i\|$	0.1350	0.1396	0.1407	0.1379	0.1326	0.1247	0.1232	0.1189	0.1150	0.1096*	0.1137	0.1163
ΣR_i^2(x10^3)	6.74	6.80	6.74	6.56	6.33	6.15	6.13	6.07	6.02	5.96*	5.99	6.03
1985 Residual (Absolute Value)	0.0606	0.0540	0.0462	0.0371	0.0275	0.0167	0.0136	0.0088	0.0046	0.0005*	0.0044	0.0069
VPA 4+ Biomass (year i) on USA Autumn Survey Index (3+ Mean Weight Per Tow) (year i-1)												
a	55233	53588	52223	51071	50089	49240	49090	48785	48502	48232	47977	47853
b	1083	1165	1233	1290	1339	1381	1389	1404	1418	1432	1444	1450
r	0.6755	0.7172	0.7471	0.7688	0.7850	0.7973	0.7996	0.8032	0.8067	0.8099	0.8128	0.8141*
$\Sigma\|R_i\|$	10817	9663	8705	7898	7209	6617	6510	6298	6099	5911	5732	5646*
ΣR_i^2(x10^7)	4.891	3.595	2.816	2.368	2.136	2.050	2.048	2.045*	2.057	2.080	2.111	2.130
1984 Residual (Absolute Value)	6099	4758	3645	2706	1905	1215	1082	844	675	394	186	86*

Table 19. Estimates of fishing mortality (F), stock size (thousands of fish) and stock biomass (metric tons) derived from Virtual Population Analysis for Georges Bank and South (NAFO Division 5Z and Statistical Area 6) Atlantic cod, 1978-1985.

	YEAR							
AGE	1978	1979	1980	1981	1982	1983	1984	1985
				FISHING MORTALITY				
1	<0.001	0.002	0.007	0.001	0.030	0.014	0.003	0.013
2	0.167	0.099	0.240	0.347	0.457	0.463	0.234	0.321
3	0.417	0.414	0.466	0.535	0.640	0.610	0.793	0.820
4	0.390	0.513	0.382	0.377	0.627	0.702	0.626	0.820
5	0.391	0.339	0.482	0.234	0.539	0.682	0.592	0.820
6	0.154	0.406	0.733	0.557	0.566	0.612	0.717	0.820
7	0.337	0.224	0.996	0.649	0.625	0.966	0.757	0.820
8	0.403	0.457	0.505	0.481	0.611	0.632	0.701	0.820
9+	0.403	0.457	0.505	0.481	0.611	0.632	0.701	0.820
MEAN F	0.403	0.457	0.505	0.481	0.611	0.632	0.701	0.820
REC AGE	3+	3+	3+	3+	3+	3+	3+	3+

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986
				STOCK SIZE AT AGE					
1	27407.4	22753.8	17590.8	41225.3	17511.2	8655.1	33640.9	(13665)	(27500)
2	3165.3	22438.4	18553.9	14316.9	34112.5	13910.3	6991.0	(27510)	11043.4
3	24579.7	2193.5	16643.3	11943.2	8282.9	17688.9	7165.9	4528.9	16341.9
4	7417.7	13260.4	1187.6	8554.7	5729.5	3576.2	7872.8	2653.5	1633.1
5	2826.1	4112.1	6501.0	663.6	4802.0	2505.0	1451.0	3445.3	956.9
6	546.5	1565.4	2399.3	3288.3	429.9	2293.2	1037.1	657.5	1242.4
7	1476.9	383.5	853.6	944.2	1543.0	199.8	1018.1	414.4	237.1
8	152.1	863.4	251.0	258.0	404.0	676.0	62.3	391.0	149.4
9+	155.4	158.3	504.7	556.2	370.5	440.5	664.6	241.2	228.0
TOT NUMBERS	67727.1	67728.8	64485.2	81750.5	73185.5	49945.1	59903.6	53506.5	59332.2
TOT WEIGHT	113270.7	127272.3	127681.2	134583.8	126693.3	103639.0	105876.9	90242.8	89251.7

AGE	1978	1979	1980	1981	1982	1983	1984	1985	1986
				STOCK BIOMASS AT AGE					
1	14763.2	15336.1	11047.0	28363.0	9613.7	6629.8	30714.1	(10932)	(22000)
2	2956.4	25961.2	21225.7	16077.9	37591.9	14911.9	8962.5	(33149)	13307.3
3	46037.8	3911.0	32321.3	22393.5	17137.4	32742.1	13823.1	8546.0	30837.2
4	23588.3	43229.0	3722.0	24791.4	17257.2	11193.6	23539.6	8417.0	5180.2
5	10886.3	17624.4	32446.4	3023.8	20634.2	10653.9	6255.4	15104.3	4194.8
6	2446.6	8947.7	13858.2	21439.9	2493.0	13548.0	5876.4	3932.1	7429.3
7	9501.2	2682.1	6723.8	7087.4	12868.9	1430.3	7733.4	3098.3	1772.9
8	1159.3	7588.2	2268.8	2372.7	3761.7	6674.3	550.0	3812.5	1456.8
9+	1931.6	1992.7	4067.9	9034.1	5335.2	5855.1	8422.5	3251.5	3073.1
3+ NUMBERS	37154.6	22536.6	28340.5	26208.3	21561.8	27379.6	19271.7	12331.9	20788.8
3+ WEIGHT	95551.1	85975.0	95408.5	90142.9	79487.7	82097.3	66200.3	46161.7	53944.4

Table 20. Data used in estimating population numbers at age 1 and age 2 from USA research vessel bottom trawl survey/VPA relationships using $\bar{F}_{85(3-7)}=0.82$. Research vessel survey indices represent stratified mean number per tow at age; VPA values are in millions of fish.

Year (i)	USA Research Vessel Mean Catch Per Tow: Spring Age 1 (i)	USA Research Vessel Mean Catch Per Tow: Autumn Age 1 (i)	VPA Age 1 (i)	USA Research Vessel Mean Catch Per Tow: Spring Age 2 (i)	USA Research Vessel Mean Catch Per Tow: Autumn Age 1 (i-1)	VPA Age 2 (i)
1978	.241	1.505	22067.6	.120	.192	3165.3
1979	.279	1.314	22753.8	.871	1.505	22438.4
1980	.025	.664	17590.8	1.452	1.314	18553.9
1981	1.869	2.860	41225.3	1.555	.664	14316.9
1982	.396	.561	17511.2	2.755	2.860	34112.5
1983	.211	.415	8655.1	1.261	.561	13910.3
1984	.258	1.600		.296	.415	6991.0
1985	.098	.220		2.633	1.600	
1986	.871			.423	.220	

Functional (Geometric Mean) Regressions

	VPA Age 1 on Survey Age 1 Indices (i) (1978-1983)		VPA Age 2 on Spring Survey Age 2 (i) and Autumn Survey Age 1 (i-1) Indices (1978-1984)	
Regression Parameters	Spring	Autumn	Spring	Autumn
a	13607.275	7162.403	2484.100	4270.728
b	15941.791	11863.559	11564.333	11129.438
r	0.8842	0.9654	0.8826	0.9692
Year Class Estimate	Estimated No. (000's)		Estimated No. (000's)	
1984 Cohort in 1985 (at age 1)	15169	12086	-	-
	$\bar{X}$ = 13628			
1983 Cohort in 1985 (at age 2)	-	-	32933	22078
			$\bar{X}$ = 27506	
1985 Cohort in 1986 (at age 1)	27493	-		

Table 21. Data used in yield per recruit analysis and in catch and spawning stock projections for Georges Bank cod.

Age	Stock Size 1986 (000's)	Exploitation Pattern	Mean Weight[1] of Catch (kg)	Mean Weight[1] of Stock (kg)	Maturity[4] Ogive
1	27500[2]	0.0165	0.984	0.800[3]	-
2	11043	0.5173	1.522	1.244	0.25
3	16342	1.0	2.316	1.908	0.63
4	1633	1.0	3.844	3.081	0.86
5	957	1.0	5.345	4.348	1.00
6	1242	1.0	6.717	5.823	1.00
7	237	1.0	8.600	7.537	1.00
8	149	1.0	10.198	9.292	1.00
9	141	1.0	12.157	11.052	1.00
10+	87	1.0	14.359	14.359	1.00

For age 1 stock sizes in projections (1987 and 1988), the VPA geometric mean from 1978-1985 was used: ~20 million fish).

[1]Average of 1984-1985 values.
[2]Predicted value from VPA/Spring Survey functional regression.
[3]1985 value used.
[4]Values from Gabriel (1985). Maturity ogive only used in Y/R analysis, not in stock projections.

Table 22. Yield per recruit, total stock biomass per recruit, and spawning stock biomass per recruit analyses for Georges Bank cod.

Fishing Mortality (F)	Yield Per Recruit	Stock Biomass Per Recruit	Spawning Stock Biomass Per Recruit
.01	0.250	26.686	24.418
.05	0.936	20.668	18.424
.10	1.400	15.700	13.486
.15	1.617	12.699	10.333
.155($F_{0.1}$)	1.631	11.520	10.073
.20	1.719	10.305	8.144
.25	1.739	8.944	6.807
.280(F_{max})	1.762	8.501	6.375
.30	1.759	7.583	5.471
.40	1.721	6.031	3.962
.50	1.664	5.064	3.034
.60	1.608	4.418	2.424
.70	1.557	3.963	2.001
.80	1.512	3.628	1.696
.90	1.474	3.373	1.468
1.00	1.440	3.173	1.293

Table 23. Short-term catch and stock size projections for Georges Bank cod, 1986-1987. Biomass and catch values are expressed in thousands (000's) of metric tons. Spawning stock biomass is considered to be age 3+ and refer to the beginning of the year.

1986				1987					1988	
Stock Biomass	Spawning Stock Biomass	$\bar{F}_{(3-7)}$	Catch	Mgmt Option	Stock Biomass	Spawning Stock Biomass	$\bar{F}_{(3-7)}$	Catch	Stock Biomass	Spawning Stock Biomass
89.3	53.9	0.82	38.6	$F_{87} = F_{85}$	83.1	39.5	0.82	35.5	78.9	42.8
		0.58	30.0	$F_{87} = F_{86}$	92.4	48.7	0.58	32.0	93.3	57.1
		0.58	30.0	F_{max}			0.28	17.4	108.7	72.4
		0.58	30.0	$F_{0.1}$			0.16	10.1	116.4	80.1

Table 24. Distribution of USA commercial landings (metric tons, live) of Atlantic cod from the Gulf of Maine (Area 5Y), by gear type, 1965-1985. The percentage of total USA commercial landings of Atlantic cod from the Gulf of Maine, by gear type, for each year is also presented. Data only reflect Gulf of Maine cod landings that could be identified by gear type.

	Landings (metric tons, live)						Percentage of Annual Landings					
Year	Otter Trawl	Sinking Gill Net	Line Trawl	Handline	Other Gear	Total Landings	Otter Trawl	Sinking Gill Net	Line Trawl	Handline	Other Gear	Total
1965	2480	501	462	168	1	3612	68.7	13.9	12.8	4.6	-	100.0
1966	2549	830	308	150	4	3841	66.4	21.6	8.0	3.9	0.1	100.0
1967	4312	734	206	274	<1	5526	78.0	13.3	3.7	5.0	-	100.0
1968	4143	1377	213	339	4	6076	68.2	22.7	3.5	5.6	-	100.0
1969	6553	851	258	162	4	7828	83.7	10.9	3.3	2.1	-	100.0
1970	5967	951	407	178	9	7512	79.4	12.7	5.4	2.4	0.1	100.0
1971	5117	1043	927	98	8	7193	71.1	14.5	12.9	1.4	0.1	100.0
1972	4004	1492	1234	54	2	6786	59.0	22.0	18.2	0.8	-	100.0
1973	3542	1182	1305	23	9	6061	58.4	19.5	21.5	0.4	0.2	100.0
1974	5056	1412	904	36	17	7425	68.1	19.0	12.2	0.5	0.2	100.0
1975	6255	1480	920	12	8	8675	72.1	17.1	10.6	0.1	0.1	100.0
1976	6701	2511	621	4	41	9878	67.8	25.4	6.3	0.1	0.4	100.0
1977	8415	2872	534	6	166[1]	11993	70.2	23.9	4.5	-	1.4	100.0
1978	7958	3438	393	10	91[2]	11890	66.9	28.9	3.3	0.1	0.8	100.0
1979	7567	2900	334	19	167[3]	10987	68.9	26.4	3.0	0.2	1.5	100.0
1980	8420	3733	251	48	61	12513	67.3	29.8	2.0	0.4	0.5	100.0
1981	7937	4102	276	23	45	12383	64.1	33.1	2.2	0.2	0.4	100.0
1982	9758	3453	188	46	34	13479	72.4	25.6	1.4	0.3	0.3	100.0
1983	9975	3744	77	4	67	13867	71.9	27.0	0.6	-	0.5	100.0
1984	6646	3985	22	3	69	10725	62.0	37.2	0.2	-	0.6	100.0
1985	7119	3090	55	6	326[4]	10596	67.2	29.1	0.5	0.1	3.1	100.0

[1]Of 166 tons landed, 107 tons were by mid-water pair trawl and 42 tons were by drifting gill nets.

[2]Of 91 tons landed, 56 tons were by Danish seine and 27 tons were by drifting gill nets.

[3]Of 167 tons landed, 119 tons were by drifting gill nets and 38 tons were by Danish seine.

[4]Of 326 tons landed, 268 tons were by longline (153 tons large; 106 tons market; 9 tons scrod) and 37 tons were by Danish seine.

Table 25. USA commercial landings (L)[1], days fished (DF)[2], and landings per day fished (L/DF), by vessel tonnage class (Class 2:5-50 GRT; Class 3:51-150 GRT; Class 4:151-500 GRT), of Atlantic cod for otter trawl trips catching cod in the Gulf of Maine (Area 5Y), 1965-1985. Data are also provided for otter trawl trips in which cod comprised 50% or more of the total trip catch, by weight (directed trip).

	Class 2			Class 3			Class 4			Total	
Year	L	DF	L/DF	L	DF	L/DF	L	DF	L/DF	L	L/DF[3]
					All Trips						
1965	1412	2691	0.52	935	965	0.97	46	92	0.50	2393	0.70
1966	1265	2379	0.53	1093	938	1.17	113	83	1.36	2471	0.85
1967	1790	2175	0.82	2341	1232	1.90	108	196	0.55	4239	1.41
1968	1839	2696	0.68	1955	1266	1.54	219	182	1.20	4013	1.13
1969	2992	3301	0.91	2874	1497	1.92	549	337	1.63	6415	1.42
1970	3359	4834	0.69	2010	1666	1.21	389	425	0.92	5758	0.89
1971	2917	4000	0.73	1727	1475	1.17	293	422	0.69	4937	0.88
1972	2190	4104	0.53	1463	1637	0.89	192	244	0.79	3845	0.68
1973	2018	3915	0.52	1172	1430	0.82	194	252	0.77	3384	0.64
1974	2292	3954	0.58	2108	1455	1.45	458	367	1.25	4858	1.02
1975	3108	4423	0.70	2599	1818	1.43	311	373	0.83	6018	1.02
1976	3168	4404	0.72	3143	2096	1.50	262	527	0.50	6573	1.08
1977	3816	4354	0.88	3903	2448	1.59	341	631	0.54	8060	1.21
1978	3859	5063	0.76	3334	2618	1.27	489	809	0.60	7682	0.97
1979	3731	5623	0.66	3169	2425	1.31	475	779	0.61	7375	0.94
1980	3967	6252	0.63	3497	3181	1.10	571	908	0.63	8035	0.83
1981	3722	4912	0.76	3253	3277	0.99	737	986	0.75	7712	0.86
1982	3619	6086	0.59	4466	4343	1.03	1281	1448	0.88	9366	0.84
1983	3473	5512	0.63	4874	4731	1.03	1326	1782	0.74	9673	0.85
1984	2188	5444	0.40	3217	5042	0.64	883	1668	0.53	6288	0.54
1985	1801	4890	0.37	3457	5921	0.58	1515	2675	0.57	6773	0.52
					≥50% Trips						
1965	394	183	2.15	310	74	4.19	1	1	1.00	705	3.05
1966	253	92	2.75	329	85	3.87	12	4	3.00	594	3.38
1967	656	179	3.66	1202	270	4.45	1	1	1.00	1859	4.17
1968	656	155	4.23	995	224	4.44	50	16	3.13	1701	4.32
1969	1399	324	4.32	1384	292	4.74	104	38	2.74	2887	4.46
1970	1369	395	3.47	719	152	4.73	46	15	3.07	2134	3.89
1971	1033	370	2.79	540	124	4.35	74	24	3.08	1647	3.31
1972	621	283	2.19	322	88	3.66	46	11	4.18	989	2.76
1973	380	179	2.12	96	33	2.91	1	1	1.00	477	2.28
1974	467	186	2.51	529	92	5.75	181	31	5.84	1177	4.48
1975	1047	331	3.16	1039	232	4.48	66	14	4.71	2152	3.84
1976	1197	384	3.12	1277	308	4.15	22	6	3.67	2496	3.65
1977	1390	386	3.60	1825	334	5.46	44	6	7.33	3259	4.69
1978	1314	421	3.12	1373	297	4.62	48	7	6.86	2735	3.94
1979	1114	382	2.92	1233	287	4.30	46	7	6.57	2393	3.70
1980	1198	360	3.33	1205	283	4.26	99	22	4.50	2502	3.82
1981	1587	317	5.01	1218	273	4.46	98	15	6.53	2903	4.83
1982	1354	381	3.55	2296	499	4.60	334	54	6.19	3984	4.38
1983	1399	397	3.52	2609	603	4.33	224	29	7.72	4232	4.24
1984	478	215	2.23	941	313	3.01	21	5	4.20	1440	2.77
1985	438	269	1.63	1024	319	3.21	205	67	3.06	1667	2.78

[1]Metric tons, live weight.

[2]Days fished with trawl on bottom was derived by dividing hours fished with trawl on bottom by 24.0.

[3]Total landings per day fished was derived by weighting individual tonnage class landings rates by the percentage of total landings in each vessel class and summing the weighted landings rates over the three vessel class categories.

Table 26. USA sampling of Atlantic cod from the Gulf of Maine (NAFO Division 5Y), 1980-1985. Both the number of samples and number of cod measured (in parenthesis) are provided. Data reflect samples from commercial landings only.

Year	Length Samples by Market Category				Age Samples	
	Scrod	Market	Large	Total	No.	Aged
1980	7 (364)	-	-	7 (364)	7	87
1981	7 (426)	6 (553)	2 (210)	15 (1189)	15	266
1982	25 (1681)	18 (1937)	5 (430)	48 (3848)	48	866
1983	38 (2169)	22 (2200)	11 (872)	71 (5241)	67	1348
1984	25 (1335)	18 (1654)	12 (936)	55 (3925)	55	1224
1985	23 (1305)	25 (2392)	21 (1549)	69 (5426)	66	1546

Table 27. Catch at age (thousands of fish; metric tons) and mean weight (kg) and mean length (cm) at age of USA commercial landings of Atlantic cod from the Gulf of Maine (NAFO Division 5Y) 1982-1985.

Year	Age 1	2	3	4	5	6	7	8	9	10	11+	Total
USA Commercial Catch in Numbers (000's) at Age												
1982	30	1380	1633	1143	633	69	91	61	41	4	33	5118
1983	-	866	2357	1058	638	422	47	61	23	9	15	5496
1984	4	446	1240	1500	437	194	74	19	15	11	17	3957
1985	-	407	1445	991	630	128	78	32	4	11	11	3737
USA Commercial Catch in Weight (Tons) at Age												
1982	24	1595	2717	3160	3019	461	813	608	531	41	613	13582
1983	-	1009	3913	2619	2410	2518	271	643	227	102	269	13981
1984	3	516	2071	4080	1607	1145	603	186	193	152	250	10806
1985	-	513	2523	2816	2814	705	615	363	51	141	152	10693
USA Commercial Mean Weight (kg) at Age												
1982	0.80	1.16	1.66	2.76	4.77	6.74	8.94	9.93	12.92	10.62	18.46	2.65[1]
1983	-	1.16	1.66	2.47	3.78	5.96	5.81	10.52	10.09	10.90	17.81	2.54
1984	0.59	1.16	1.67	2.72	3.68	5.90	8.12	9.60	12.89	13.95	15.03	2.73
1985	-	1.26	1.74	2.84	4.47	5.33	7.90	11.22	11.42	13.39	14.53	2.86
USA Commercial Mean Length (cm) at Age												
1982	43.2	48.3	53.8	63.4	76.8	86.1	94.6	97.9	107.4	101.0	120.7	59.9[2]
1983	-	48.6	53.8	61.4	70.8	82.4	80.5	98.8	97.5	100.0	118.7	59.8
1984	39.0	48.4	54.1	63.4	69.7	81.8	91.5	96.7	106.9	112.0	112.0	61.6
1985	-	49.8	55.1	64.6	74.9	80.3	90.8	101.9	103.1	108.2	109.7	62.8

[1]Mean length of fish in catch.

