

STATUS OF THE GEORGES BANK AND GULF OF MAINE

ATLANTIC COD STOCKS - 1982

by

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## SUMMARY

The Georges Bank and Gulf of Maine Atlantic cod (*Gadus morhua*) stocks are important elements of the United States Northwest Atlantic groundfish fisheries. Total 1981 commercial landings from these two stocks was 55,490 metric tons, the third highest annual catch since 1907. Projected 1982 commercial landings are expected to be about the same as in 1981. Total USA commercial landings in 1981 were 46,383 metric tons, the second highest in 73 years. Cod was the dominant species landed in the 1981 USA groundfish fishery, accounting for more catch, by weight, than any other single species. Recreational landings of cod significantly increased during 1981 and 1982 based on reports from party and charter boat captains.

Commercial 1981 landings from the Georges Bank cod stock totaled 42,357 metric tons, the third highest since 1968. USA and Canadian landings accounted for 80% and 20%, respectively, of the 1981 catch; the USA catch was the second highest since 1932. The 1978 year class dominated the 1981 USA landings, accounting for 37% of the fish landed. The 1975 year class also continued to be important in contributing to fishery yield. Research vessel abundance and biomass indices indicate that current stock size has remained stable at a relatively high level, despite the near-record annual landings in recent years. This stability has been maintained through a succession of better than average year classes produced almost on an annual basis since 1975. Recent fishing mortality appears to be only slightly higher than  $F_{max}$  (0.39 vs 0.30) but is lower than the levels observed in the mid-1960's and mid-1970's. Given the presently high level of stock abundance and current fishing and management regimens, annual commercial landings of about 40,000 metric tons appear to be sustainable during the next 2-3 years.

Commercial 1981 Gulf of Maine cod landings were 13,133 metric tons, the second highest yearly catch since 1945. For the fifth consecutive year, total commercial landings exceeded 12,000 metric tons. USA 1981 landings accounted for 95% of the total catch and represented the third highest domestic harvest since 1932. Canadian landings accounted for the remaining 5% of the 1981 total. The 1977 and 1978 year classes were dominant in the size-frequency samples obtained from USA commercial landings. In samples of "market" cod, which constituted 47% of the 1981 USA commercial catch by weight, these two year classes accounted for 72% of the numbers at age. Spring 1982 NEFC offshore catch per tow indices were among the highest observed indicative of continued high levels of stock abundance and biomass. All year-classes produced during 1977-1980 appear to be above average in strength; these four cohorts currently comprise over 81% of the Gulf of Maine population, by number, and by 1983, will account for the bulk of the spawning stock. Such a balance of age groups in the spawning population normally provides a buffer against poor recruitment. Recent fishing mortality rates appear to have stabilized but at a level higher than  $F_{max}$  and higher than levels observed in the mid and late 1960's and early 1970's. Given current resource conditions, continued short-term annual fishery yields of 12,000 metric tons appear to be sustainable under present fishing and management practices. Both potential yield and total reproductive potential of the stock, however, could be enhanced by reducing fishing mortality to the  $F_{max}$  level and delaying age at first capture in the fishery.

## INTRODUCTION

The Georges Bank and Gulf of Maine Atlantic cod (Gadus morhua) stocks are significant components of the groundfish fisheries off the northeastern coast of the United States. Combined 1981 commercial cod landings from these stocks totaled 55,490 tons<sup>1</sup> (Table 1), 10% less than in 1980 (61,836 tons), but still the third largest annual commercial catch since 1907. Total USA commercial landings in 1981 were 46,383 tons, the second highest in 73 years. Cod was the dominant species in the 1981 USA Atlantic groundfish fishery, accounting for more landings than haddock and yellowtail flounder combined (United States Department of Commerce 1982).

This report describes the current status of the Georges Bank (NAFO Division 5Z and Statistical Area 6) and Gulf of Maine (NAFO Division 5Y) cod stocks based on examination of research survey and commercial and recreational fisheries data. Analyses and statistics presented herein represent an update of previous assessments (Serchuk and Wood 1981).