[2]Mean weight per fish in catch.

Table 28. USA commercial vessel trips, days fished[1] and average days fished per trip, by vessel tonnage class (Class 2: 5-50 GRT; Class 3: 51-150 GRT; Class 4: 151-500 GRT) for otter trawl trips landing Atlantic cod from the Gulf of Maine (Area 5Y), 1965-1985. Data are also provided for otter trawl trips in which cod comprised 50% or more of the total trip catch, by weight (directed trip).

	Vessel Tonnage Class											
	Class 2			Class 3			Class 4			Totals		
Year	Total Trips	Days Fished	Days Fished per Trip	Total Trips	Days Fished	Days Fished per Trip	Total Trips	Days Fished	Days Fished per Trip	Total Trips	Days Fished	Days Fished per Trip
					All Trips							
1965	5354	2691	0.50	1145	965	0.84	60	92	1.53	6559	3748	0.57
1966	4637	2379	0.51	1130	938	0.83	38	83	2.18	5805	3400	0.59
1967	3903	2175	0.56	1277	1232	0.96	98	196	2.00	5278	3603	0.68
1968	3587	2696	0.75	1293	1266	0.98	99	182	1.84	4979	4144	0.83
1969	3679	3301	0.90	1494	1497	1.00	186	337	1.81	5359	5135	0.96
1970	4342	4834	1.11	1585	1666	1.05	214	425	1.99	6141	6925	1.13
1971	3908	4000	1.02	1272	1475	1.16	204	422	2.07	5384	5897	1.10
1972	3933	4104	1.04	1326	1637	1.23	130	244	1.88	5389	5985	1.11
1973	4688	3915	0.84	1241	1430	1.15	146	252	1.73	6075	5597	0.92
1974	5145	3954	0.77	1274	1455	1.14	193	367	1.90	6612	5776	0.87
1975	5498	4423	0.80	1437	1818	1.27	198	373	1.88	7133	6614	0.93
1976	4734	4404	0.93	1687	2096	1.24	228	527	2.31	6649	7027	1.06
1977	4664	4354	0.93	2010	2448	1.22	298	631	2.12	6972	7433	1.07
1978	4655	5063	1.09	1754	2618	1.49	444	809	1.82	6853	8490	1.24
1979	5218	5623	1.08	1777	2425	1.36	445	779	1.75	7440	8827	1.19
1980	5344	6252	1.17	2240	3181	1.42	396	908	2.29	7980	10341	1.30
1981	7131	4912	0.69	2879	3277	1.14	385	986	2.56	10395	9175	0.88
1982	7737	6086	0.79	3148	4343	1.38	448	1448	3.23	11333	11877	1.05
1983	7460	5512	0.74	3575	4731	1.32	446	1782	4.00	11481	12025	1.05
1984	7006	5444	0.78	3554	5042	1.42	403	1668	4.14	10963	12154	1.11
1985	6196	4890	0.79	3612	5921	1.64	649	2675	4.12	10457	13486	1.29
					≥50% Trips							
1965	493	394	0.80	116	74	0.64	2	1	0.50	611	469	0.77
1966	241	253	1.05	102	84	0.82	2	4	2.00	345	341	0.99
1967	418	656	1.57	231	270	1.17	1	1	1.00	650	927	1.43
1968	386	656	1.70	251	224	0.89	7	16	2.29	644	896	1.39
1969	645	1399	2.17	325	292	0.90	15	38	2.53	985	1729	1.76
1970	695	1369	1.97	217	152	0.70	11	15	1.36	923	1536	1.66
1971	550	1033	1.88	193	124	0.64	7	24	3.43	750	1181	1.57
1972	492	621	1.26	134	88	0.66	9	11	1.22	635	720	1.13
1973	354	380	1.07	54	33	0.61	2	1	0.50	410	414	1.01
1974	491	467	0.95	98	92	0.94	17	31	1.82	606	590	0.97
1975	676	1047	1.55	218	232	1.06	11	14	1.27	905	1293	1.43
1976	554	1197	2.16	334	308	0.92	6	6	1.00	894	1511	1.69
1977	492	1390	2.83	391	334	0.85	10	6	0.60	893	1730	1.94
1978	460	1314	2.86	281	297	1.06	6	7	1.17	747	1618	2.17
1979	504	1114	2.21	331	287	0.87	10	7	0.70	845	1408	1.67
1980	500	1198	2.40	360	283	0.79	12	22	1.83	872	1503	1.72
1981	752	1587	2.11	390	273	0.70	13	15	1.15	1155	1875	1.62
1982	802	1354	1.69	565	499	0.88	23	54	2.35	1390	1907	1.37
1983	910	1399	1.54	855	603	0.71	24	29	1.21	1789	2031	1.14
1984	427	215	0.50	334	313	0.94	1	5	5.00	762	796	1.04
1985	397	269	0.68	331	319	0.96	18	67	3.72	746	655	0.88

[1]Days fished with trawl on the bottom was derived by dividing hours fished with trawl on bottom by 24.0.

Table 29. Percentage within vessel tonnage class[1] of vessel class Atlantic cod landings (L)[2], vessel trips (T), and effort (DF)[3] of otter trawlers landing cod from the Gulf of Maine (Area 5Y) in which cod comprised 50% or more of trip catch weight (directed trip).

	Vessel Tonnage Class											
	Class 2			Class 3			Class 4			Total		
Year	L	T	DF	L	T	DF	L	T	DF	L	T	DF
1965	27.9	9.2	6.8	33.2	10.1	7.7	2.2	3.3	1.1	29.5	9.3	6.9
1966	20.0	5.2	3.9	30.1	9.0	9.1	10.6	5.3	4.8	24.0	5.9	5.3
1967	36.6	10.7	8.2	51.3	18.1	21.9	0.9	1.0	0.5	43.9	12.3	12.5
1968	35.7	10.8	5.7	50.9	19.4	17.7	22.8	7.1	8.8	42.4	12.9	9.5
1969	46.8	17.5	9.8	48.2	21.8	19.5	18.9	8.1	11.3	45.0	18.4	12.7
1970	40.8	16.0	8.2	35.8	13.7	9.1	11.8	5.1	3.5	37.1	15.0	8.1
1971	35.4	14.1	9.3	31.3	15.2	8.4	25.3	3.4	5.7	33.4	13.9	8.8
1972	28.4	12.5	6.9	22.0	10.1	5.4	24.0	6.9	4.5	25.7	11.8	6.4
1973	18.8	7.6	4.6	8.2	4.4	2.3	0.5	1.4	0.4	14.1	6.7	3.8
1974	20.4	9.5	4.7	25.1	7.7	6.3	39.5	8.8	8.4	24.2	9.2	5.3
1975	33.7	12.3	7.5	40.0	15.2	12.8	21.2	5.6	3.8	35.8	12.7	8.7
1976	37.8	11.7	8.7	40.6	19.8	14.7	8.4	2.6	1.1	38.0	13.4	9.9
1977	36.4	10.5	8.9	46.8	19.5	13.6	12.9	3.4	1.0	40.4	12.8	9.8
1978	34.1	9.9	8.3	41.2	16.0	11.3	9.8	1.4	0.9	35.6	10.9	8.5
1979	29.9	9.7	6.8	38.9	18.6	11.8	9.7	2.2	0.9	32.4	11.4	7.6
1980	30.2	9.4	5.8	34.5	16.1	8.9	17.3	3.0	2.4	31.1	10.9	6.4
1981	42.6	10.5	6.4	37.4	13.5	8.3	13.3	3.4	1.5	37.6	11.1	6.6
1982	37.4	10.4	6.3	51.4	17.9	11.5	26.1	5.1	3.7	42.5	12.3	7.9
1983	40.3	12.2	7.2	53.5	23.9	12.7	16.9	5.4	1.6	43.8	15.6	8.6
1984	21.8	6.1	3.9	29.3	9.4	6.2	2.4	0.2	0.3	22.9	7.0	4.4
1985	24.3	6.4	5.5	29.6	9.2	5.4	13.5	2.7	2.5	24.6	7.1	4.9

[1]Class 2: 5-50 GRT; Class 3: 51-150 GRT; Class 4: 151-500 GRT.

[2]Metric tons, live weight.

[3]Effort is expressed as days fished with trawl on the bottom and derived from hours fished with trawl on bottom divided by 24.0.

Table 30. Percentage age composition, by number and weight, of Atlantic cod in USA commercial landings from the Gulf of Maine (NAFO Division 5Y) and in NEFC offshore spring research vessel bottom trawl surveys in the Gulf of Maine (Strata 26-30; 36-40), 1982-1986. Age 0 and age 1 cod caught in the surveys have been excluded from the analyses to facilitate comparison with the commercial data.

Year / Data Source	Age 1	2	3	4	5	6	7	8	9	10	11+	Total
Percentage Age Composition by Number												
1982												
USA Catch	0.6	27.0	31.9	22.3	12.4	1.3	1.8	1.2	0.8	0.1	0.6	100.0
Spring Survey	-	*30.0*	*15.2*	*20.4*	*25.4*	*3.4*	*3.2*	-	*1.2*	*1.2*	-	*100.0*
1983												
USA Catch	-	15.8	42.9	19.2	11.6	7.7	0.8	1.1	0.4	0.2	0.3	100.0
Spring Survey	-	*29.9*	*25.4*	*19.6*	*10.9*	*5.5*	*2.8*	-	*2.8*	*0.5*	*2.6*	*100.0*
1984												
USA Catch	0.1	11.3	31.3	37.9	11.0	4.9	1.9	0.5	0.4	0.3	0.4	100.0
Spring Survey	-	*31.8*	*35.3*	*22.8*	*5.8*	*1.6*	*1.8*	*0.9*	-	-	-	*100.0*
1985												
USA Catch	-	10.9	38.7	26.5	16.8	3.4	2.1	0.9	0.1	0.3	0.3	100.0
Spring Survey	-	*9.6*	*25.0*	*26.7*	*27.2*	*3.8*	*4.6*	*2.1*	-	*1.0*	-	*100.0*
1986												
USA Catch												
Spring Survey	-	*21.4*	*42.0*	*25.1*	*4.8*	*3.0*	*1.8*	*0.7*	-	-	*1.2*	*100.0*
Percentage Age Composition by Weight												
1982												
USA Catch	0.2	11.7	20.0	23.3	22.2	3.4	6.0	4.5	3.9	0.3	4.5	100.0
Spring Survey	-	*5.5*	*8.2*	*20.6*	*40.8*	*6.1*	*8.1*	-	*4.9*	*5.8*	-	*100.0*
1983												
USA Catch	-	7.2	28.0	18.7	17.3	18.0	2.0	4.6	1.6	0.7	1.9	100.0
Spring Survey	-	*4.6*	*11.3*	*15.1*	*16.8*	*10.7*	*8.2*	-	*12.3*	*2.2*	*18.8*	*100.0*
1984												
USA Catch	<0.1	4.8	19.2	37.7	14.9	10.6	5.6	1.7	1.8	1.4	2.3	100.0
Spring Survey	-	*10.0*	*27.9*	*33.1*	*17.8*	*3.9*	*5.6*	*1.7*	-	-	-	*100.0*
1985												
USA Catch	-	4.8	23.6	26.3	26.3	6.6	5.8	3.4	0.5	1.3	1.4	100.0
Spring Survey	-	*1.7*	*11.1*	*25.0*	*37.2*	*6.4*	*6.4*	*6.8*	-	*5.4*	-	*100.0*
1986												
USA Catch												
Spring Survey	-	*3.6*	*30.1*	*25.6*	*7.6*	*9.8*	*8.7*	*4.5*	-	-	*10.1*	*100.0*

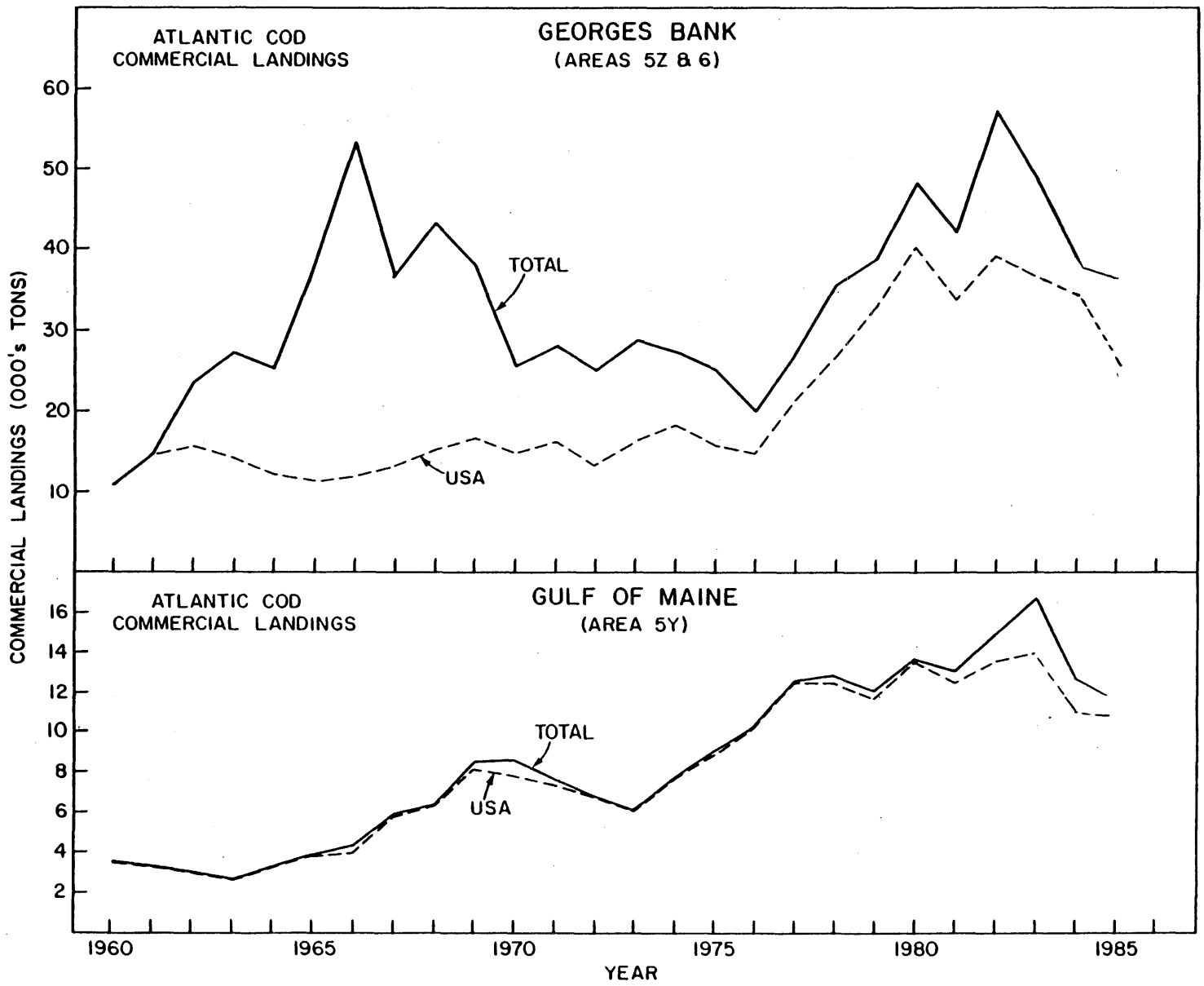


Figure 1. Commercial landings (000's of metric tons, live weight) of Atlantic cod from Georges Bank (NAFO Division 5Z and Statistical Area 6) and the Gulf of Maine (NAFO Division 5Y), 1960-1985.

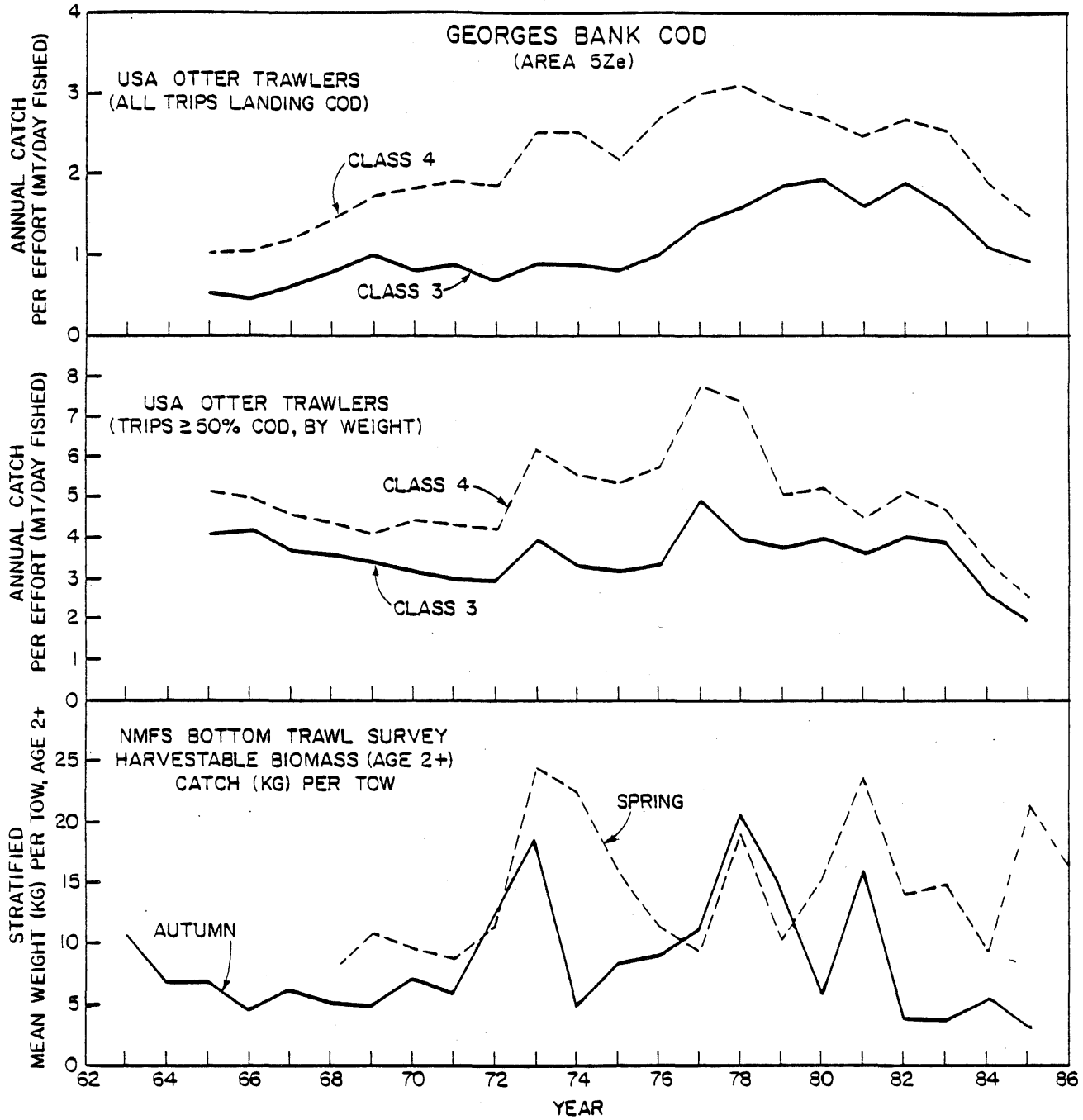


Figure 2. Commercial catch rates (mt/day fished) of Atlantic cod from USA tonnage class 3 and 4 otter trawlers fishing on Georges Bank (NAFO Subdivision 5Ze), 1965-1985, compared with NMFS spring and autumn offshore bottom trawl survey harvestable biomass (age 2+) catch per tow indices, 1963-1986. Commercial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

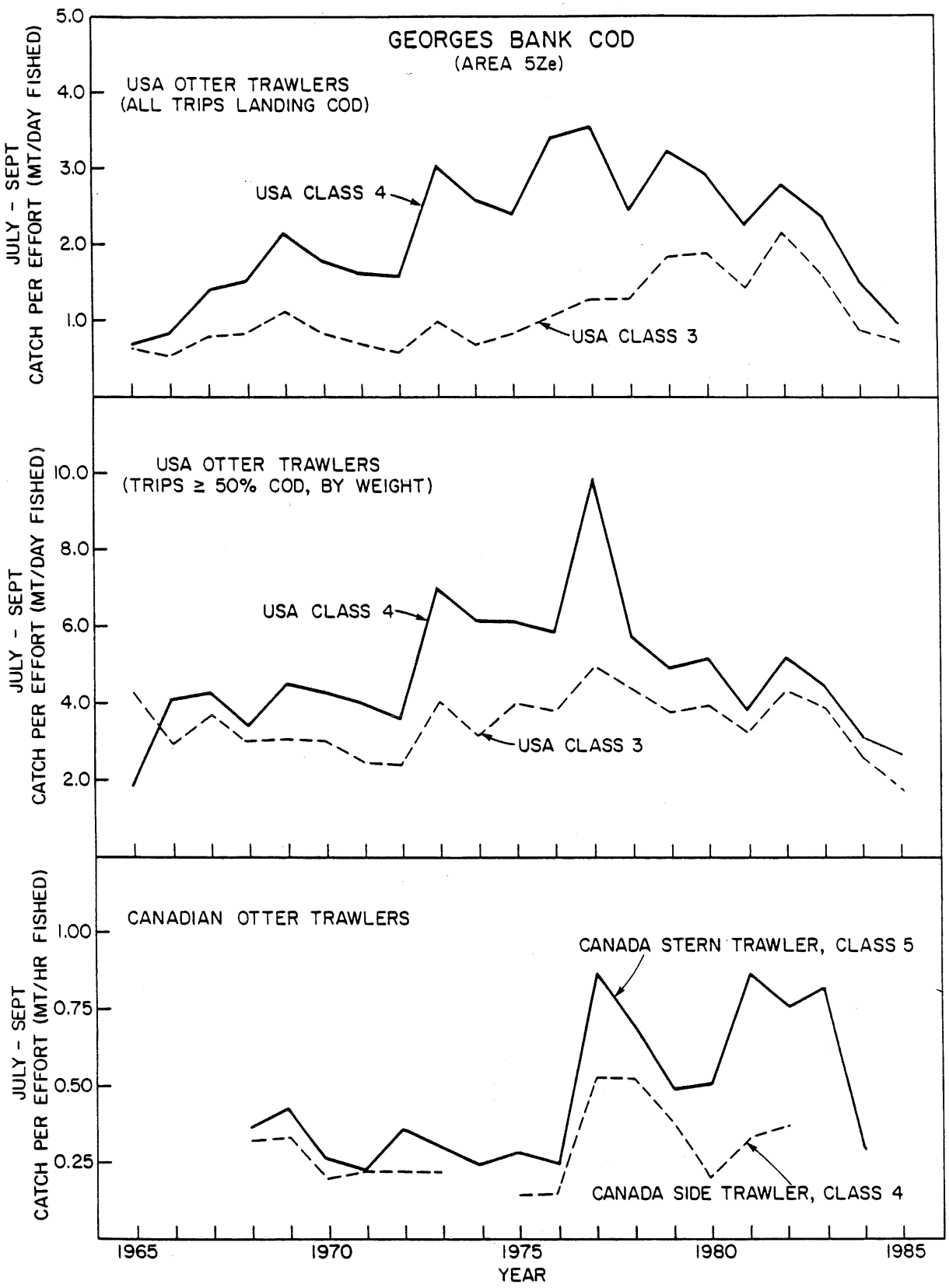


Figure 3. Commercial July-September catch rates of Atlantic cod from USA and Canadian otter trawlers fishing on Georges Bank (NAFO Subdivision 5Ze), 1965-1985. USA catch rate data are presented for all otter trawl trips landing cod and for trips in which cod comprised 50% or more of the trip catch, by weight.

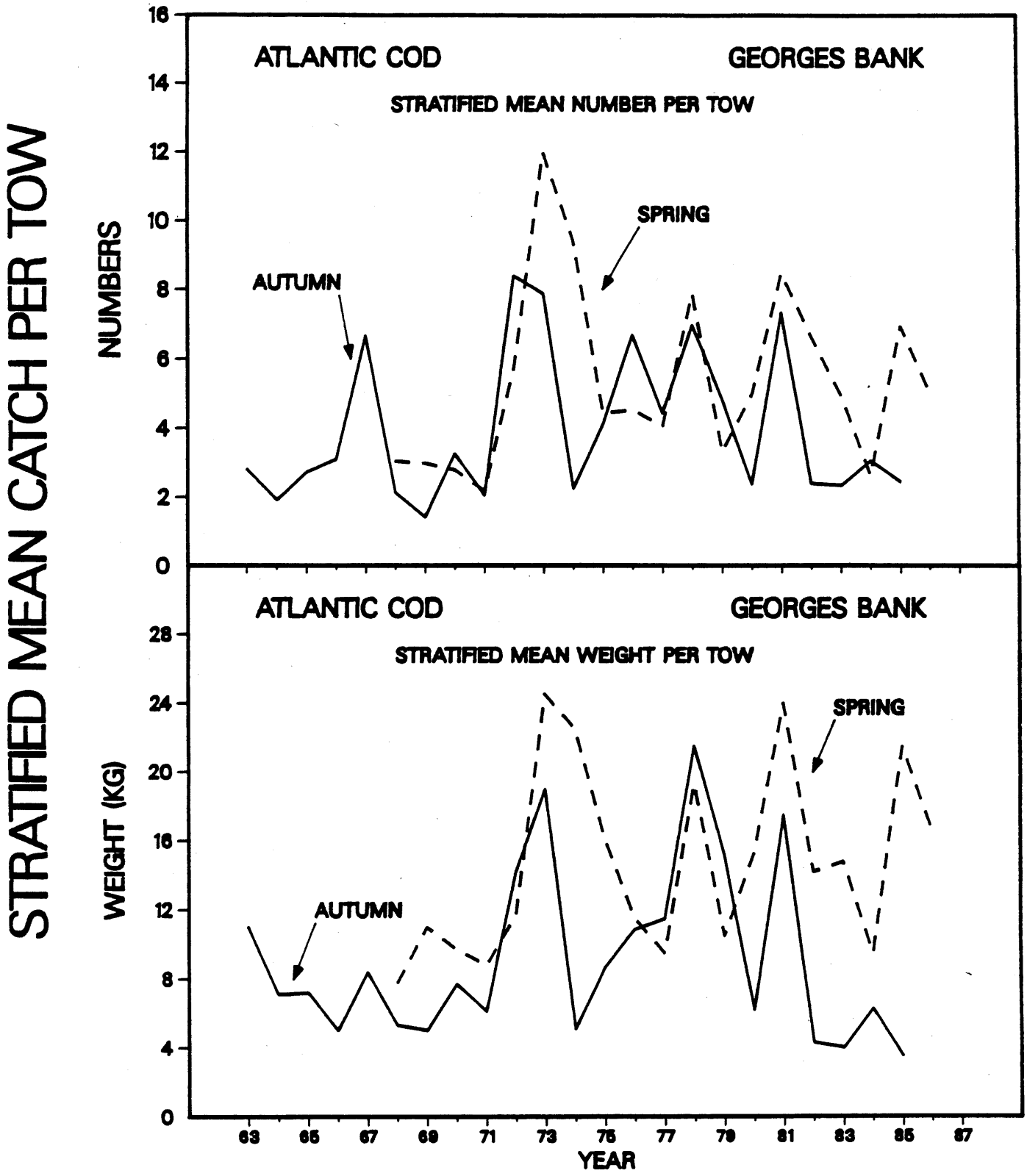


Figure 4. Stratified mean number per tow and stratified mean weight (kilograms) per tow of Atlantic cod in NEFC spring and autumn offshore bottom trawl surveys on Georges Bank Strata 13-25), 1963-1986.

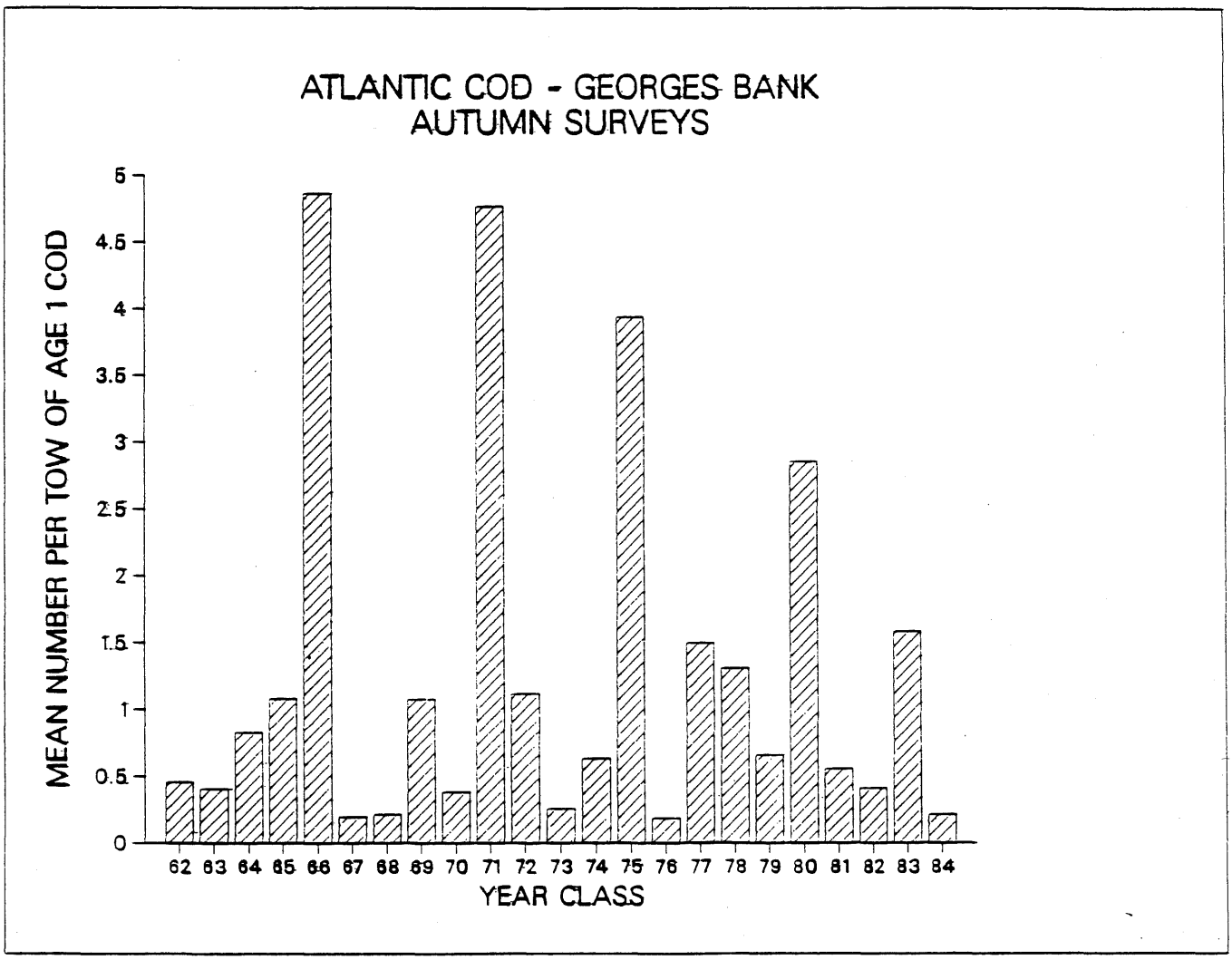


Figure 5. Relative year class strength of Atlantic cod on Georges Bank. Values represent the stratified mean number per tow of age 1 cod taken in NMFS autumn bottom trawl surveys on Georges Bank, 1963-1985.

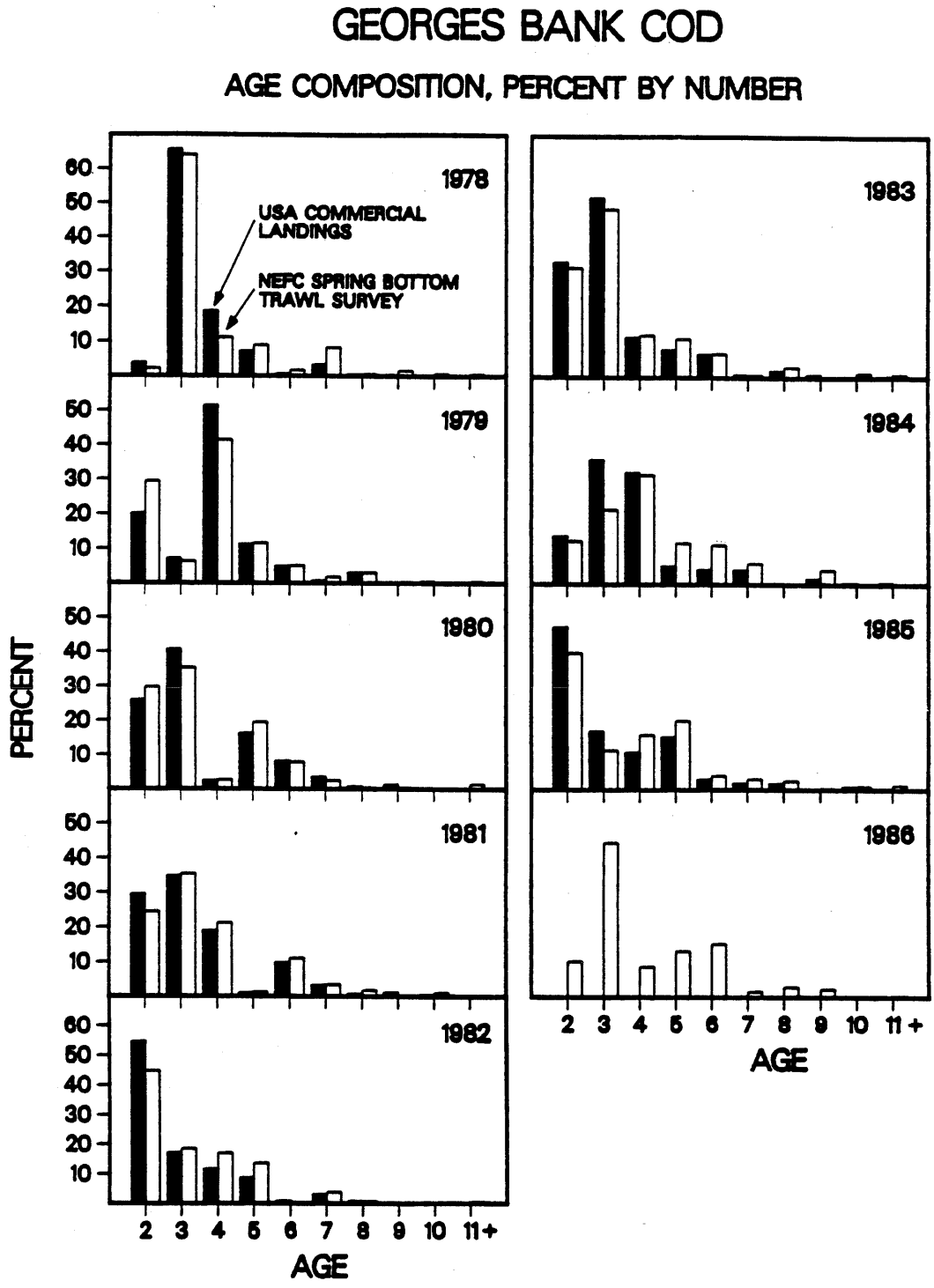


Figure 6. Comparison of percentage age composition (by number) of Atlantic cod in USA commercial landings from Georges Bank and South (NAFO Division 5Z and Statistical Area 6) and in NEFC spring bottom trawl surveys on Georges Bank (Strata 13-25), 1978-1986. Age 0 and 1 cod caught in the surveys were excluded from the age composition analyses to facilitate comparison with the commercial data.

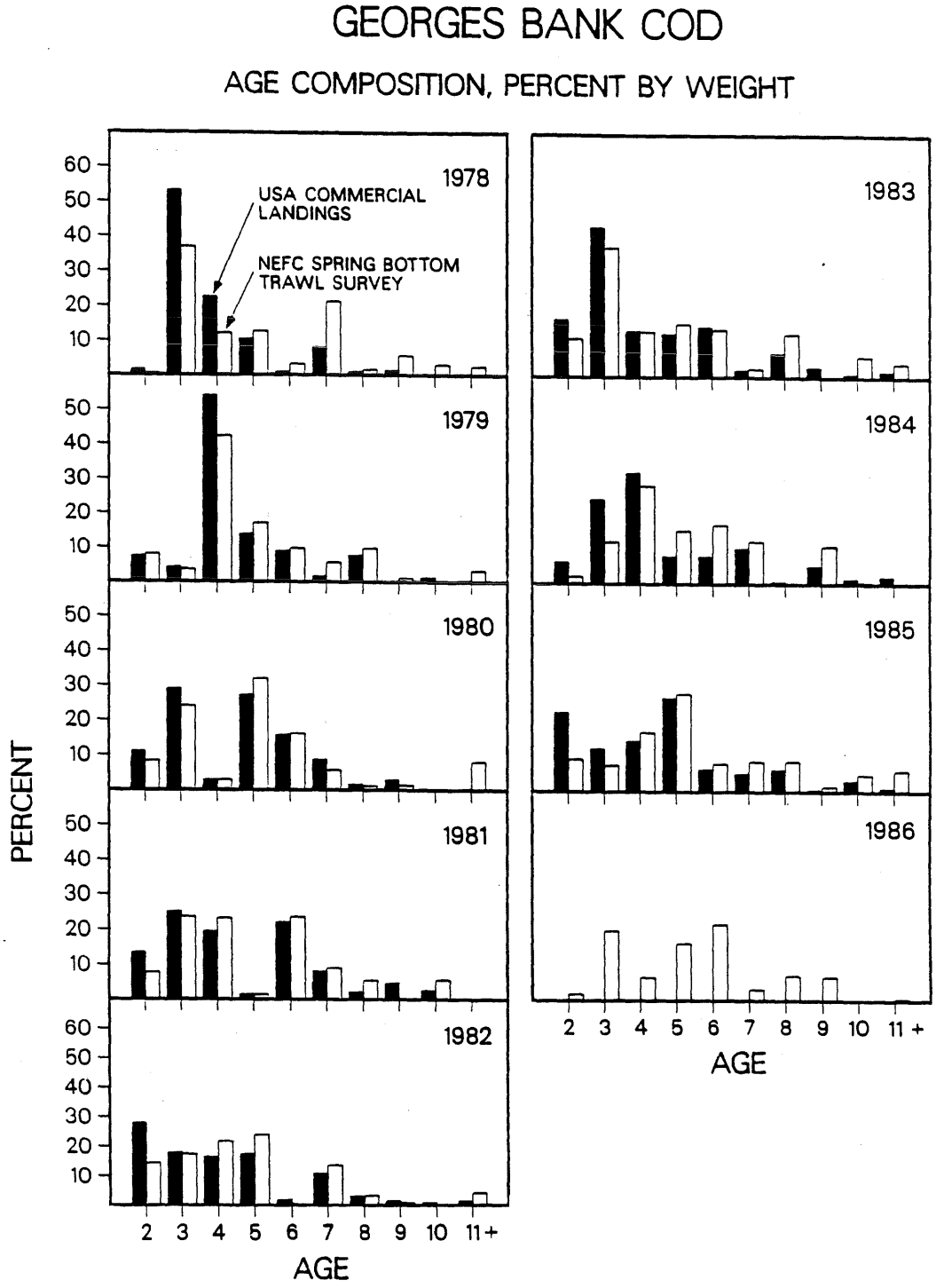


Figure 7. Comparison of percentage age composition (by weight) of Atlantic cod in USA commercial landings from Georges Bank and South (NAFO Division 5Z and Statistical Area 6) and in NEFC spring bottom trawl surveys on Georges Bank (Strata 13-25), 1978-1986. Age 0 and 1 cod caught in the surveys were excluded from the age composition analyses to facilitate comparison with the commercial data.