### GEORGES BANK STOCK

#### Commercial Landings

Provisional commercial landings in 1981 from the Georges Bank stock were 42,357 tons, 12% lower than in 1980 (48,147 tons). The 1981 nominal catch was the third highest since 1968 (Table 1, Figure 1). USA 1981 landings were 33,849 tons, 15% less than the record 1980 catch of 40,053 tons, but still the second highest annual domestic catch since 1932. Provisional Canadian landings in 1981 totaled 8,508 tons, a 414 ton increase (5%) from 1980.

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<sup>1</sup>Tons in this paper refer to metric tons, live weight

Throughout 1981 and until 30 March 1982, the Georges Bank cod fishery was regulated under Amendment 4 to the Fishery Management Plan (FMP) for Atlantic Groundfish; the FMP proper was implemented by emergency regulations on 15 March 1977. The amended FMP provided for a USA commercial catch allocation during calendar year 1981 of 29,620 tons, although the fishery is managed on a "fishing year" basis from 1 October to 30 September. The FMP allotted 5,380 tons to Canada which included an unspecified USA recreational allocation. Both USA and Canadian 1981 commercial landings exceeded annual FMP allocations (14% and 58%, respectively).

Since 31 March 1982, the Georges Bank cod fishery has been regulated under a new management plan, the Interim Plan for Atlantic Groundfish (Interim Plan), which eliminated quota management for cod, haddock, and yellowtail flounder. Management measures under the Interim Plan are limited to area/mesh regulations, seasonal spawning area closures, minimum mesh sizes, minimum fish retention lengths (17 inches for commercially caught cod and 15 inches for cod caught recreationally) and data reporting requirements (New England Fishery Management Council 1981).

Since implementation of the Interim Plan, USA commercial Georges Bank cod landings have been on par with reported catches for the same time period in 1981. During April-June 1982, USA commercial landings were 11,169 tons compared to 10,726 tons in the second calendar quarter of 1981. During January-June 1982, USA commercial landings totaled 18,041 tons (Table 1), only 89 tons more than in the first half of 1981. Canadian Georges Bank landings for the first six months of 1982 were 2,389 tons (Table 1), more than twice the January-June 1981 catch of 1,019 tons. Canada initially established a 1982 cod quota of 15,000 tons for the Canadian commercial Georges Bank cod fishery. However, this quota was revised upward on 20 August 1982 to allow for a 1982 Canadian cod catch of 22,500 tons from Georges Bank.

Given current landings patterns, the anticipated total (USA and Canada) 1982 commercial Georges Bank cod catch should approximate the 1981 total of 42,000 tons.

#### Commercial Catch Composition

Market category distribution of the 1981 USA commercial landings (January-September) was virtually identical to that for 1980 (Table 2). "Market" cod (1.1-4.5 kg; 2.5-10.0 lbs) comprised 48% of the catch by weight, "large" cod ( $\geq 4.5$  kg;  $\geq 10.0$  lbs), 38% and "scrod" cod (0.7-1.1 kg; 1.5-2.5 lbs), 11%.

Age composition of the USA landings during 1981 (January-September) was estimated from monthly length frequency and age samples, by market category. Numbers at age were obtained by applying quarterly age/length keys to quarterly market category length frequency distributions, and summing over market categories and quarters. These results have been summarized, as relative proportions at age within market categories and overall, in Table 3.

The 1978 year class (age 3) comprised 37% of the catch in numbers, followed by the 1979 year class (age 2) with 25%, the 1977 year class (age 4) with 22% and the 1975 year class (age 6) with 11% (Table 3). Year class dominance expectedly varied within market categories. "Scrod" landings were dominated by the 1979 year class (58%), "market" landings by the 1978 year class (47%), and "large" landings by the 1975 year class (57%). Since "market" and "large" cod accounted for 86% of the 1981 USA catch by weight, the 1978 and 1975 year classes continue to be significant in sustaining the fishery.