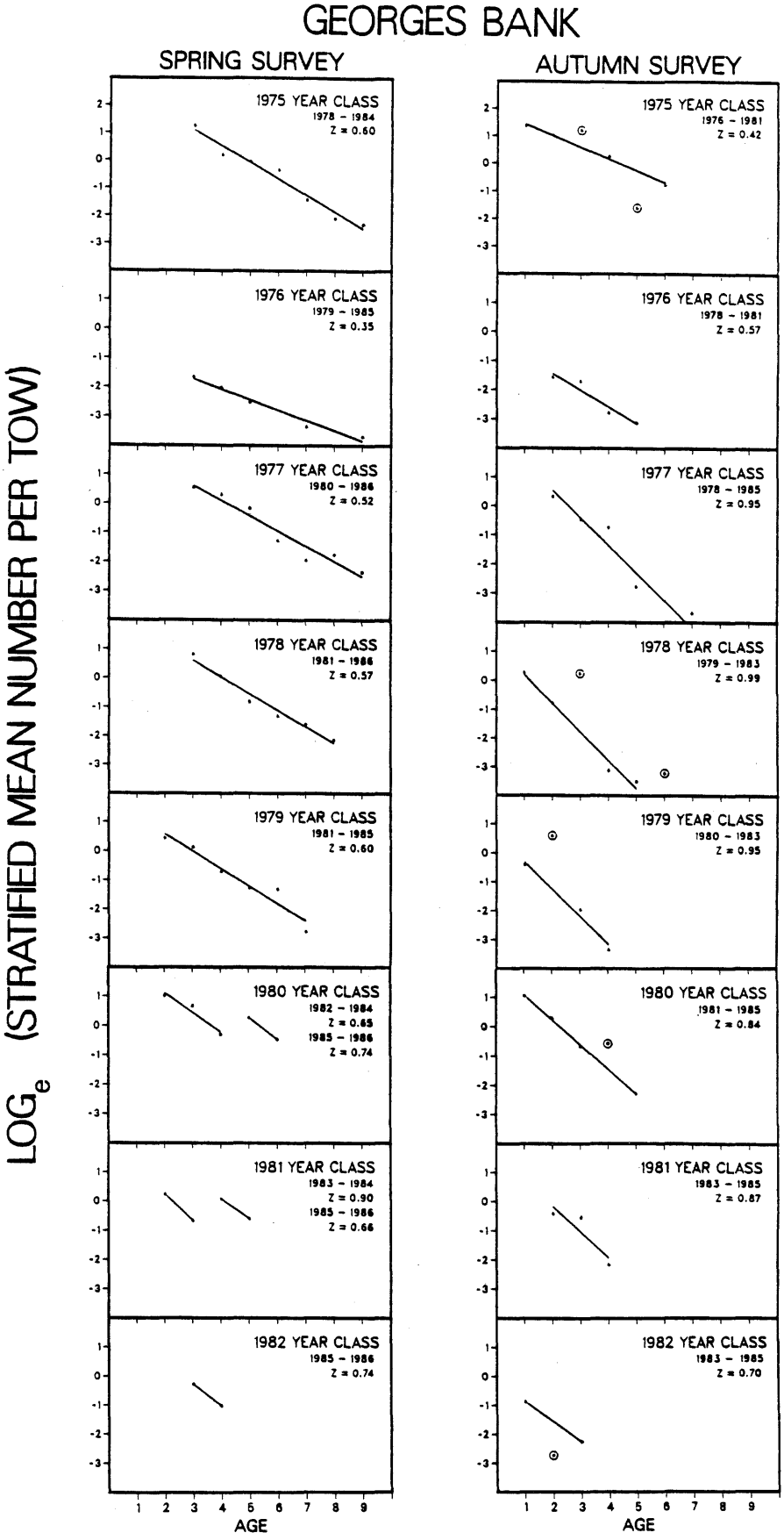


Figure 8. Catch curves for the 1975 - 1982 year classes of Atlantic cod on Georges Bank derived from NMFS spring and autumn offshore bottom trawl survey catch data (circled points not used in calculations).

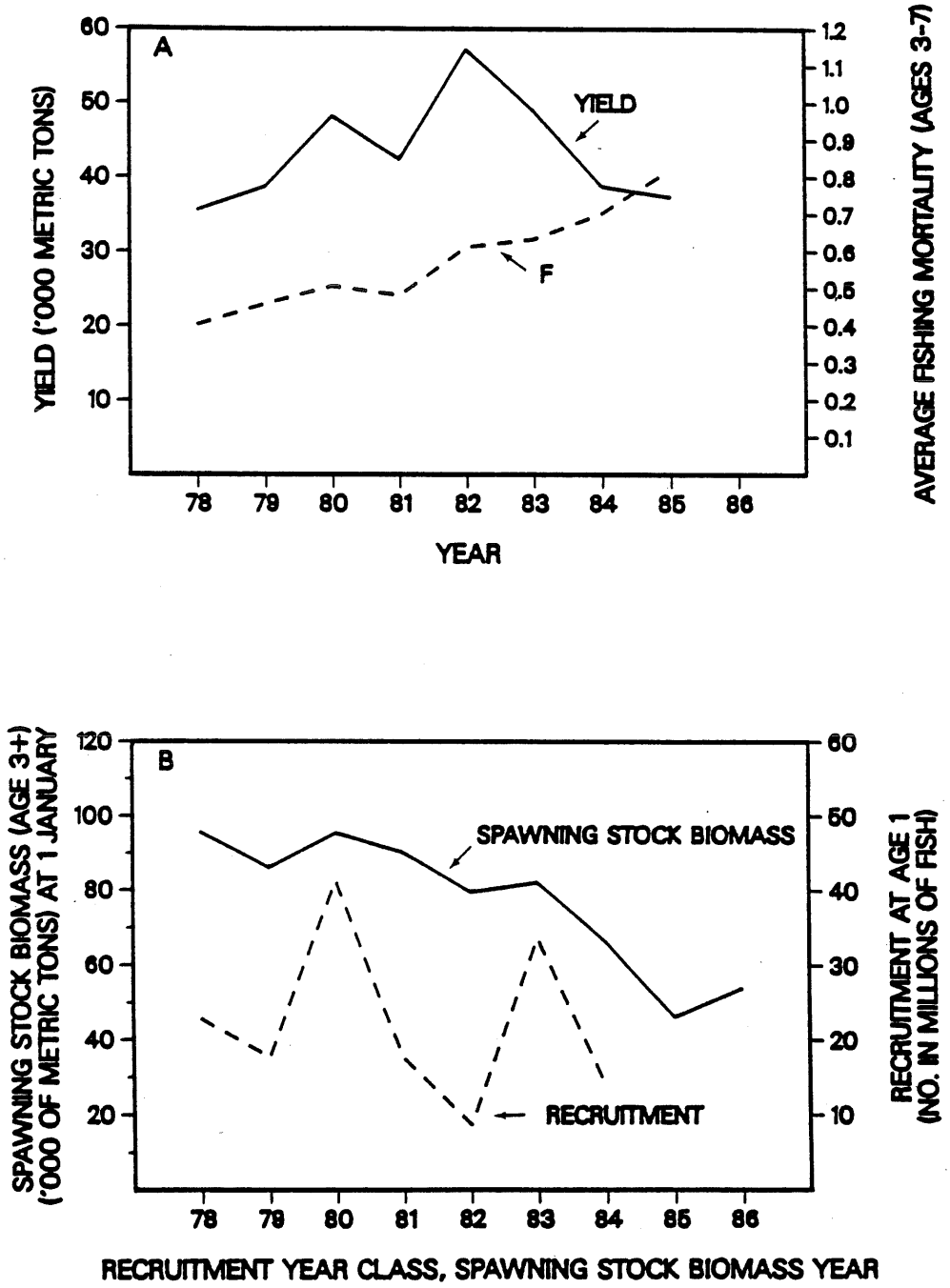
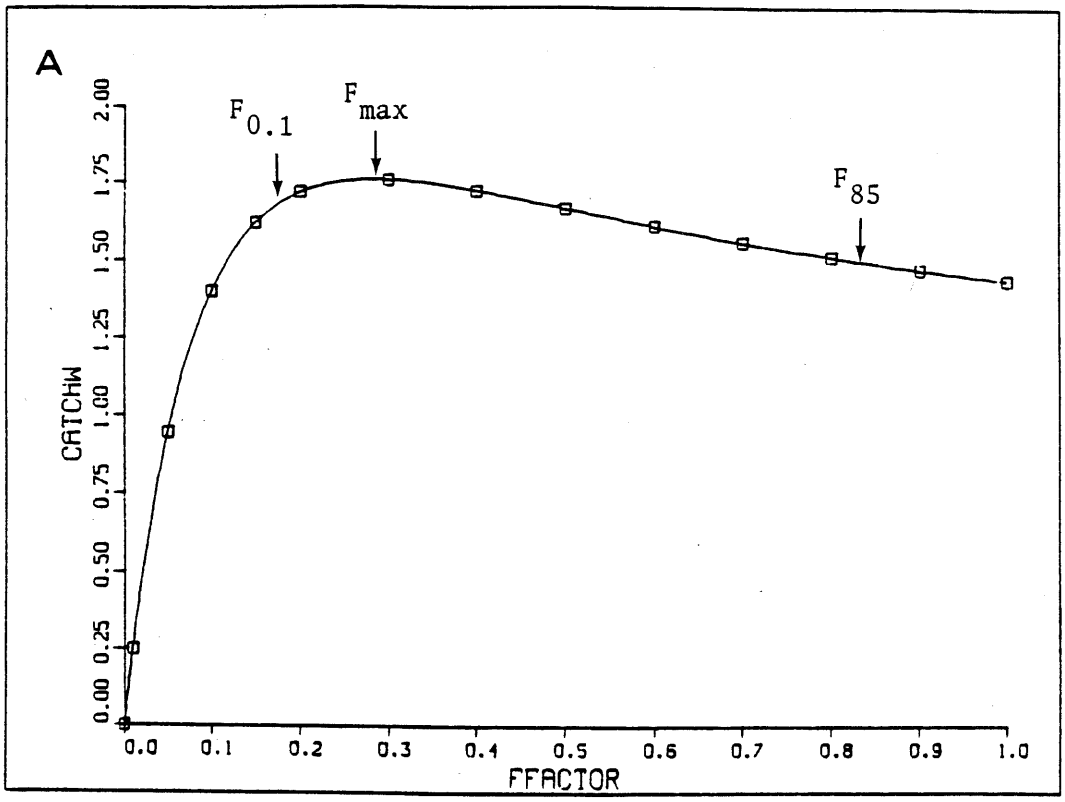


Figure 9. (A) Trends in yield and fishing mortality; and (B) trends in spawning stock biomass (age 3+) and recruitment (at age 1) for Georges Bank and South (NAFO Division 5Z and Statistical Area 6) Atlantic cod.



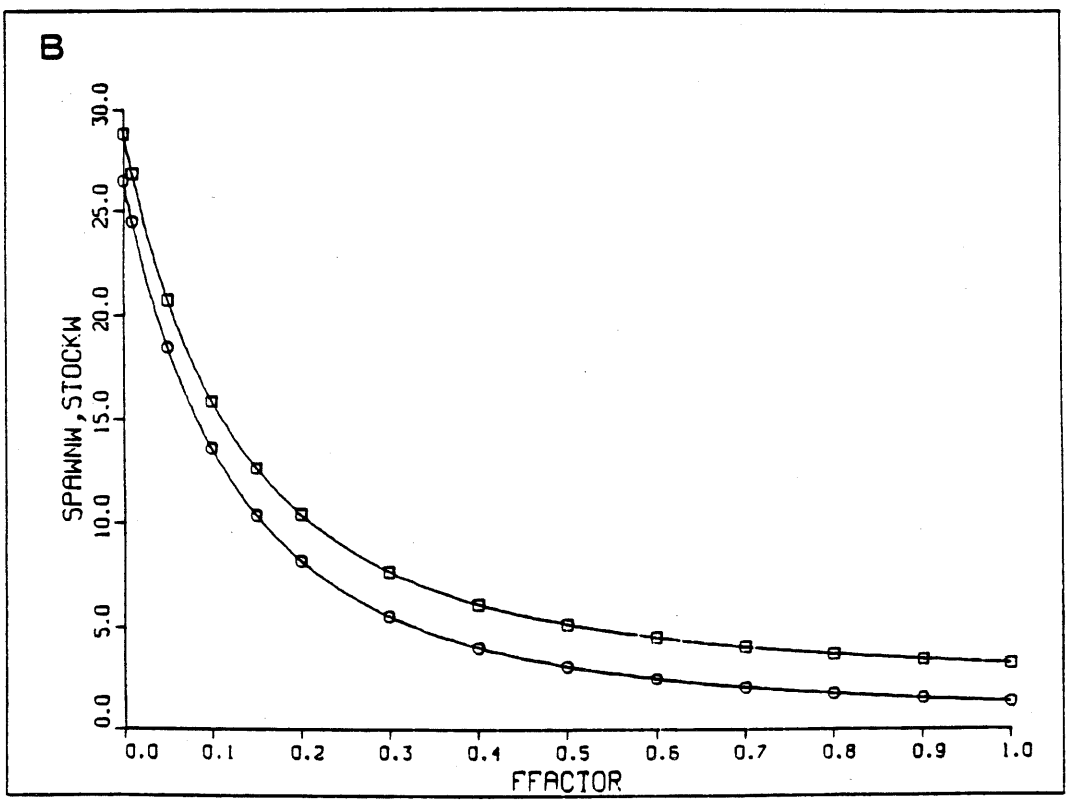


Figure 10. (A) Long-term yield per recruit; and (B) long-term total stock and spawning stock biomass per recruit relationships for Georges Bank and South (NAFO Division 5Z and Statistical Area 6) Atlantic cod.

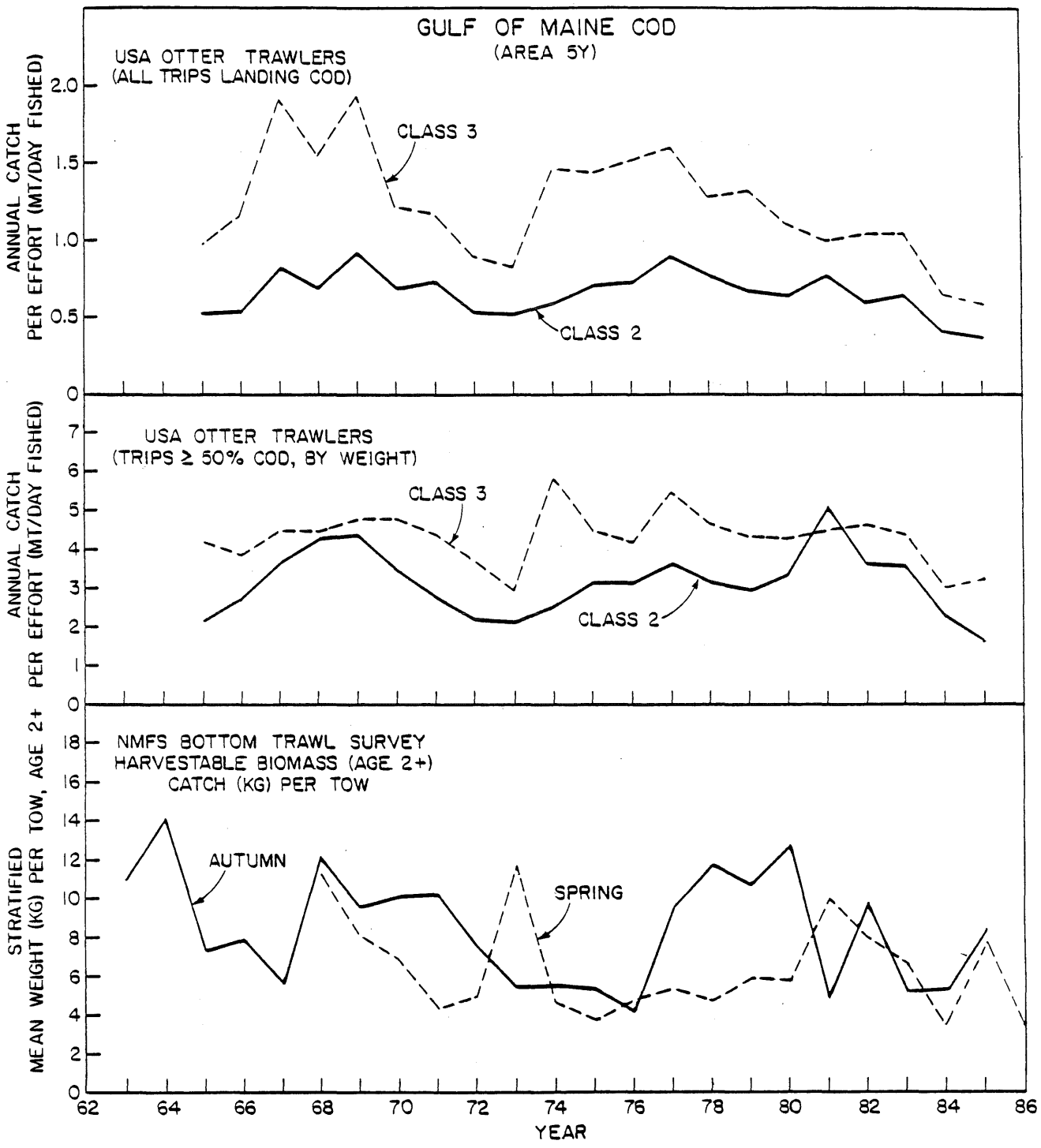


Figure 11. Commercial catch rates (mt/day fished) of Atlantic cod from USA tonnage class 2 and 3 otter trawlers fishing in the Gulf of Maine (NAFO Division 5Y), 1965-1985, compared with NMFS spring and autumn offshore bottom trawl harvestable biomass (age 2+) catch per tow indices, 1963-1985. Commercial USA catch rates are presented for all otter trawl trips landing cod and for trips in which cod comprised 50% or more of the trip catch, by weight.

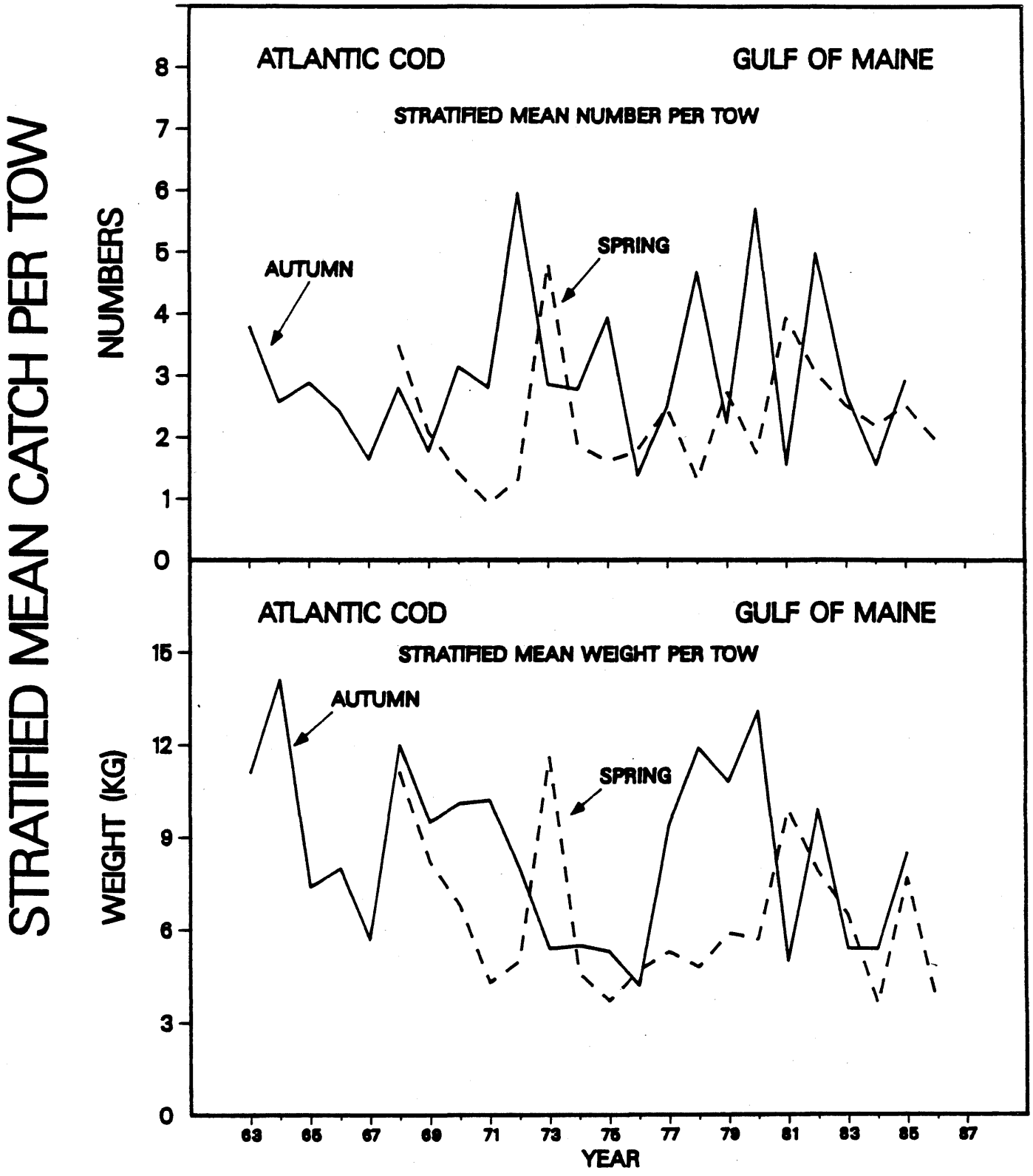


Figure 12. Stratified mean number per tow and stratified mean weight (kilograms) per tow of Atlantic cod in NEFC spring and autumn offshore bottom trawl surveys in the Gulf of Maine (Strata 26-30; 36-40), 1963-1986.

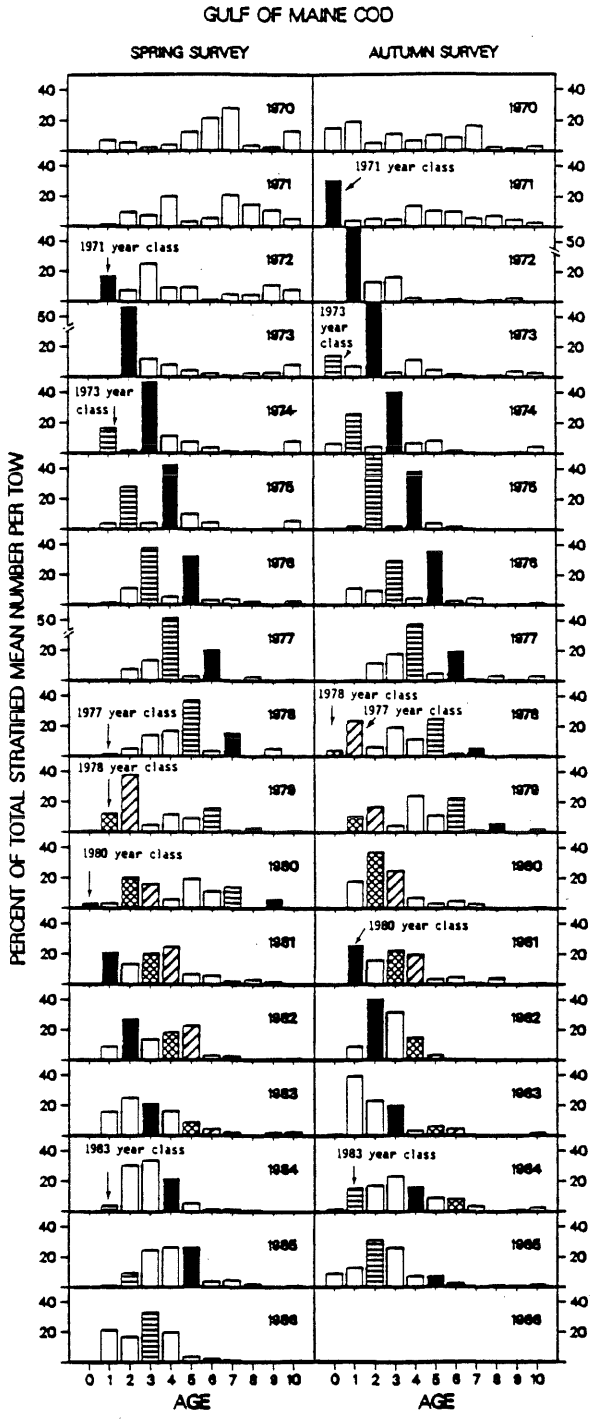


Figure 13. Age composition (percent by number) of Atlantic cod in NMFS spring and autumn offshore bottom trawl surveys in the Gulf of Maine (Strata 26-30 and 36-40), 1970-1986.

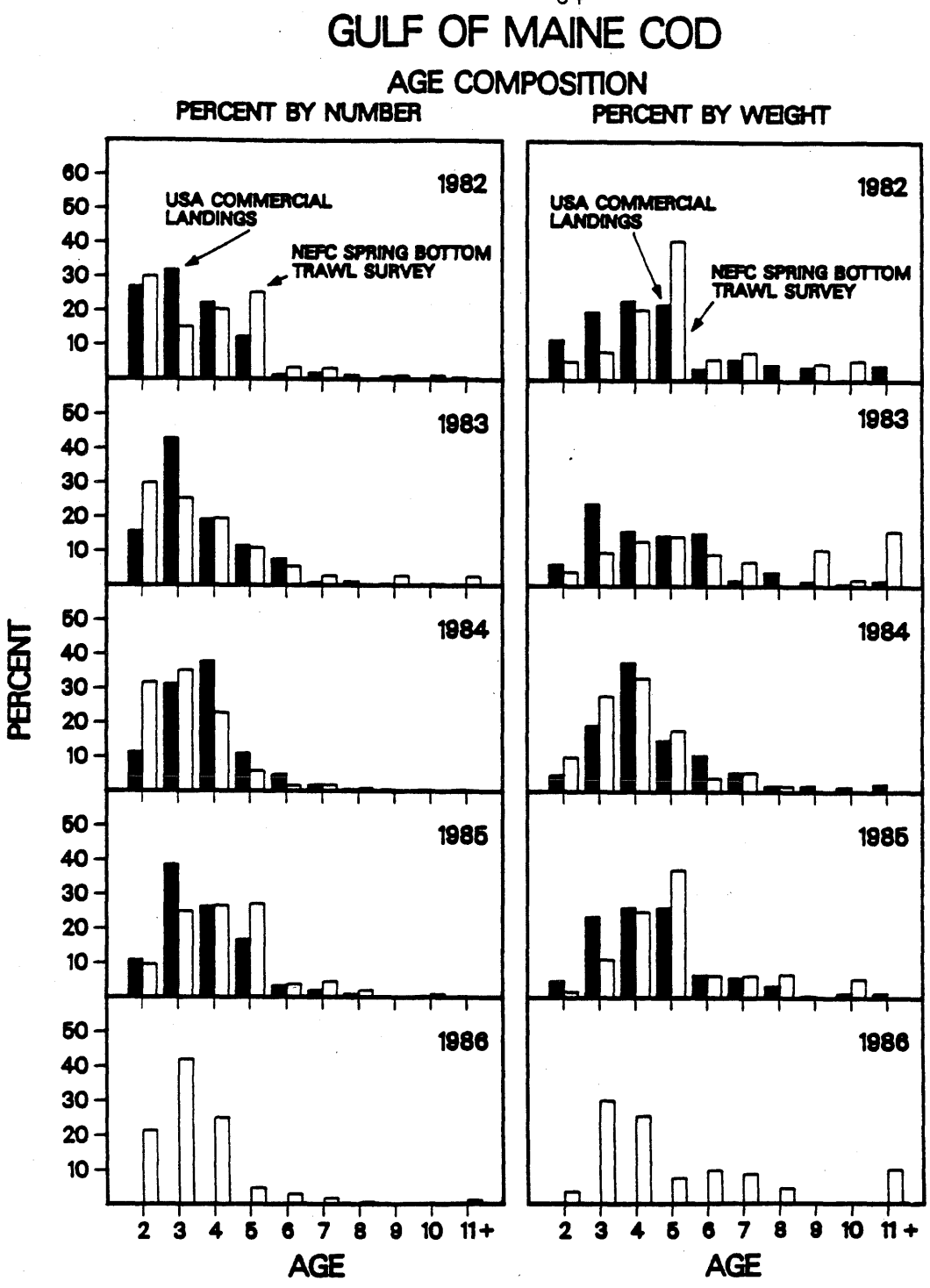


Figure 14. Percentage age composition (by number and weight) of Atlantic cod in USA commercial landings from the Gulf of Maine (NAFO Division 5Y) and commercial-sized cod (age 2+) in NEFC spring offshore bottom trawl surveys in the Gulf of Maine (Strata 26-30 and 36-40), 1982-1986. Age 0 and 1 fish caught in the surveys were excluded from the age composition analyses to facilitate comparison with the commercial data.

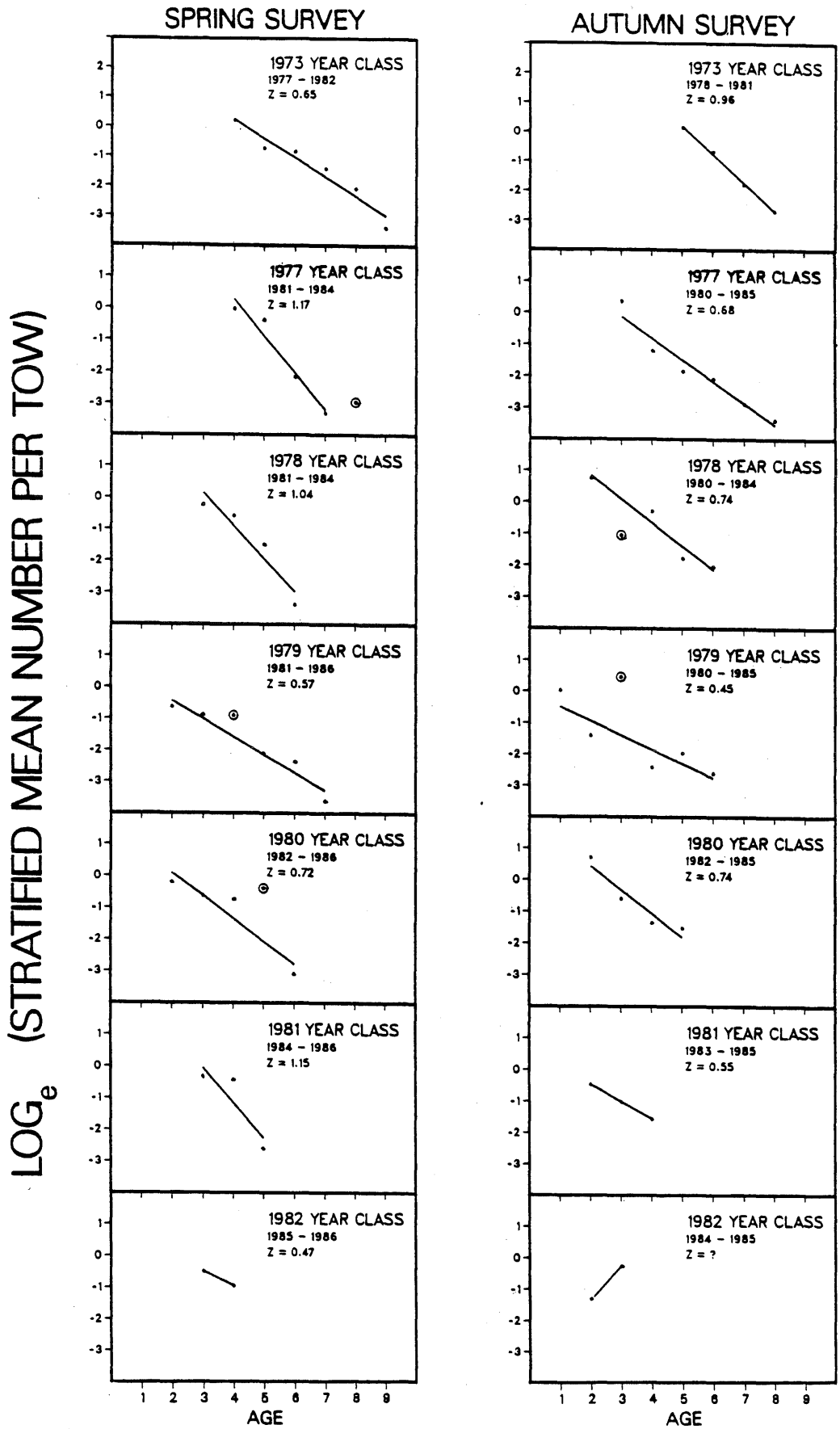


Figure 15. Catch curves for the 1973 and 1977-1982 year classes of Atlantic cod from the Gulf of Maine derived from NEFC spring and autumn offshore bottom trawl survey catch at age data (circled points not used in calculations).

APPENDIX

Appendix Table 1. Estimated numbers(000's) and weight (metric tons) of Atlantic cod caught by marine recreational anglers and brought ashore in whole form, 1979-1985. Mean weight per fish landed is also presented.

	North Atlantic			Mid-Atlantic			Total		
Year	Numbers (000's)	Metric tons	Weight(kg) per fish	Numbers (000's)	Metric tons	Weight(kg) per fish	Numbers (000's)	Metric tons	Weight(kg) per fish
1979	989	1207	1.2204	7	48	6.8571	996	1255	1.2600
1980	874	2319	2.6533	31	8	0.2581	905	2327	2.5713
1981	2610	4280	1.6398	417	1183	2.8389	3027	5463	1.8048
1982	809	1330	1.6440	35	217	6.2000	844	1547	1.8329
1983	1334	2826	2.1184	167	583	3.4910	1502	2409	2.2696
1984	1054	2166	2.0550	80	259	3.2375	1134	2425	2.1384
1985	889	2128	2.3937	57	311	5.4561	946	2439	2.5782

Appendix

Table 2. Estimated number (000's of fish), weight (metric tons, live), and mean weight(kg) per fish of Atlantic cod caught by marine recreational fishermen in 1960, 1965, 1970, 1974, and 1979-1985. Estimated catch in numbers is presented by State. Data derived from Salt-Water Angling Surveys (1960, 1965, and 1970), the Northeastern United States Regional Marine Recreational Angler Survey (1974), and the 1979-1985 Marine Recreational Fishery Statistics Surveys.

	State[1]										No. of[2] cod	Weight[3]	Mean weight
Year	ME	NH	MA	RI	CT	NY	NJ	MD	VA	Other	(000's)	(mt)	(kg)
1960	-	-	-	-	-	-	-	-	-	-	4791	14016	2.93
1965	-	-	-	-	-	-	-	-	-	-	5032	13565	2.70
1970	-	-	-	-	-	-	-	-	-	-	3844	16292	4.24
1974	162	83	951	959	-	410	207	-	-	129	2901	12368	4.26
1979	640	130	1979	331	3	*	*	-	-	-	3091	3818	1.24
1980	397	770	1166	70	-	34	2	-	-	-	2439	6385	2.62
1981	601	101	3289	446	3	405	-	77	-	-	4922	8649	1.76
1982	271	435	1358	599	-	586	-	-	-	-	3249	8011	2.47
1983	201	300	2210	800	-	216	-	-	-	28	3755	8290	2.21
1984	538	293	1050	582	-	99	-	3	-	-	2565	5392	2.10
1985	1006	128	1566	902	9	62	-	-	-	-	3673	8982	2.45

[1]Prior to 1974 survey, catches by State were not estimated.

[2]Since 1979 survey, number caught has been subdivided into:

	1979	1980	1981	1982	1983	1984	1985
(A) Number brought ashore in whole form:	996	905	3027	844	1502	1134	946
(B) Number brought ashore filleted or otherwise not in whole form:	1670	964	1674	2226	1798	1094	2317
(C) Number caught but released alive:	425	570	221	179	455	337	410

[3]Total weight caught during 1960, 1965, 1970, and 1974 surveys was directly estimated. For 1979-1985 surveys, total weight caught was derived by multiplying the total number of cod caught in each region (North Atlantic and Mid-Atlantic) by the mean weight of cod landed in whole form in each region and summing.

* = less than 30 thousand fish.

Appendix

Table 3. Estimated total number of Atlantic cod (000's fish) caught by marine recreational anglers, by region and area of fishing, 1979-1985. The percentage of total number of cod caught is presented in parentheses.

	North Atlantic					Mid-Atlantic					All Regions				
Year	Ocean ≤3 m	Ocean >3 mi	Inland	Undefined	Total	Ocean ≤3 mi	Ocean >3 mi	Inland	Undefined	Total	Ocean ≤3 mi	Ocean >3 mi	Inland	Undefined	Total
1979	427	1971	651	34	3083	3	5	-	-	8	430	1976	651	34	3091
	(13.9)	(63.9)	(21.1)	(1.1)	(100.0)	(37.5)	(62.5)	-	-	(100.0)	(13.9)	(63.9)	(21.1)	(1.1)	(100.0)
1980	230	1178	524	471	2403	-	36	-	-	36	230	1214	524	471	2439
	(9.6)	(49.0)	(21.8)	(19.6)	(100.0)	-	(100.0)	-	-	(100.0)	(9.4)	(49.8)	(21.5)	(19.3)	(100.0)
1981	1604	2536	275	25	4440	28	445	9	-	482	1632	2981	284	25	4922
	(36.1)	(57.1)	(6.2)	(0.6)	(100.0)	(5.8)	(92.3)	(1.9)	-	(100.0)	(33.1)	(60.6)	(5.8)	(0.5)	(100.0)
1982	907	1503	244	9	2663	28	558	-	-	586	935	2061	244	9	3249
	(34.1)	(56.4)	(9.2)	(0.3)	(100.0)	(4.8)	(95.2)	-	-	(100.0)	(28.8)	(63.4)	(7.5)	(0.3)	(100.0)
1983	1168	1921	71	351	3511	21	191	32	-	244	1189	2112	103	351	3755
	(33.3)	(54.7)	(2.0)	(10.0)	(100.0)	(8.6)	(78.3)	(13.1)	-	(100.0)	(31.7)	(56.2)	(2.7)	(9.4)	(100.0)
1984	856	1543	62	2	2463	4	95	3	-	102	860	1638	65	2	2565
	(34.8)	(62.6)	(2.5)	(0.1)	(100.0)	(3.9)	(93.1)	(3.0)	-	(100.0)	(33.5)	(63.9)	(2.5)	(0.1)	(100.0)
1985	926	2414	271	-	3611	-	62	-	-	62	926	2476	271	-	3673
	(25.6)	(66.9)	(7.5)	-	(100.0)	-	(100.0)	-	-	(100.0)	(25.2)	(67.4)	(7.4)	-	(100.0)

* = less than 30 thousand fish reported.
- = None reported.

Appendix

Table 4. Estimated total number of Atlantic cod (000's of fish) caught by marine recreational anglers, by region and mode of fishing, 1979-1985. The percentage of total number of cod caught is presented in parentheses.

	North Atlantic					Mid-Atlantic					All Regions				
Year	Man-made	Beach/ Bank	Party/ Charter	Private/ Rental	Total	Man-Made	Beach/ Bank	Party/ Charter	Private/ Rental	Total	Man-Made	Beach/ Bank	Party/ Charter	Private/ Rental	Total
1979	94	5	771	2213	3083	2	-	6	-	8	96	5	777	2213	3091
	(3.0)	(0.2)	(25.0)	(71.8)	(100.0)	(25.0)	-	(75.0)	-	(100.0)	(3.1)	(0.2)	(25.1)	(71.6)	(100.0)
1980	7	429	988	979	2403	131	-	36	-	167	7	429	1024	979	2439
	(0.3)	(17.9)	(41.1)	(40.7)	(100.0)	(78.4)	-	(21.6)	-	(100.0)	(3.0)	(17.6)	(42.0)	(40.1)	(100.0)
1981	*	*	2615	1808	4440	-	-	417	65	482	*	*	3032	1873	4922
	(0.4)		(58.9)	(40.7)	(100.0)	-	-	(86.5)	(13.5)	(100.0)	(0.3)		(61.6)	(38.1)	(100.0)
1982	29	-	1440	1194	2663	-	-	485	101	586	29	-	1925	1295	3249
	(1.1)	-	(54.1)	(44.8)	(100.0)	-	-	(82.8)	(17.2)	(100.0)	(0.9)	-	(59.2)	(39.9)	(100.0)
1983	*	*	1862	1626	3511	-	-	209	35	244	*	*	2071	1661	3755
	(0.7)		(53.0)	(46.3)	(100.0)	-	-	(85.7)	(14.3)	(100.0)	(0.6)		(55.2)	(44.2)	(100.0)
1984	*	*	1207	1244	2463	-	-	91	11	102	*	*	1298	1255	2565
	(0.5)		(49.0)	(50.5)	(100.0)	-	-	(89.2)	(10.8)	(100.0)	(0.5)		(50.6)	(48.9)	(100.0)
1985	*	*	1961	1630	3611	-	-	62	-	62	*	*	2023	1630	3763
	(0.6)		(54.3)	(45.1)	(100.0)	-	-	(100.0)	-	(100.0)	(0.5)		(55.1)	(44.4)	(100.0)

* = Less than 30 thousand fish reported.
- = None reported.