#### Distribution of USA Commercial Landings by Gear

In 1981, otter trawl landings accounted for 86.2% of the USA commercial Georges Bank cod catch, a slight proportional increase from 1980 (84.7%), and

nearly equal to the 1965-1980 otter trawl average (86.4%) (Table 4). Line trawl landings, which amounted to 1,102 tons in 1980 (2.9%), declined to only 120 tons in 1981 (0.4%), the lowest catch in the 1965-1981 time series. Handline landings which were absent from the 1980 catch totaled 584 tons in 1981 (1.8% of USA catch). The shifts in line trawl, handline, and gill net landings (3,513 tons in 1981) between 1980 and 1981 primarily reflect changes in gear usage by vessels landing in Chatham, Massachusetts. The localized occurrence of "slime" (algae and/or siphonophores) and dogfish during spring 1981 (and 1982) prompted many vessels in the Chatham day-trip gillnet fleet to switch fishing gear for the period in which these species hampered gill net operations.

#### Research Vessel Survey Indices

Indices of cod abundance (stratified mean catch per tow in numbers) and biomass (stratified mean weight per tow in kilograms) derived from Northeast Fisheries Center (NEFC) and State of Massachusetts research vessel bottom-trawl surveys have been used to evaluate trends in population size and recruitment of the Georges Bank cod stock. Offshore ( $\geq 27$  m) NEFC surveys of Georges Bank (sampling strata 13-25: Appendix Figure 1) have been conducted annually in the autumn since 1963, in the spring since 1968 and in summer during 1977-1981. Inshore areas ( $< 27$  m) shoalward of Georges Bank have been sampled since 1977 during NEFC spring, summer, and autumn inshore surveys (sampling strata 45-46 and 55-56: Appendix Figure 2) and since 1978 during State of Massachusetts spring and autumn inshore bottom-trawl surveys (Massachusetts sampling strata 11-21 in Regions 1-3: Appendix Figure 3). Details on NEFC survey sampling design and methodology are provided by Grosslein (1969), Azarovitz (1981) and Clark (1981). A description of the State of Massachusetts bottom trawl sampling program is given in Howe et al. (1979, 1980, 1981).

Spring and autumn NEFC offshore catch per tow indices for Georges Bank cod indicate similar trends, both in abundance and biomass, during the survey time series (Table 5 and Figures 2 and 3). Catch per tow values were relatively low and stable during 1963-1971, but have subsequently fluctuated at a generally higher level during 1972-1982. The sharp increases in the number per tow indices in 1967, 1972-1973, 1976, 1978, and 1981 reflect above average recruitment of the 1966, 1971, 1975, 1977, and 1980 year classes at ages 0 and 1 (Figure 2, Appendix Table 1). The proportional dominance of these year classes in the spring and autumn offshore survey catches is depicted in Figures 4 and 5, respectively.

The range of fluctuation between the highest and lowest annual number per tow indices in both the spring and autumn offshore surveys is relatively small (6X in both time series) in comparison with other groundfish species (i.e., Georges Bank haddock, 57X - Clark et al. 1982; Georges Bank yellowtail flounder, 12X - Clark et al. 1981). Variability in weight per tow values for Georges Bank cod is even less, with only a threefold difference between the most extreme spring survey values and a fourfold difference in the most extreme autumn indices<sup>2</sup>. Such stability in population abundance and biomass has generally not been observed for most other Northwest Atlantic fish stocks (Clark and Brown 1979).

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<sup>2</sup>The spring 1973 number and weight per tow indices as presented in Table 5 were not used in these comparisons since these high values resulted from one tow (Strata 20-4) in which an anomalously large quantity of cod was taken (1,884 fish weighing 2.56 tons). Exclusion of this tow resulted in the number per tow index being 11.98 and the weight per tow index being 24.5 kg.

Although both number and weight per tow indices in the spring 1982 survey declined from 1981 (-24% and -41%, respectively: Table 5), the current values are still among the top third of values observed. Similarly, the autumn 1981 indices are near the highest recorded (Figures 2 and 3). NEFC 1981 offshore summer survey indices declined from the high 1980 values (Table 5), although these differences were not statistically significant ( $P > 0.05$ ). In toto, the current offshore survey data suggest that both abundance and biomass of the Georges Bank stock have continued to remain at near-record high levels.

Distributions of stratified mean number per tow at age data from the offshore surveys (Figures 4 and 5, Appendix Table 1) reveal that stock size has remained high due to a periodic good recruitment every 3-5 years. The best year classes (1966, 1971, 1975) have remained important components of the exploitable population (age 2+) for 5-6 years thereby resulting in a fishable population supported by a number of age groups. This heterogeneous age composition has apparently provided significant resiliency to the stock relative to variable fishery exploitation rates.

Estimates of the relative strength of the more recent year classes of Georges Bank cod are available from both offshore and inshore survey series. NEFC spring, summer, and autumn offshore surveys since 1977 indicate that the 1977, 1978, and 1980 year classes appear to be either above average or strong (Figures 4 and 5, Appendix Table 1). Both NEFC and State of Massachusetts inshore survey (Appendix Tables 3 and 4) catch per tow indices for ages 0-2 cod tend to support these evaluations but also suggest that the 1979 year class may additionally be above average. Catch per tow indices for the 1979 cohort at ages 0 and 1 in the spring NEFC and Massachusetts inshore surveys were higher than corresponding values for the 1980 cohort at these ages. The age 1 catch

per tow index in the 1980 NEFC summer inshore survey (i.e., 1979 year class) was the highest of any age 1 value observed (Appendix Table 5). Inconsistencies in trend in successive catch-at-age values coupled with the limited time series, however, preclude heavy reliance on year-class strength determinations from the summer inshore survey data.

The relative strengths of the 1981 and 1982 year classes, based on age 0 and 1 indices, from 1981 and 1982 Massachusetts and NEFC inshore spring surveys appear to be strong and average, respectively (Appendix Tables 3 and 4). Catch-per-tow values at age 0 (1981 cohort) in the 1981 Massachusetts and NEFC spring inshore surveys were the second highest observed; the 1982 NEFC spring age 1 index (1981 cohort) was the highest in that series. The spring 1982 age 0 indices (1982 cohort), however, are all near the median age 0 levels for the spring inshore and offshore survey series.

Overall, the period since 1975 has been one in which better than average year classes have been produced by the Georges Bank stock almost on an annual basis.

The most recent NEFC offshore surveys (Autumn 1981 and Spring 1982) indicate that the current Georges Bank cod population is dominated by 1978-1980 year classes. Collectively, these three year classes accounted for 81% of the autumn 1981 total catch-per-tow index and 75% of the spring 1982 value. The proportional representation of nearly all year classes in the spring and autumn 1981 offshore surveys was nearly identical to that in the 1981 USA landings (Table 3), when fish less than 35 cm (non-commercial size) were excluded from the survey age composition data. This correspondence implies that the 1981 fishery harvested cohorts from the Georges Bank stock in proportion to their relative abundance.

### Mortality Estimates

Pooled estimates of instantaneous total mortality (Z) and fishing mortality (F) were calculated for four time periods encompassed by the NEFC autumn and spring offshore surveys: 1964-1967, 1968-1972, 1973-1977, and 1978-1981 (Table 6). Total mortality was estimated from the survey catch per tow at age data (Appendix Table 1) for fully recruited age groups (age 3+) 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, e.g. the 1978-1981 values were derived from

Autumn:  $\ln(\Sigma 3 \text{ and older fish for } 1977-1980 / \Sigma 4 \text{ and older fish for } 1978-1981)$

Spring:  $\ln(\Sigma 4 \text{ and older fish for } 1978-1981 / \Sigma 5 \text{ and older fish for } 1979-1982)$

The difference in age groups used in the autumn and spring survey analyses resulted from the desire to evaluate total mortality over identical year classes within each period, e.g. the 1978-1981 autumn value estimates total mortality for the 1974 and older year classes. Similarly, the 1978-1981 spring value estimates total mortality for these same year classes (1974 and older).