Appendix

Table 5. Percentage distribution of USA commercial otter trawl landings (metric tons) of Atlantic cod, by vessel tonnage class[1], from Georges Bank (Area 5Ze) and the Gulf of Maine, 1965-1985.

	Georges Bank (Area 5Ze)				Gulf of Maine (Area 5Y)			
Year	Class 2	Class 3	Class 4	Total	Class 2	Class 3	Class 4	Total
1965	4.9	51.8	43.3	100.0	59.0	39.1	1.9	100.0
1966	3.9	48.2	47.9	100.0	51.2	44.2	4.6	100.0
1967	4.3	51.6	44.1	100.0	42.2	55.2	2.6	100.0
1968	2.6	56.8	40.6	100.0	45.8	48.7	5.5	100.0
1969	3.3	60.2	36.5	100.0	46.6	44.8	8.6	100.0
1970	4.5	59.7	35.8	100.0	58.3	34.9	6.8	100.0
1971	4.5	61.6	33.9	100.0	59.1	35.0	5.9	100.0
1972	5.1	62.7	32.2	100.0	57.0	38.0	5.0	100.0
1973	2.6	62.9	34.5	100.0	59.6	34.7	5.7	100.0
1974	4.2	58.4	37.4	100.0	47.2	43.4	9.4	100.0
1975	4.2	58.3	37.5	100.0	51.6	43.2	5.2	100.0
1976	3.4	64.2	32.4	100.0	48.2	47.8	4.0	100.0
1977	4.6	71.5	23.9	100.0	47.4	48.4	4.2	100.0
1978	5.6	71.2	23.2	100.0	50.2	43.4	6.4	100.0
1979	3.6	69.5	26.9	100.0	50.6	43.0	6.4	100.0
1980	3.3	65.7	31.0	100.0	49.4	43.5	7.1	100.0
1981	4.3	61.6	34.1	100.0	48.3	42.2	9.5	100.0
1982	4.2	61.4	34.4	100.0	38.6	47.7	13.7	100.0
1983	2.7	55.3	42.0	100.0	35.9	50.4	13.7	100.0
1984	1.4	56.9	41.7	100.0	34.8	51.2	14.0	100.0
1985	1.7	60.0	38.3	100.0	26.6	51.0	22.4	100.0

[1]Class 2: 5-50 GRT; Class 3: 51-150 GRT; Class 4: 151-500 GRT.

Appendix Table 6. Stratified mean catch per tow at age (numbers) of Atlantic cod in NEFC offshore spring and autumn bottom trawl surveys on Georges Bank[1], 1963-1986[2].

Year	Age 0	1	2	3	4	5	6	7	8	9	10+	Totals 0+	1+	2+	3+	4+	5+
Spring[3]																	
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	2.783	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	1.693	.327	.076	.208	.078	.141	.074	.080	5.748	5.712	3.852	2.677	.984	.657
1973[4]	.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	3.234	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	1.566
1981[5]	.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	.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	.000	.087	4.937	4.885	4.674	3.413	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
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	7.782	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	.173	.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

[1] Spring and autumn: Strata 13-25.

[2] Catch per tow at age values for 1963-1969 obtained by applying combined 1970-1981 age-length keys to stratified mean catch per tow at length distributions from each survey.

[3] Spring surveys during 1973-1981 were accomplished with a "41 Yankee" trawl. In all other years, spring surveys were accomplished with a "36 Yankee" trawl. No adjustments have been made to the catch per tow data for these gear differences.

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

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

Appendix Table 7. Standardized stratified mean weight (kg) per tow at age of Atlantic cod in NEFC offshore spring and autumn bottom trawl surveys on Georges Bank[1], 1963-1986.

	Age											Totals					
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+
Spring[2]																	
1968	<.01	.02	.79	1.07	1.52	1.19	1.02	.71	.49	.42	.54	7.77	7.77	7.75	6.96	5.89	4.37
1969	.00	.01	.43	2.30	1.85	1.41	1.43	1.12	.78	.51	1.13	10.97	10.97	10.96	10.53	8.23	6.38
1970	.00	.04	.44	.60	2.55	.50	2.12	1.15	.30	1.05	.91	9.66	9.66	9.62	9.18	8.58	6.03
1971	.00	.02	.40	.67	.41	1.55	.48	1.52	1.68	.40	1.65	8.78	8.78	8.76	8.36	7.69	7.28
1972[3]	<.01	.24	1.09	3.65	1.19	.30	1.34	.52	1.29	1.03	1.09	11.74	11.74	11.50	10.41	6.36	5.57
1973[3]	<.01	.03	5.97	2.96	5.60	1.31	1.03	1.89	.26	1.45	4.01	24.51	24.51	24.48	18.51	15.55	9.95
1974	.00	.04	2.02	7.33	1.54	6.34	1.77	.55	1.28	.20	1.40	22.47	22.47	22.43	20.41	13.08	11.54
1975	.00	.01	.23	3.28	6.17	.82	3.26	.57	.59	.73	.42	16.08	16.08	16.07	15.84	12.56	6.39
1976	<.01	.15	1.22	1.22	1.69	4.35	.61	1.45	.22	.00	.60	11.51	11.51	11.36	10.14	8.92	7.23
1977	.00	<.01	1.93	1.49	1.26	1.04	2.98	.26	.35	.00	.22	9.53	9.53	9.53	7.60	6.11	4.85
1978	<.01	.15	.09	7.09	2.34	2.44	.62	4.10	.31	1.09	1.05	19.28	19.28	19.13	19.04	11.95	9.61
1979	<.01	.05	.84	.38	4.41	1.79	1.02	.59	1.02	.12	.24	10.46	10.46	10.41	9.57	9.19	4.78
1980	<.01	.01	1.29	3.69	.45	4.90	2.48	.88	.19	.21	1.24	15.34	15.34	15.33	14.04	10.35	9.90
1981	<.01	.31	1.86	5.62	5.52	.33	5.62	2.15	1.30	.00	1.33	24.04	24.04	23.73	21.87	16.25	10.73
1982[4]	<.01	.06	2.04	2.46	3.06	3.38	.06	1.93	.47	.13	.60	14.19	14.19	14.13	12.09	9.63	6.57
1983	<.01	.06	1.42	4.75	1.68	1.96	1.76	.31	1.59	.00	1.31	14.84	14.84	14.78	13.36	8.61	6.93
1984	.00	.02	.20	1.17	2.71	1.48	1.64	1.19	.00	1.05	.05	9.51	9.51	9.49	9.29	8.12	5.41
1985	<.01	.02	1.99	1.64	3.66	6.04	1.75	1.86	1.87	.33	2.36	21.52	21.52	21.50	19.51	17.87	14.21
1986	<.01	.18	.37	3.90	1.31	3.20	4.25	.62	1.40	1.34	.11	16.68	16.68	16.50	16.13	12.23	10.92
Autumn																	
1963	<.01	.20	.70	1.78	2.61	1.46	1.66	1.22	.66	.08	.59	10.96	10.96	10.76	10.06	8.28	5.67
1964	<.01	.24	.62	1.16	1.66	.55	.75	.45	.41	.34	.96	7.14	7.14	6.90	6.28	5.12	3.46
1965	.01	.35	.89	1.22	1.42	.70	.98	.75	.56	.16	.17	7.21	7.20	6.85	5.96	4.74	3.32
1966	.04	.47	.92	.88	.81	.47	.57	.43	.29	.01	.13	5.02	4.98	4.51	3.59	2.71	1.90
1967	<.01	2.17	.89	.96	1.27	.57	.71	.38	.43	.16	.84	8.38	8.38	6.21	5.32	4.36	3.09
1968	<.01	.12	1.54	1.22	.65	.30	.39	.23	.19	.07	.59	5.30	5.30	5.18	3.64	2.42	1.77
1969	.00	.14	.65	1.18	.96	.37	.30	.12	.23	.26	.75	4.96	4.96	4.82	4.17	2.99	2.03
1970	.01	.67	1.57	.81	1.73	.65	.00	.18	.44	.47	1.21	7.74	7.73	7.06	5.49	4.68	2.95
1971	.01	.19	.57	.70	.76	1.48	.78	.29	.59	.00	.72	6.09	6.08	5.89	5.32	4.62	3.86
1972	.02	1.65	1.14	3.55	1.14	1.06	2.42	.60	1.59	.16	.86	14.19	14.17	12.52	11.38	7.83	6.69
1973	<.01	.39	4.64	2.02	5.52	.68	1.53	1.04	.47	.70	2.03	19.02	19.02	18.63	13.99	11.97	6.45
1974	<.01	.10	.65	2.28	.44	.60	.54	.00	.45	.00	.00	5.06	5.06	4.96	4.31	2.03	1.59
1975	.01	.25	.47	1.14	5.02	.42	.90	.00	.00	.00	.47	8.68	8.67	8.42	7.95	6.81	1.79
1976	.00	1.74	1.61	.97	.71	2.73	.35	1.74	.32	.53	.22	10.92	10.92	9.18	7.57	6.60	5.89
1977	<.01	.10	3.92	1.75	.97	.94	2.52	.07	.22	.00	1.05	11.54	11.54	11.44	7.52	5.77	4.80
1978	.02	.75	.29	10.22	3.42	1.68	1.12	2.86	.51	.39	.20	21.46	21.44	20.69	20.40	10.18	6.76
1979	<.01	.74	2.49	.59	6.67	1.65	1.18	.39	1.09	.07	.34	15.21	15.21	14.47	11.98	11.39	4.72
1980	.01	.33	.80	1.85	.42	1.37	.45	.65	.32	.00	.00	6.20	6.19	5.86	5.06	3.21	2.79
1981	.01	1.46	3.13	3.96	2.29	.23	4.48	.41	.59	.17	.81	17.54	17.53	16.07	12.94	8.98	6.69
1982	.00	.38	2.34	.48	.20	.48	.00	.10	.00	.00	.30	4.28	4.28	3.90	1.56	1.08	.88
1983	.01	.26	1.13	1.84	.17	.23	.01	.00	.08	.00	.29	4.02	4.01	3.75	2.62	.78	.61
1984	<.01	.67	.15	1.84	2.36	.06	.33	.25	.06	.25	.37	6.34	6.34	5.67	5.52	3.68	1.32
1985	.03	.14	1.50	.32	.65	.78	.00	.00	.06	.00	.00	3.48	3.45	3.31	1.81	1.49	.84

[1] Strata 13-25.

[2] Spring surveys during 1973-1981 were accomplished with a "41 Yankee" trawl. In all other years, spring surveys were accomplished with a "36 Yankee" trawl. No adjustments have been made to the catch per tow data for these gear differences.

[3] Excludes unusually high catch of 1,894 cod (2,558 kg) at station 230 (Strata tow 20-4).

[4] Excludes unusually high catch of 1,032 cod (4,096 kg) at station 323 (Strata tow 16-7).

Appendix Table 8. Stratified mean catch per tow in numbers and weight (kg) of Atlantic cod in Massachusetts inshore spring and autumn bottom trawl surveys in territorial waters adjacent to the Georges Bank area (Mass. Regions 1-3) and in the Gulf of Maine (Mass. Regions 4-5), 1978- 1985.

Year	Age 0	1	2	3	4	5	6	7	8	9	10+	Totals 0+	1+	2+	3+	Stratified mean weight per tow (kg)
							Georges Bank Area (Mass. Regions 1-3)[1]									
Spring																
1978	42.589	1.403	.054	.034	.109	.000	.000	.000	.000	.000	.000	44.099	1.510	.107	.053	0.41
1979	5.286	7.121	.124	.014	.020	.002	.000	.000	.000	.000	.000	12.567	7.281	.160	.036	0.97
1980	5.092	3.965	1.973	.045	.002	.003	.019	.000	.000	.000	.000	11.099	6.007	2.042	.069	1.90
1981	31.453	.127	.047	.114	.011	.000	.000	.000	.011	.000	.000	31.763	.310	.183	.136	0.59
1982	13.303	.628	.191	.234	.110	.062	.002	.021	.002	.000	.019	14.572	1.269	.641	.450	2.17
1983	8.814	4.422	.533	.206	.042	.058	.000	.000	.000	.000	.000	14.075	5.261	.839	.306	1.84
1984	1.314	1.016	.096	.076	.033	.000	.000	.000	.000	.000	.000	2.535	1.221	.205	.109	0.47
1985	4.676	.172	.127	.019	.019	.000	.000	.000	.000	.000	.000	5.013	.337	.165	.038	0.25
Autumn																
1978	7.318	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	7.318	.000	.000	.000	0.11
1979	.156	.230	.002	.000	.000	.000	.000	.000	.000	.000	.000	.388	.232	.002	.000	0.09
1980	.475	.045	.000	.000	.000	.000	.000	.000	.000	.000	.000	.520	.045	.000	.000	0.03
1981	1.131	.115	.000	.000	.000	.000	.000	.000	.000	.000	.000	1.246	.115	.000	.000	0.08
1982	.061	.019	.000	.000	.000	.000	.000	.000	.000	.000	.000	0.080	.019	.000	.000	0.01
1983	.165	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	0.165	.000	.000	.000	<0.01
1984	.000	.019	.000	.000	.000	.000	.000	.000	.000	.000	.000	0.019	.019	.000	.000	0.02
1985	.019	.019	.000	.000	.000	.000	.000	.000	.000	.000	.000	0.038	.038	.000	.000	0.01
							Gulf of Maine Area (Mass. Regions 4-5)[2]									
Spring																
1978	21.965	12.784	4.162	4.572	.872	1.028	.000	.000	.023	.000	.000	45.406	23.441	10.657	6.495	12.16
1979	56.393	36.630	2.581	1.533	4.659	1.195	.183	.000	.000	.000	.069	104.043	47.650	11.020	8.439	20.53
1980	8.156	50.311	12.679	.971	.745	.737	.080	.214	.000	.025	.000	73.918	65.762	15.451	2.772	17.71
1981	19.753	24.794	23.884	3.122	1.279	.041	.146	.022	.022	.000	.000	73.063	53.310	28.516	4.632	21.79
1982	1.489	16.235	7.060	3.418	1.147	.232	.011	.057	.045	.000	.000	29.694	28.205	11.970	4.910	13.42
1983	.453	27.703	18.572	5.331	.501	1.221	.142	.022	.000	.000	.000	53.945	53.492	25.789	7.217	19.77
1984	.206	2.896	5.408	2.271	.865	.138	.162	.000	.000	.000	.000	11.946	11.740	8.844	3.436	8.63
1985	.793	2.711	3.822	2.794	.692	.000	.000	.000	.000	.000	.000	10.812	10.019	7.308	3.486	6.42
Autumn																
1978	151.533	2.082	.000	.120	.140	.318	.000	.080	.000	.000	.000	154.273	2.740	.658	.658	3.02
1979	4.933	3.430	.042	.000	.026	.000	.000	.000	.000	.000	.000	8.431	3.498	.068	.026	0.99
1980	5.680	8.834	.052	.000	.000	.050	.000	.000	.000	.000	.000	14.616	8.936	.102	.102	1.57
1981	2.018	5.652	7.290	.729	.000	.000	.000	.000	.000	.000	.000	15.689	13.671	8.019	.729	6.65
1982	4.667	2.346	1.005	.060	.050	.000	.000	.000	.000	.000	.000	8.128	3.461	1.115	.110	1.35
1983	1.308	.651	.100	.013	.000	.000	.000	.000	.000	.000	.000	2.072	.764	.113	.013	0.18
1984	12.296	.344	.022	.013	.000	.000	.000	.000	.000	.000	.000	12.675	.379	.035	.013	0.18
1985	2.832	.419	.018	.010	.000	.000	.000	.000	.000	.000	.000	3.279	.447	.028	.018	0.09

[1]Massachusetts strata 11-21.

[2]Massachusetts strata 25-36.

Appendix Table 9. Stratified mean catch per tow in numbers and weight (kg) of Atlantic cod in NEFC inshore spring and autumn bottom trawl surveys in inshore waters adjacent to Georges Bank and in the lower Gulf of Maine, 1978-1986.

Year	Age 0	1	2	3	4	5	6	7	8	9	10+	Totals 0+	1+	2+	3+	Stratified Mean Weight Per Tow (kg)
Inshore of Georges Bank[1]																
Spring																
1978[2]	.000	.000	.000	.308	.000	.000	.000	.000	.000	.000	.000	.308	.308	.308	.308	0.37
1979[3]	5.880	.000	1.094	.276	1.163	.255	.120	.000	.018	.000	.000	8.806	2.926	2.926	1.832	7.32
1980[3]	1.598	.363	.401	.683	.050	.605	.479	.092	.000	.000	.000	4.271	2.673	2.310	1.909	10.33
1981[3]	5.653	.164	.593	.706	.379	.050	.264	.036	.018	.000	.000	7.863	2.210	2.046	1.453	8.18
1982	1.197	.973	2.627	.360	.292	.411	.008	.044	.008	.000	.000	5.920	4.723	3.750	1.123	6.72
1983	.000	.446	1.845	1.736	.124	.249	.249	.125	.124	.124	.000	5.022	5.022	4.576	2.731	14.05
1984	.000	1.856	7.207	6.092	3.434	1.037	.719	.085	.000	.000	.000	20.430	20.430	18.574	11.367	40.31
1985	.411	.000	1.390	1.706	.683	.456	.249	.000	.000	.000	.000	4.895	4.484	4.484	3.094	12.26
1986[3]	.000	.633	3.331	2.263	.000	.000	.106	.000	.000	.000	.000	6.333	6.333	5.700	2.369	9.64
Autumn																
1979	.124	.124	3.630	.616	3.637	.522	.321	.000	.308	.025	.000	9.307	9.183	9.059	5.429	38.41
1980[3]	.000	.364	.124	.878	.240	.954	.145	.042	.083	.000	.000	2.830	2.830	2.466	2.342	20.99
1981[3]	.000	.484	.586	1.838	.817	.043	.647	.075	.123	.044	.094	4.751	4.751	4.267	3.681	24.98
1982				No cod taken								0.000	0.000	0.000	0.000	0.00
1983	.249	.373	.373	.249	.000	.000	.000	.000	.000	.000	.000	1.244	.995	.622	.249	1.99
1984	.000	.000	.000	.124	.498	.000	.000	.000	.124	.000	.000	0.746	.746	.746	.746	6.28
1985	.057	.115	.143	.115	.038	.076	.000	.000	.000	.000	.000	0.544	.487	.372	.229	1.70
Lower Gulf of Maine[1]																
Spring																
1978						Not Sampled								Not Sampled		
1979[4]	.258	.369	1.299	.880	1.867	.996	1.224	.051	.297	.025	.000	7.266	7.008	6.639	5.340	16.65
1980[5]	.067	14.704	15.518	5.111	.800	1.870	.701	.449	.000	.075	.000	39.295	39.228	24.524	9.006	23.98
1981	.076	8.999	34.977	25.062	4.711	.669	.433	.075	.243	.000	.257	75.502	75.426	66.427	31.450	68.66
1982	.000	8.406	22.691	7.703	3.042	.765	.287	.047	.000	.099	.000	42.950	42.950	35.544	11.853	32.92
1983	.000	11.796	8.585	1.856	2.378	.832	.261	.108	.000	.000	.000	25.816	25.816	14.020	5.435	17.90
1984	.000	1.842	3.458	1.467	.735	.057	.061	.023	.015	.000	.000	7.658	7.658	5.816	2.358	5.69
1985	.000	1.008	2.445	3.124	.937	.352	.000	.174	.000	.000	.000	8.040	8.040	7.032	4.587	8.25
1986[6]	.000	.647	3.286	.547	1.595	.000	.435	.100	.499	.200	.200	7.509	7.509	6.862	3.576	14.90
Autumn																
1979[6]	.189	8.319	1.417	.110	.349	.062	.015	.000	.000	.000	.000	10.461	10.272	1.953	.536	3.82
1980[6]	.000	4.256	4.594	.434	.047	.032	.203	.000	.000	.000	.000	9.566	9.566	5.310	.716	9.88
1981[7]	.200	.807	1.769	.501	.528	.022	.000	.000	.000	.000	.000	3.827	3.627	2.820	1.051	4.68
1982[5]	.000	1.289	1.933	1.595	.629	.101	.100	.000	.000	.000	.000	5.647	5.647	4.358	2.425	5.74
1983[6]	.225	2.948	3.299	1.348	.000	.113	.000	.113	.000	.000	.000	8.046	7.821	4.873	1.574	7.33
1984						Not Sampled								Not Sampled		
1985	.216	2.578	.952	2.384	.691	.735	.000	.000	.000	.000	.000	7.556	7.340	4.762	3.810	9.90

[1] Inshore of Georges Bank: Inshore strata 45-46, 55-56; Lower Gulf of Maine: Inshore strata 58-61, 63-66.