The pooled mortality estimates indicate that total mortality was lowest during 1968-1972 and highest during 1964-1967. Mortality estimates among time periods, however, display only moderate variation (Table 6). Total mortality rates derived from spring data range from  $Z = 0.45$  to  $0.80$ ; autumn survey total mortality values range between  $Z = 0.49$  and  $0.73$ . No consistent differences in trend are evident between spring and autumn estimates. Hence, an average of the two estimates was calculated for each time period. Over all time periods, total mortality rates range from  $Z = 0.47$  to  $0.73$  with a trend towards slightly decreasing levels of mortality in recent years.

Assuming instantaneous natural mortality ( $M$ ) = 0.20 (Paloheimo and Koehler 1968; Pinhorn 1975; Minet 1978), average fishing mortality rates ranged between  $F = 0.27$  and  $0.53$  during the 1964-1981 time frame (Table 6). Although almost all of the period values are above  $F_{\max}$  ( $F_{\max} = 0.30$ , Serchuk et al. 1979), fishing mortality estimates have trended downward with time. The 1977-1981 estimated  $F$  value of  $0.39$  is slightly above  $F_{\max}$ .

Estimates of  $Z$  and  $F$  were also derived from catch curve analysis of NEFC offshore spring and autumn stratified mean number per tow at age values for the strong 1971 and 1975 year classes (Figure 6). For the 1971 year class, an average  $Z = 0.66$  was determined from the spring and autumn data (Spring:  $Z = 0.746$ ; Autumn:  $Z = 0.583$ ). This value reflects total mortality during 1973-1979 period (i.e., ages 3-8) and is of the same magnitude as the pooled average mortality estimates for 1973-1977 ( $Z = 0.69$ ) and 1977-1981 ( $Z = 0.59$ ) (Table 6). For the 1975 year class, the survey catch curves produced an average  $Z$  of  $0.51$  (Spring:  $Z = 0.592$ ; Autumn:  $Z = 0.423$ ) for the period 1977-1982. This value differs only slightly from the estimated average  $Z$  of  $0.59$  for the 1978-1981 period. Hence, the catch curve results tend to corroborate the estimates of mortality derived from the pooled data, although it should be realized that these analyses are not mutually independent.

Trends in fishing mortality were also evaluated by examining relative exploitation indices (ratios between total commercial landings and NEFC offshore weight per tow values) for the 1964-1981 time period (Table 7). Average total commercial landings and average survey biomass indices were calculated for the same four time periods used in the pooled mortality analyses (i.e., 1964-1967, 1968-1972, 1973-1977, and 1978-1981). Relative exploitation indices ("E" values) for each period were obtained by dividing the average annual commercial catch in weight during the period by the average survey weight per tow value.

E values are proportional to fishing mortality although this relationship is not linear (Clark 1981). Equally, E values differ from fishing mortality rates in that they are related to biomass rather than abundance in numbers.

Relative exploitation indices derived using both spring and autumn survey catch per tow data reveal similar trends (Table 7). E values were highest during 1964-1967 and sequentially declined during 1968-1972 and 1973-1977. Values for the most recent period are slightly higher than during 1973-1977, although still below the 1964-1972 indices. Thus, these results are generally consistent with the pooled mortality analyses in indicating that fishing mortality in the more recent years has remained at a level lower than during the mid-1960's, when total effort (primarily due to distant-water fisheries) peaked. Because reported USA commercial landings during 1978-1981 may significantly underestimate actual landings (Serchuk and Wood 1981), it is likely that the exploitation rate for this period is higher than calculated. However, the actual 1978-1981 landings would need to have been nearly twice that reported for the 1978-1981 mean exploitation index to equal the 1964-1967 value. Since annual total nominal commercial catches of Georges Bank cod have never exceeded 55,000 tons, this circumstance appears unrealistic.

All of the mortality-related analyses tend to be consonant in indicating that recent fishing mortality levels have been reduced from former periods, that these levels have been relatively stable, and that the most recent F values slightly exceed  $F_{max}$ .

#### Recreational Fishery

The Georges Bank cod stock supports a significant recreational fishery along the northeast coast of the United States from Massachusetts to New Jersey. A review of recreational landings which included results from the 1979 NMFS

Marine Recreational Fishery Statistics Survey, was presented in Serchuk and Wood (1981). More recent recreational fishery statistics are currently not available. However, informal reports on the winter 1981-1982 party and charter boat cod fisheries (The New England Fisherman; The Long Island Fisherman; The Fisherman), indicate substantial improvement in recreational cod fishing.

Schaefer (1982) reported that the New York/New Jersey winter party boat fishery had the "best codfish season in at least 10 years." Miller (1982) noted that during spring 1982 open and party boats operating out of Montauk, New York had "perhaps the best cod season in the last decade." Similar descriptions of excellent recreational cod fishing by party boat captains fishing out of ports in Connecticut, Rhode Island, and Massachusetts, appeared throughout spring 1982. Most reports indicated sizable landings of "market" cod. The summer 1982 Cox's Ledge and Block Island cod fisheries were also reported to be exceptionally good by party boat captains from Montauk and Point Judith, Rhode Island (Cestaro 1982; Fleet 1982).

#### Implications of the Current Georges Bank Cod Assessment

Results of the present assessment indicate that the Georges Bank cod stock biomass continues to remain at the relatively high levels noted during the past several years, despite near-record annual landings. Autumn 1981 and Spring 1982 NEFC offshore survey number and weight per tow indices were among the highest recorded. Stock stability at high levels has been maintained through a succession of above average and strong year classes, moderate fishing mortality rates, and proportional harvesting of the stock relative to its age/size composition.

Pre-recruit indices for the 1980 and 1981 year classes indicate that both cohorts may be strong ones; these year classes will initially recruit to the otter trawl fishery in the latter part of 1982 and 1983, respectively, given current and anticipated fishing practices (i.e., minimum cod-end mesh sizes and minimum fish sizes). Hence, it is expected that annual total commercial catches of about 40,000 tons (the 1981 level) should be sustainable over the next 2-3 years without major adverse consequences to the resource.

#### GULF OF MAINE STOCK

##### Commercial Landings

Total 1981 commercial landings of Gulf of Maine cod were 13,133 tons (Table 1), 556 tons less than in 1980, and the second highest annual catch since 1945. For the fifth consecutive year, total commercial landings exceeded 12,000 tons (Figure 1). The 1981 USA catch was 12,534 tons, 7% less than in 1980 (13,528 tons), but still the third highest since USA cod landings have been maintained by stock area (1932). USA landings accounted for 95% of the 1981 total commercial harvest; Canadian landings (599 tons) accounted for the remaining 5% of the commercial catch.

Total cod landings during 1981 and the first calendar quarter of 1982 were regulated under an amended Atlantic Groundfish FMP as implemented on 15 March 1977. For 1981, optimum yield was established as 12,000 tons. The USA commercial fishery was allocated 9,500 tons and the USA recreational FCZ charter and party boat fishery allotted 2,500 tons. Since 31 March 1982, the Gulf of Maine cod fishery has been regulated under the Interim Groundfish Plan which defines optimum yield as equivalent to the actual USA harvest obtained in accordance with the management measures of the plan (Gulf of Maine cod management measures are essentially identical to those for Georges Bank).