[2] Only strata 45-46 sampled.

[3] Only strata 45-46 and 55 sampled.

[4] Only strata 58-60, 64 and 66 sampled.

[5] Only strata 58-61, 64-66 sampled.

[6] Only strata 58-61, 65-66 sampled.

[7] Only strata 61 and 64-66 sampled.

Appendix Table 10. Stratified mean catch (number) per tow of Atlantic cod from NMFS autumn bottom trawl surveys on Georges Bank (Strata 13-25), 1963-1985. Standard deviation of the mean (S.D.), coefficient of variation (C.V.: 100 S.D./Mean), and 95% confidence units are provided as indices of variability.

Year	Number of tows	Linear				ln(X+1)				Re-transformed	
		Mean	S.D.	C.V.	Confidence limits	Mean	S.D.	C.V.	Confidence limits	Mean	Confidence limits
1963	57	2.8	0.792	28.3	1.3 - 4.4	0.76	0.142	18.7	0.48 - 1.04	2.3	1.5 - 3.4
1964	63	1.9	0.396	20.7	1.1 - 2.7	0.58	0.102	17.6	0.38 - 0.78	1.5	1.1 - 2.1
1965	66	2.7	0.798	29.3	1.2 - 4.3	0.70	0.119	17.0	0.47 - 0.94	2.1	1.5 - 2.9
1966	67	3.1	0.754	24.4	1.6 - 4.6	0.74	0.102	13.8	0.54 - 0.94	2.4	1.8 - 3.2
1967	67	6.7	1.698	25.6	3.3 - 10.0	1.18	0.148	12.5	0.89 - 1.47	5.7	4.0 - 7.9
1968	69	2.1	0.510	24.1	1.1 - 3.1	0.56	0.093	16.8	0.37 - 0.74	1.6	1.2 - 2.1
1969	73	1.4	0.257	18.2	0.9 - 1.9	0.58	0.080	13.8	0.42 - 0.74	1.3	1.0 - 1.7
1970	70	3.3	0.559	17.2	2.2 - 4.3	0.77	0.102	13.3	0.57 - 0.97	2.7	2.0 - 3.5
1971	73	2.0	0.438	21.4	1.2 - 2.9	0.63	0.101	15.9	0.44 - 0.83	1.8	1.3 - 2.4
1972	73	8.4	1.983	23.6	4.5 - 12.3	1.05	0.103	9.9	0.85 - 1.25	5.5	4.3 - 7.0
1973	73	7.9	1.864	23.7	4.2 - 11.5	1.08	0.144	13.4	0.80 - 1.36	6.2	4.5 - 8.6
1974	74	2.2	0.476	21.3	1.3 - 3.2	0.53	0.092	17.2	0.35 - 0.71	1.6	1.2 - 2.1
1975	73	4.1	2.063	50.2	0.1 - 8.2	0.65	0.104	15.8	0.45 - 0.86	2.1	1.6 - 2.8
1976	67	6.7	2.081	31.1	2.6 - 10.8	0.92	0.154	16.8	0.61 - 1.22	4.7	3.2 - 6.7
1977	101	4.4	0.710	16.1	3.0 - 5.8	0.92	0.081	8.8	0.76 - 1.08	3.5	2.9 - 4.3
1978	156	7.0	1.068	15.3	4.9 - 9.1	1.02	0.087	8.6	0.85 - 1.19	5.4	4.4 - 6.6
1979	145	4.8	0.931	19.3	3.0 - 6.6	0.95	0.088	9.3	0.78 - 1.12	4.0	3.2 - 4.9
1980	92	2.4	0.426	18.1	1.5 - 3.2	0.56	0.087	15.5	0.39 - 0.73	1.7	1.3 - 2.2
1981	71	7.3	3.120	42.5	1.2 - 13.4	1.05	0.155	14.8	0.75 - 1.35	5.6	3.8 - 7.9
1982	92	2.4	0.712	29.9	1.0 - 3.8	0.48	0.081	16.6	0.33 - 0.64	1.4	1.0 - 1.8
1983	114	2.3	0.531	22.8	1.3 - 3.4	0.42	0.057	13.5	0.31 - 0.53	1.2	1.0 - 1.4
1984	77	3.0	0.903	29.7	1.3 - 4.8	0.65	0.115	17.6	0.43 - 0.88	2.2	1.5 - 3.0
1985	69	2.4	0.940	38.7	0.6 - 4.3	0.48	0.112	23.5	0.26 - 0.69	1.4	0.9 - 2.0

Appendix Table 11. Stratified mean catch (weight, kg) per tow of Atlantic cod from NMFS autumn bottom trawl surveys on Georges Bank (Strata 13-25), 1963-1985. Standard deviation of the mean (S.D.) coefficient of variation (C.V.: 100 S.D./Mean), and 95% confidence limits are provided as indices of variability.

Year	Number of tows	Linear				ln(X+1)				Re-transformed	
		Mean	S.D.	C.V.	Confidence limits	Mean	S.D.	C.V.	Confidence limits	Mean	Confidence limits
1963	57	10.9	2.98	27.2	5.1 - 16.8	1.38	0.236	17.1	0.92 - 1.84	11.7	7.0 - 19.2
1964	63	7.1	2.07	29.0	3.1 - 11.2	1.00	0.192	19.1	0.63 - 1.38	6.1	3.9 - 9.3
1965	66	7.2	2.31	32.1	2.7 - 11.7	1.01	0.164	16.2	0.69 - 1.33	5.7	3.8 - 8.2
1966	67	5.0	1.10	21.8	2.9 - 7.2	0.92	0.159	17.3	0.61 - 1.23	4.5	3.0 - 6.5
1967	67	8.4	1.91	22.9	4.6 - 12.1	1.33	0.174	13.1	0.98 - 1.67	8.0	5.4 - 11.7
1968	69	5.3	1.32	25.0	2.7 - 7.9	0.81	0.141	17.6	0.53 - 1.08	3.9	2.7 - 5.5
1969	73	5.0	0.99	20.0	3.0 - 6.9	0.99	0.124	12.6	0.75 - 1.23	4.5	3.3 - 6.0
1970	70	7.7	1.45	18.7	4.9 - 10.6	1.09	0.147	13.5	0.80 - 1.37	7.0	5.0 - 9.7
1971	73	6.1	1.55	25.5	3.0 - 9.1	0.95	0.139	14.6	0.68 - 1.22	5.1	3.6 - 7.0
1972	73	14.2	5.14	36.2	4.1 - 24.3	1.36	0.106	7.8	1.16 - 1.57	10.9	8.6 - 13.6
1973	73	19.0	5.56	29.2	8.1 - 29.9	1.42	0.186	13.1	1.06 - 1.79	16.2	11.0 - 23.8
1974	74	5.1	1.08	21.2	3.0 - 7.2	0.79	0.150	18.9	0.50 - 1.08	3.9	2.7 - 5.6
1975	73	8.7	3.56	41.0	1.7 - 15.7	1.03	0.134	13.0	0.76 - 1.29	5.7	4.2 - 7.8
1976	67	10.9	2.61	23.9	5.8 - 16.0	1.27	0.148	11.6	0.99 - 1.56	10.4	7.6 - 14.3
1977	101	11.5	1.62	14.0	8.4 - 14.7	1.42	0.111	7.8	1.20 - 1.64	11.9	9.4 - 15.0
1978	156	21.5	3.27	15.2	15.1 - 27.9	1.59	0.113	7.1	1.37 - 1.81	23.2	18.4 - 29.3
1979	145	15.2	1.96	12.9	11.4 - 19.0	1.56	0.126	8.1	1.31 - 1.81	18.3	14.1 - 23.7
1980	92	6.2	1.52	24.5	3.2 - 9.2	0.83	0.146	17.6	0.54 - 1.12	4.6	3.2 - 6.4
1981	71	17.5	8.20	46.8	1.5 - 33.6	1.36	0.203	14.9	0.97 - 1.76	14.1	9.2 - 21.5
1982	92	4.3	1.33	31.2	1.7 - 6.9	0.59	0.089	15.0	0.42 - 0.77	2.3	1.8 - 2.9
1983	114	4.0	0.79	19.8	2.5 - 5.6	0.61	0.089	14.7	0.43 - 0.78	2.4	1.8 - 3.0
1984	77	6.3	1.97	31.0	2.5 - 10.2	0.95	0.155	16.3	0.65 - 1.25	5.1	3.5 - 7.3
1985	69	3.5	1.55	44.5	0.4 - 6.5	0.52	0.137	26.2	0.25 - 0.79	1.9	1.2 - 2.7

Appendix Table 12. Stratified mean catch (number) per tow of Atlantic cod from NMFS spring bottom trawl surveys on Georges Bank (Strata 13-25), 1968-1986. Standard deviation of the mean (S.D.), coefficient of variation (C.V.: 100 S.D./mean), and 95% confidence limits are provided as indices of variability.

	Number	Linear				ln (x+1)				Re-Transformed	
Year	of tows	Mean	S.D.	C.V.	Confidence limits	Mean	S.D.	C.V.	Confidence limits	Mean	Confidence limits
1968	69	3.0	0.641	21.1	1.8- 4.3	0.94	0.123	13.1	0.70-1.18	2.9	2.1- 4.0
1969	74	3.0	0.464	15.6	2.1- 3.9	0.99	0.102	10.2	0.79-1.19	3.0	2.3- 3.9
1970	69	2.8	0.529	19.0	1.8- 3.8	0.95	0.109	11.5	0.74-1.17	2.7	2.0- 3.6
1971	73	2.2	0.348	16.0	1.5- 2.9	0.80	0.088	11.0	0.63-0.98	2.1	1.6- 2.7
1972	76	5.7	0.897	15.6	4.0- 7.5	1.31	0.117	8.9	1.08-1.54	6.0	4.6- 7.8
1973[1]	70	12.0	1.586	13.2	8.9-15.1	1.82	0.120	6.6	1.58-2.05	14.0	10.9-18.0
1974	66	9.4	1.705	18.0	6.1-12.8	1.51	0.133	8.8	1.25-1.77	9.9	7.4-13.2
1975	71	4.4	1.625	36.8	1.2- 7.6	0.98	0.112	11.4	0.76-1.20	3.2	2.4- 4.2
1976	69	4.5	0.849	18.8	2.9- 6.2	1.12	0.105	9.4	0.92-1.33	4.1	3.1- 5.3
1977	71	4.0	0.495	12.3	3.1- 5.0	1.16	0.085	7.3	1.00-1.33	4.0	3.2- 4.9
1978	79	7.9	1.367	17.3	5.2-10.6	1.59	0.109	6.9	1.37-1.80	7.9	6.2-10.0
1979	127	3.3	0.463	14.0	2.4- 4.2	0.94	0.075	8.0	0.79-1.08	2.9	2.4- 3.5
1980	68	5.0	1.219	24.6	2.6- 7.4	1.11	0.111	10.0	0.89-1.33	4.2	3.2- 5.5
1981	66	8.5	1.442	17.0	5.6-11.3	1.66	0.121	7.3	1.43-1.90	8.6	6.5-11.1
1982[2]	72	6.7	1.793	26.9	3.1-10.2	1.24	0.136	11.0	0.98-1.51	5.6	4.1- 7.6
1983	69	4.9	1.170	23.7	2.6- 7.2	1.08	0.113	10.5	0.86-1.30	4.2	3.2- 5.5
1984	72	2.6	0.436	16.7	1.8- 3.5	0.89	0.093	10.5	0.71-1.07	2.4	1.8- 3.0
1985	68	6.9	1.560	22.5	3.9-10.0	1.48	0.103	7.0	1.27-1.68	6.3	4.9- 7.9
1986	68	5.0	0.704	14.0	3.7- 6.4	1.32	0.116	8.8	1.10-1.55	5.1	3.9- 6.9

[1]Excludes unusually high catch of 1,894 cod (2,558 kg) at station 230 (Strata tow 20-4).

[2]Excludes unusually high catch of 1,032 cod (4,096 kg) at station 323 (Strata tow 16-7).

Appendix Table 13. Stratified mean catch (weight) per tow of Atlantic cod from NMFS spring bottom trawl surveys on Georges Bank (Strata 13-25), 1968-1986. Standard deviation of the mean (S.D.), coefficient of variation (C.V.: S.D. 100/mean), and 95% confidence limits are provided as indices of variability.

	Number	Linear				ln (x+1)				Re-Transformed	
Year	of tows	Mean	S.D.	C.V.	Confidence limits	Mean	S.D.	C.V.	Confidence limits	Mean	Confidence limits
1968	69	7.8	1.543	19.8	4.8- 10.8	1.39	0.183	13.2	1.03-1.75	8.7	5.8-13.0
1969	74	11.0	1.664	15.2	7.7- 14.2	1.61	0.162	10.1	1.29-1.93	13.0	9.2-18.2
1970	69	9.7	1.938	20.0	5.9- 13.5	1.52	0.185	12.2	1.16-1.88	10.6	7.1-15.6
1971	73	8.8	1.973	22.5	4.9- 12.6	1.39	0.164	11.8	1.07-1.71	8.7	6.0-12.4
1972	76	11.7	1.592	13.6	8.6- 14.9	1.70	0.156	9.2	1.40-2.01	14.9	10.7-20.6
1973[1]	70	24.5	2.986	12.2	18.7- 30.4	2.33	0.155	6.7	2.03-2.63	34.6	25.3-47.3
1974	66	22.5	3.731	16.6	15.1- 29.8	2.09	0.176	8.4	1.75-2.44	31.5	22.0-45.0
1975	71	16.1	5.481	34.1	5.4- 26.8	1.74	0.172	9.9	1.40-2.08	14.9	10.4-21.3
1976	69	11.5	1.682	14.6	8.2- 14.8	1.68	0.154	9.2	1.38-1.98	12.9	9.3-17.8
1977	71	9.5	1.285	13.5	7.0- 12.0	1.67	0.122	7.3	1.43-1.91	10.5	8.1-13.7
1978	79	19.3	2.968	15.4	13.5- 25.1	2.24	0.146	6.5	1.96-2.53	23.4	17.3-31.5
1979	127	10.5	1.434	13.7	7.6- 13.3	1.51	0.124	8.2	1.27-1.75	11.0	8.4-14.3
1980	68	15.3	3.222	21.0	9.0- 21.6	1.78	0.168	9.4	1.45-2.11	16.5	11.6-23.3
1981	66	24.0	3.738	15.6	16.7- 31.5	2.49	0.171	6.9	2.16-2.82	30.9	21.8-43.5
1982[2]	72	14.2	3.972	28.0	6.4- 22.0	1.71	0.179	10.5	1.36-2.06	13.9	9.5-20.1
1983	69	14.8	2.685	18.1	9.6- 20.1	1.71	0.178	10.4	1.36-2.06	17.2	11.8-24.8
1984	72	9.5	1.938	20.4	5.7- 13.3	1.44	0.162	11.3	1.12-1.76	9.8	6.8-13.8
1985	68	21.5	4.162	19.4	13.3- 29.7	2.30	0.138	6.0	2.03-2.57	22.6	17.0-29.9
1986	68	16.7	2.562	15.4	11.7- 21.7	2.06	0.171	8.3	1.73-2.40	21.3	14.9-30.1

[1]Excludes unusually high catch of 1,894 cod (2,558 kg) at station 230 (Strata tow 20-4).

[2]Excludes unusually high catch of 1,032 cod (4,096 kg) at station 323 (Strata tow 16-7).

Appendix Table 14. Stratified mean catch per tow at age (numbers) of Atlantic cod in NEFC offshore spring and autumn bottom trawl surveys in the Gulf of Maine[1], 1963-1986[2].

Year	Age											Totals					
	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+
Spring[3]																	
1968	.082	.393	.791	.902	.542	.345	.133	.083	.071	.038	.106	3.486	3.404	3.011	2.220	1.318	.776
1969	.000	.000	.023	.197	.564	.517	.406	.164	.092	.057	.065	2.085	2.085	2.085	2.062	1.865	1.301
1970	.000	.102	.079	.035	.060	.175	.299	.394	.048	.038	.184	1.414	1.414	1.312	1.233	1.198	1.138
1971	.000	.016	.091	.070	.187	.031	.053	.192	.132	.099	.046	.917	.917	.901	.810	.740	.553
1972	.000	.226	.098	.333	.126	.128	.023	.068	.065	.147	.105	1.319	1.319	1.093	.995	.662	.536
1973	.000	.022	2.724	.581	.397	.224	.125	.061	.143	.161	.392	4.830	4.830	4.808	2.084	1.503	1.106
1974	.000	.305	.036	.871	.211	.142	.073	.031	.031	.013	.149	1.862	1.862	1.557	1.521	.650	.439
1975	.004	.060	.448	.068	.683	.166	.071	.003	.003	.012	.092	1.610	1.606	1.546	1.098	1.030	.347
1976	.000	.027	.195	.672	.098	.575	.055	.069	.042	.000	.047	1.780	1.780	1.753	1.558	.886	.788
1977	.000	.016	.191	.334	1.278	.070	.507	.004	.065	.000	.024	2.489	2.489	2.473	2.282	1.948	.670
1978	.000	.022	.067	.183	.223	.491	.048	.205	.005	.068	.005	1.317	1.317	1.295	1.228	1.045	.822
1979	.028	.343	1.045	.136	.320	.257	.439	.038	.091	.008	.034	2.739	2.711	2.368	1.323	1.187	.867
1980	.057	.057	.357	.278	.100	.339	.194	.246	.000	.105	.011	1.744	1.687	1.630	1.273	.995	.895
1981	.000	.823	.537	.800	.987	.266	.233	.089	.126	.086	.000	3.947	3.947	3.124	2.587	1.787	.800
1982	.012	.273	.827	.419	.563	.701	.095	.088	.000	.034	.032	3.044	3.032	2.759	1.932	1.513	.950
1983	.008	.401	.627	.534	.411	.229	.116	.059	.000	.058	.065	2.508	2.500	2.099	1.472	.938	.527
1984	.000	.097	.662	.735	.475	.122	.034	.037	.019	.000	.000	2.181	2.181	2.084	1.422	.687	.212
1985	.000	.028	.238	.622	.665	.677	.095	.114	.052	.000	.026	2.517	2.517	2.489	2.251	1.629	.964
1986	.000	.417	.330	.647	.387	.074	.046	.027	.011	.000	.018	1.957	1.957	1.540	1.210	.563	.176
Autumn																	
1963	.032	.416	.865	.803	.544	.371	.344	.192	.117	.061	.048	3.793	3.761	3.345	2.480	1.677	1.133
1964	.000	.059	.078	.302	.549	.547	.502	.239	.152	.073	.065	2.566	2.566	2.507	2.429	2.127	1.578
1965	.001	.545	.564	.528	.481	.318	.240	.109	.051	.028	.016	2.881	2.880	2.335	1.771	1.243	.762
1966	.109	.131	.410	.447	.460	.358	.283	.123	.050	.031	.023	2.425	2.316	2.185	1.775	1.328	.868
1967	.008	.083	.138	.368	.430	.246	.172	.104	.045	.026	.022	1.642	1.634	1.551	1.413	1.045	.615
1968	.008	.023	.115	.461	.805	.624	.402	.167	.100	.046	.061	2.812	2.804	2.781	2.666	2.205	1.400
1969	.010	.038	.079	.227	.404	.354	.299	.141	.093	.083	.040	1.768	1.758	1.720	1.641	1.414	1.010
1970	.476	.603	.170	.353	.211	.313	.271	.506	.084	.060	.094	3.141	2.665	2.062	1.892	1.539	1.328
1971	.863	.114	.153	.135	.383	.295	.278	.163	.204	.128	.082	2.798	1.935	1.821	1.668	1.533	1.150
1972	.020	3.576	.780	.978	.150	.060	.110	.025	.102	.155	.010	5.966	5.946	2.370	1.590	.612	.462
1973	.408	.210	1.393	.089	.325	.136	.050	.018	.033	.108	.087	2.857	2.449	2.239	.846	.757	.432
1974	.181	.720	.121	1.118	.187	.230	.050	.008	.008	.027	.127	2.777	2.596	1.876	1.755	.637	.450
1975	.030	.094	1.966	.086	1.510	.163	.070	.011	.002	.002	.008	3.942	3.912	3.818	1.852	1.766	.256
1976	.000	.156	.134	.405	.064	.492	.037	.061	.000	.010	.020	1.379	1.379	1.223	1.089	.684	.620
1977	.000	.018	.291	.446	.937	.123	.481	.031	.079	.018	.078	2.502	2.502	2.484	2.193	1.747	.810
1978	.202	1.111	.301	.907	.532	1.160	.091	.264	.007	.049	.041	4.665	4.463	3.352	3.051	2.144	1.612
1979	.003	.236	.381	.104	.536	.251	.501	.033	.138	.000	.053	2.236	2.233	1.997	1.616	1.512	.976
1980	.022	1.026	2.111	1.423	.403	.188	.272	.168	.024	.015	.058	5.710	5.688	4.662	2.551	1.128	.725
1981	.008	.397	.245	.352	.304	.057	.076	.024	.069	.000	.018	1.550	1.542	1.145	.900	.548	.244
1982	.000	.449	2.014	1.585	.748	.159	.000	.025	.000	.000	.000	4.980	4.980	4.531	2.517	.932	.184
1983	.029	1.064	.626	.546	.089	.169	.126	.000	.000	.000	.058	2.707	2.678	1.614	.988	.442	.353
1984	.028	.246	.270	.362	.256	.141	.131	.057	.000	.020	.042	1.553	1.525	1.279	1.009	.647	.391
1985	.266	.378	.910	.763	.209	.218	.074	.000	.034	.021	.049	2.922	2.656	2.278	1.368	.605	.396

[1] Spring and autumn: Strata 26-30 and 36-40.