Under the Interim Plan, USA commercial Gulf of Maine cod landings have generally mirrored the catch levels for the same time periods in 1981. During January-June 1982, USA commercial landings totaled 5,717 tons (Table 1), slightly less than the 6,430 tons taken during the first six months of 1981. For the January-July period, 1982 USA landings were only 1.7% less than they were in 1981. Canadian Gulf of Maine landings during January-June only differed by 5 tons between years (1981: 22 tons; 1982: 17 tons). Accordingly, a total 1982 commercial catch of about 13,000 tons (the 1981 total) is projected.

#### Commercial Catch Composition

Distribution of the 1981 USA commercial Gulf of Maine cod landings (January-September) indicated that "scrod" cod comprised 20% of the catch (by weight), "market" cod, 47%, and "large" cod, 33% (Table 2). The 1981 catch composition is virtually identical to the 1980 distribution, and similar to the patterns observed during 1977-1979.

Age composition of the 1981 USA commercial length frequency samples was derived by applying quarterly age/length keys to the quarterly market category length frequency distributions, and summing over quarters. Due to the modest number of samples obtained within each market category (Table 8), no attempt was made to prorate the sample age composition data to estimate total numbers landed at age in the 1981 USA commercial catch. The sample data, however, appear adequate to discern general trends in age composition and relative year-class strength.

"Scrod" samples were dominated by the 1979 year class (age 2) which comprised 68% of the sampled individuals. Nearly co-equal dominance by the 1978 and 1977 year classes (37% and 35%, respectively) was observed in "market" samples. The "large" samples exhibited strong proportional representation by

the 1977 year class (38%), the 1975 year class (22%) and the 1978 and 1971 year classes (11% each) (Table 8). Since "market" and "large" cod together comprised 80% of the 1981 USA commercial landings (by weight), the 1978 and 1977 year classes appear to be the most important in sustaining fishery yield.

#### Distribution of USA Commercial Landings by Gear

Annual landings patterns, by gear, have shown minor variation during the 1977-1981 period. In 1981, otter trawl landings accounted for 66.2% of the USA commercial Gulf of Maine cod catch, nearly equal to the 1977-1980 average (67.7%) (Table 9). Gill net landings, which generally accounted for less than 20% of the yearly catches prior to 1976, comprised 31% of the 1981 USA landings, the highest annual percentage in the 1965-1981 time series (Table 9). Since 1977, gill net landings have tended to constitute an increasing proportion of the domestic commercial harvest. Line trawl landings, significant during 1971-1975, have accounted for less than 3.5% of the annual catches in the past four years.

#### Research Vessel Survey Indices

As for Georges Bank cod, research vessel bottom trawl survey indices have been used as a fishery independent method of stock evaluation for Gulf of Maine cod since 1963. Offshore ( $\geq 27$  m) NEFC surveys in the Gulf of Maine (sampling strata 26-30 and 36-40: Appendix Figure 1) have been performed annually during autumn (1963-1982), spring (1968-1982), and summer (1977-1981). Additionally, inshore Gulf of Maine waters ( $< 27$  m) have been sampled annually since 1977 during NEFC spring, summer, and autumn inshore surveys (sampling strata 58-66 and 68-90: Appendix Figure 2) and since 1978 during State of Massachusetts spring and autumn inshore (0-80 m) surveys (sampling strata 25-36 in Regions 4-5:

Appendix Figure 3). Abundance and biomass indices from the NEFC inshore summer surveys were derived separately for the lower and middle-northern Gulf of Maine regions (Appendix Table 5) so that the lower Gulf of Maine values could be directly compared to Massachusetts survey indices from the same general area.

NEFC spring and autumn offshore survey abundance indices (stratified mean catch per tow in numbers) exhibit similar patterns of fluctuation throughout the survey time series (Table 5, Figure 2). Both sets of indices have displayed only a modest range of variation; the relative difference between extreme values (highest and lowest) is only 5X and 4X for the spring and autumn indices, respectively. Variability in spawning stock abundance (3+ indices) is even less, with only a threefold difference between the most extreme spring survey values and a fourfold difference between the most extreme autumn indices (Appendix Table 2). Peaks in the total number per tow indices (Figure 2) during 1972-73, 1975, 1977-78, 1980, and 1981 reflect recruitment of the above average 1971, 1973, 1977-1980 year classes (Figures 4 and 5, Appendix Table 2).