[2] Catch per tow at age values for 1963-1969 obtained by applying combined 1970-1981 age length keys to stratified mean tow at length distributions from each survey.

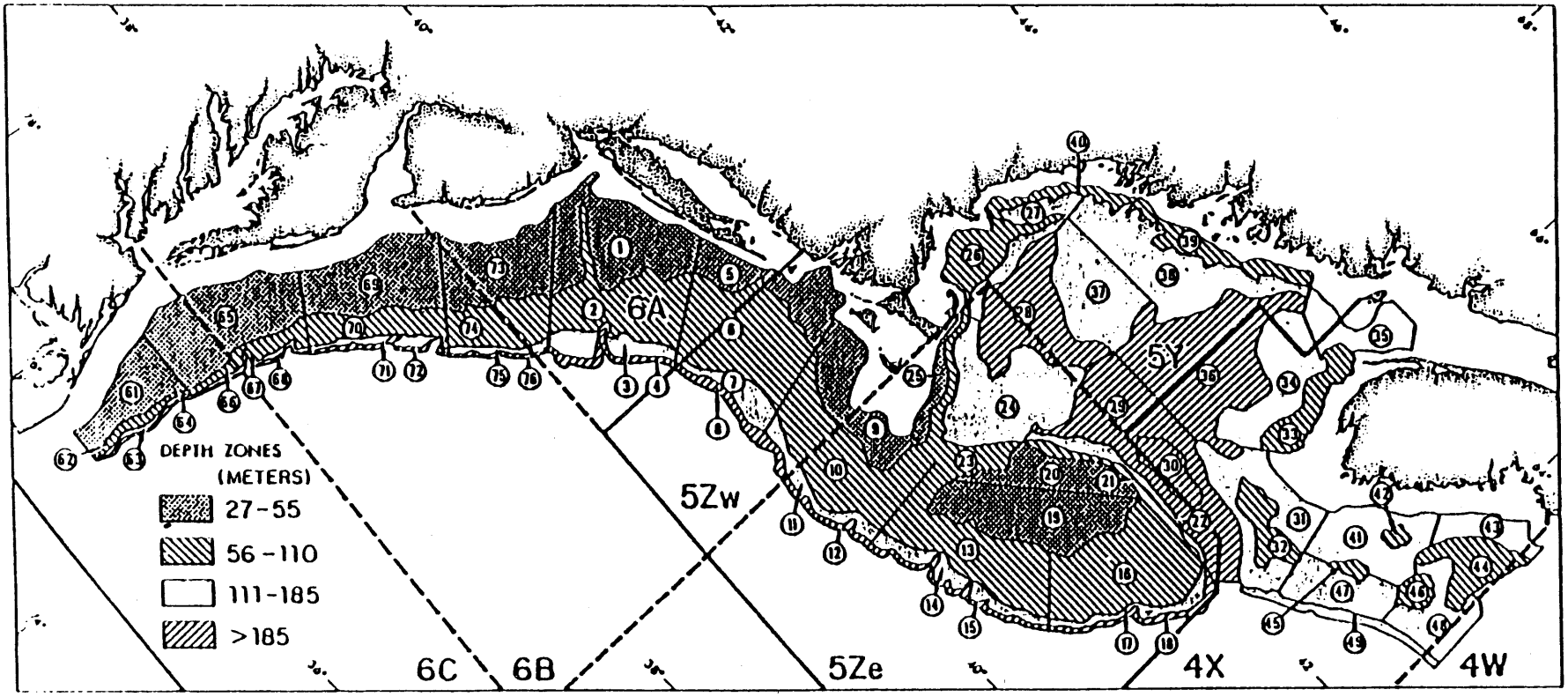
[3] Spring surveys during 1973-1981 were accomplished with a "41 Yankee" trawl. In all other years, spring surveys were accomplished with a "36 Yankee" trawl. No adjustments have been made to the catch per tow data for these gear differences.

Appendix Table 15. Standardized stratified mean weight (kg) per tow at age of Atlantic cod in NEFC offshore spring and autumn bottom trawl surveys in the Gulf of Maine[1], 1963-1986.

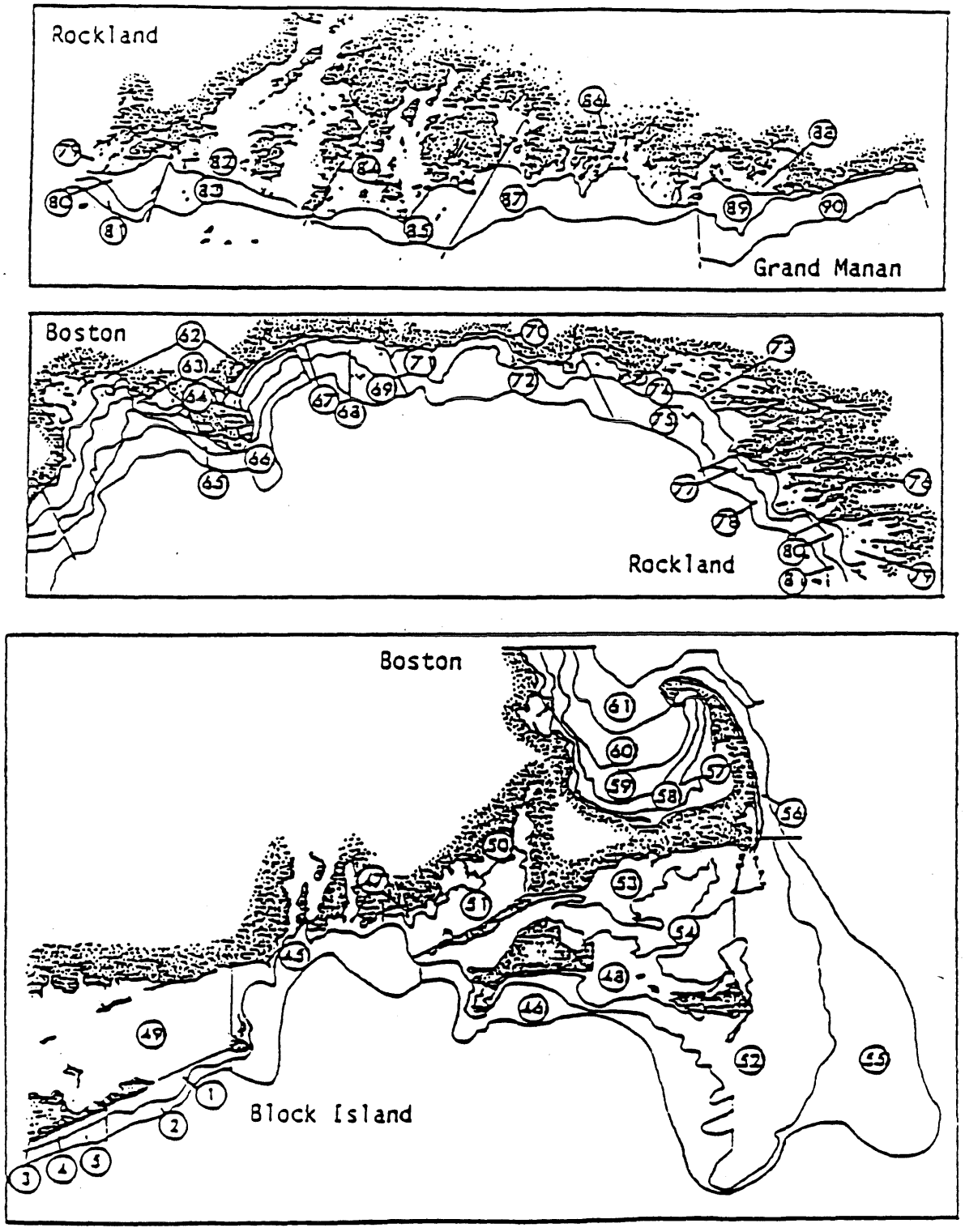
	Age											Totals					
Year	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+
Spring[2]																	
1968	.00	.01	.17	.91	1.95	1.66	1.54	.81	.74	.77	2.50	11.06	11.06	11.05	10.88	9.97	8.02
1969	.00	.00	.01	.29	1.47	1.78	1.85	.92	.68	.50	.65	8.15	8.15	8.15	8.14	7.85	6.38
1970	.00	<.01	.03	.02	.10	.42	1.43	1.91	.32	.41	2.19	6.83	6.83	6.83	6.80	6.78	6.68
1971	.00	<.01	.04	.10	.42	.11	.18	1.12	1.07	.72	.55	4.31	4.31	4.31	4.27	4.17	3.75
1972	.00	.01	.04	.57	.34	.44	.12	.42	.48	1.36	1.18	4.96	4.96	4.95	4.91	4.34	4.00
1973	.00	<.01	.53	.55	1.13	.78	.52	.37	.84	1.58	5.30	11.60	11.60	11.60	11.07	10.52	9.39
1974	.00	.01	.01	.56	.38	.64	.53	.22	.20	.07	1.97	4.59	4.59	4.58	4.57	4.01	3.63
1975	<.01	<.01	.12	.06	1.26	.59	.38	.02	.02	.11	1.16	3.72	3.72	3.72	3.60	3.54	2.28
1976	.00	<.01	.05	.49	.16	1.75	.30	.63	.61	.00	.67	4.66	4.66	4.66	4.61	4.12	3.96
1977	.00	<.01	.06	.26	1.43	.18	2.25	.03	.61	.00	.45	5.27	5.27	5.27	5.21	4.95	3.52
1978	.00	<.01	.03	.23	.40	1.34	.27	1.43	.05	.95	.05	4.75	4.75	4.75	4.72	4.49	4.09
1979	<.01	.04	.47	.19	.75	.82	1.76	.24	.82	.10	.67	5.86	5.86	5.82	5.35	5.16	4.41
1980	<.01	.01	.15	.40	.27	1.17	.80	1.54	.00	1.16	.19	5.69	5.69	5.68	5.53	5.13	4.86
1981	.00	.12	.29	1.07	2.83	1.27	1.48	.78	1.05	1.05	.00	9.94	9.94	9.82	9.53	8.46	5.63
1982	<.01	.04	.43	.65	1.63	3.22	.48	.64	.00	.39	.46	7.94	7.94	7.90	7.47	6.82	5.19
1983	<.01	.04	.30	.73	.97	1.08	.69	.53	.00	.79	1.35	6.48	6.48	6.44	6.14	5.41	4.44
1984	.00	.01	.36	1.00	1.19	.64	.14	.20	.06	.00	.00	3.60	3.60	3.59	3.23	2.23	1.04
1985	.00	<.01	.13	.85	1.91	2.85	.49	.49	.52	.00	.41	7.65	7.65	7.65	7.52	6.67	4.76
1986	.00	.04	.13	1.07	.91	.27	.35	.31	.16	.00	.36	3.60	3.60	3.56	3.43	2.36	1.45
Autumn																	
1963	<.01	.12	.58	1.05	1.44	1.75	2.34	1.54	1.12	.62	.52	11.08	11.08	10.96	10.38	9.33	7.89
1964	.00	.01	.09	.71	2.06	2.82	3.36	1.94	1.53	.76	.79	14.07	14.07	14.06	13.97	13.26	11.20
1965	<.01	.12	.35	.86	1.43	1.41	1.48	.81	.49	.29	.17	7.41	7.41	7.29	6.94	6.08	4.65
1966	<.01	.05	.29	.74	1.47	1.72	1.79	.87	.47	.28	.29	7.97	7.97	7.92	7.63	6.89	5.42
1967	<.01	.02	.13	.70	1.11	.98	1.06	.77	.42	.26	.25	5.70	5.70	5.68	5.55	4.85	3.74
1968	<.01	.01	.12	1.07	2.62	2.53	2.12	1.13	.99	.50	.91	12.00	12.00	11.99	11.87	10.80	8.18
1969	<.01	.01	.07	.52	1.41	1.64	1.81	1.07	.93	1.53	.50	9.49	9.49	9.48	9.41	8.89	7.48
1970	<.01	.13	.10	.49	.81	.98	1.62	3.43	.70	.50	1.38	10.14	10.14	10.01	9.91	9.42	8.61
1971	<.01	.03	.19	.22	1.22	1.39	1.38	1.05	1.74	1.60	1.38	10.20	10.20	10.17	9.98	9.76	8.54
1972	<.01	.48	.58	2.09	.55	.20	.67	.16	1.19	1.89	.19	8.00	8.00	7.52	6.94	4.85	4.30
1973	<.01	.02	.67	.19	1.26	.64	.27	.17	.20	1.14	.83	5.39	5.39	5.37	4.70	4.51	3.25
1974	<.01	.06	.06	1.23	.42	1.35	.36	.05	.10	.30	1.61	5.54	5.54	5.48	5.42	4.19	3.77
1975	<.01	.01	.87	.09	3.30	.44	.36	.10	.02	.02	.11	5.32	5.32	5.31	4.44	4.35	1.05
1976	.00	.06	.11	.56	.13	1.89	.25	.63	.00	.11	.42	4.16	4.16	4.10	3.99	3.43	3.30
1977	.00	.01	.18	.75	1.80	.61	3.06	.27	1.08	.28	1.38	9.41	9.41	9.41	9.23	8.48	6.68
1978	<.01	.27	.25	1.44	1.32	4.04	.42	2.27	.11	.76	1.00	11.88	11.88	11.61	11.36	9.92	8.60
1979	<.01	.11	.37	.29	1.84	1.39	3.60	.34	1.72	.00	1.17	10.83	10.83	10.72	10.35	10.06	8.22
1980	<.01	.39	1.76	3.13	1.57	1.32	1.98	1.18	.40	.25	1.11	13.09	13.09	12.70	10.94	7.81	6.24
1981	<.01	.10	.32	.84	1.32	.38	.59	.19	.84	.00	.39	4.97	4.97	4.87	4.55	3.71	2.39
1982	.00	.21	2.79	3.58	2.31	.95	.00	.08	.00	.00	.00	9.92	9.92	9.71	6.92	3.34	1.03
1983	<.01	.29	.67	1.10	.31	.80	1.12	.00	.00	.00	1.15	5.44	5.44	5.15	4.48	3.38	3.07
1984	<.01	.07	.23	.80	.91	.77	.94	.57	.00	.35	.80	5.44	5.44	5.37	5.14	4.34	3.43
1985	.01	.09	.99	1.99	.80	1.56	.78	.00	.68	.44	1.15	8.49	8.48	8.39	7.40	5.41	4.61

[1] Strata 26-30 and 36-40.

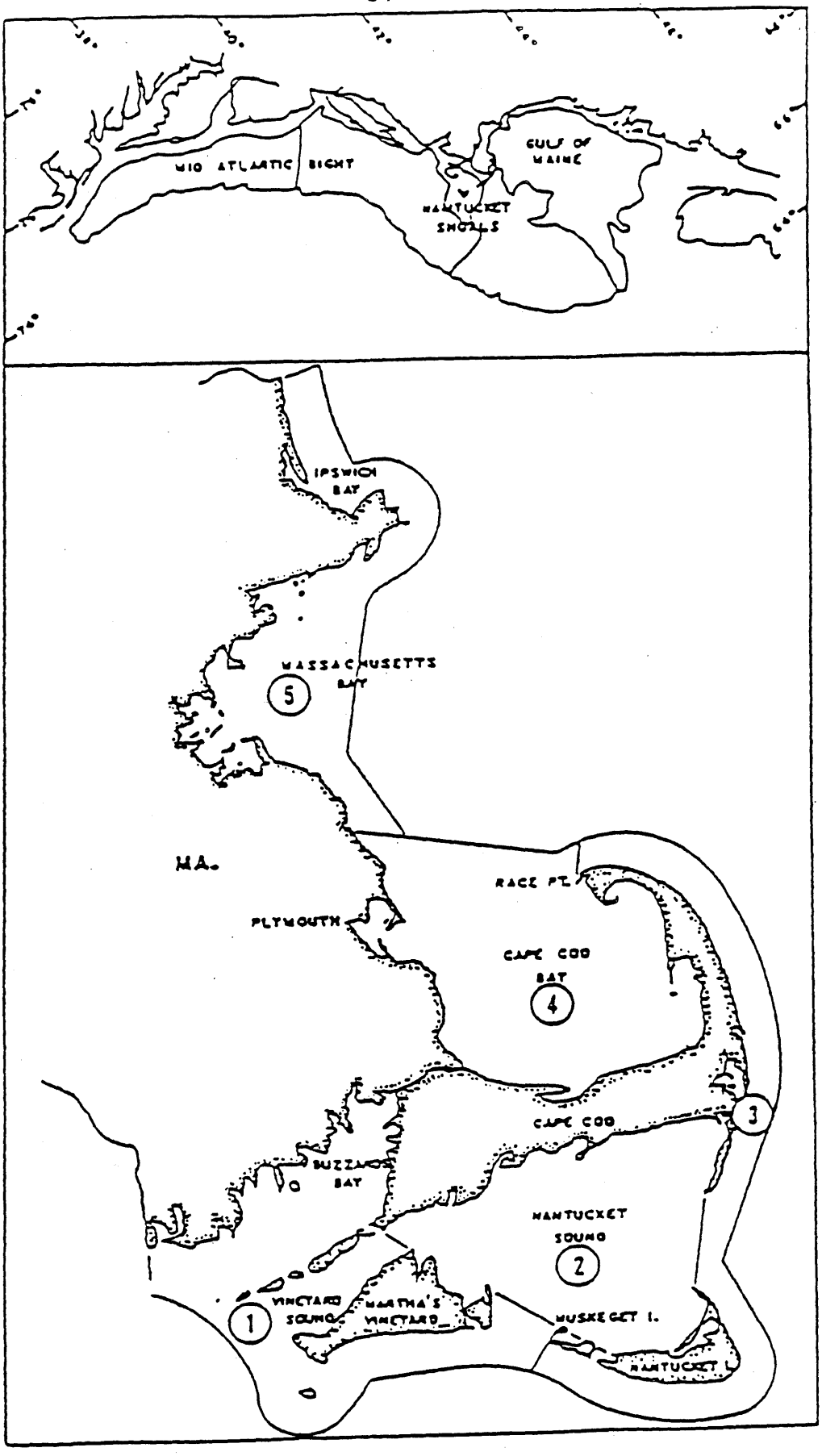
[2] Spring surveys during 1973-1981 were accomplished with a "41 Yankee" trawl. In all other years, spring surveys were accomplished with a "36 Yankee" trawl. No adjustments have been made to the catch per tow data for these gear differences.



Appendix Figure 1. Northeast Fisheries Center offshore (≥27m) bottom trawl sampling strata in the Northwest Atlantic, Cape Hatteras to Nova Scotia. Georges Bank cod sampling strata include strata 13-25, Gulf of Maine cod sampling strata include strata 26-30 and 36-40.



Appendix Figure 2. Northeast Fisheries Center inshore (<27m) bottom trawl sampling strata in the Northwest Atlantic, Long Island to Grand Manan. Inshore Georges Bank cod sampling strata include strata 45-46 and 55-56. Inshore Gulf of Maine cod sampling strata include strata 58-61 and 63-66 (lower Gulf of Maine) and 68-90 (middle and northern Gulf of Maine).



Appendix Figure 3. State of Massachusetts inshore (0-80m) bottom trawl sampling regions and their geographical location with respect to the Northwest Atlantic area from Cape Hatteras to Nova Scotia. Inshore Georges Bank cod sampling strata (11-21) are located in Regions 1-3. Inshore Gulf of Maine cod sampling strata (25-36) and located in Region 4-5.