Biomass indices (stratified mean weight per tow) from the NEFC spring and autumn offshore surveys show generally similar trends; weight per tow indices gradually declined between 1968 and 1975 but have subsequently increased to near-record levels (Figure 3). In both survey series, however, the range of indices has been narrow. Only a threefold difference exists between the highest and lowest values observed in each survey series. Hence, like the Georges Bank stock, the Gulf of Maine cod stock exhibits a stability seldom observed in other species/stocks.

The spring 1982 number and weight per tow indices from the NEFC offshore Gulf of Maine survey are both the fourth highest observed, and apart from 1981, are the highest values recorded since 1973 (Table 5). Although the 1981 autumn

NEFC offshore catch per tow indices are among the lowest in the autumn time series and thus inconsistent with the spring 1982 survey results, the reduced 1981 autumn indices are believed to reflect a change in availability rather than abundance. Between autumn 1980 and 1981, almost all year-class catch-at-age indices declined more sharply than can be explained by exploitation or natural mortality (i.e.,  $Z_{(4+/5+)} = 1.53$ ) (Appendix Table 2). Equally, the autumn 1981 indices are discordant with the relatively high abundance and biomass indices observed in the preceding three autumn surveys, as well as with those obtained during the summer 1981 offshore survey (Table 5). Accordingly, discounting the autumn 1981 survey abundance results, the recent offshore survey data indicate that the Gulf of Maine cod stock has continued to remain near the highest levels of abundance and biomass observed.

Catch at age distributions from the offshore surveys indicate that stock size has remained high due to a succession of average or above average year classes (Figures 4 and 5, Appendix Table 2). The strong 1971 and 1973 year classes dominated the Gulf of Maine population during the mid and late 1970's. Together, these cohorts accounted for between 20 and 72%, by number, of the spring survey total catch per tow indices during 1974-1980, and between 29 and 88% of the autumn survey abundance values from 1973-1979. Separately, each cohort accounted for greater than 10% of the annual survey catch until age 8 in the spring surveys and age 7 in the autumn surveys. Since 1977, the production of good year classes has apparently been much more regular, occurring almost on an annual basis. Both the 1977 and 1978 year classes have appeared to be better than average or strong in all three of the NEFC offshore survey series (Appendix Table 2, Figures 4 and 5), as well as in the NEFC inshore summer surveys (Appendix Table 5). The 1979 year class stands out as strong in both

the spring and autumn Massachusetts inshore surveys (Appendix Table 4), in the NEFC inshore summer series (Appendix Table 5), and in the spring NEFC inshore surveys (Appendix Table 3). Catch-per-tow indices for the 1980 and 1981 cohorts suggest that these year classes are probably above average and average, respectively. These evaluations, however, are somewhat tentative due to the limited number of catch at age observations for each cohort and inconsistencies in year-class strength patterns among survey series.

The only data currently available for estimating the relative year-class strength of the 1982 cohort are the age 0 indices from the 1982 NEFC offshore and inshore spring surveys and the 1982 Massachusetts spring inshore survey. As a group, these indices indicate that the 1982 year class is below average, although spring age 0 indices tend to have little, if any, correspondence with actual year-class strength. Cod are often still spawning and newly-hatched young-of-year still pelagic during the time when spring surveys are conducted.

Age distributions of cod in the most recent NEFC offshore surveys (Autumn 1981 and Spring 1982) indicate that the 1977-1980 year classes account for over 81% of the population by number, with nearly equal proportional representation by the 1977, 1978, and 1980 cohorts (Figures 4 and 5). This balance of age groups within the population will provide a heterogeneous age distribution in the future spawning stock, thereby reducing the likelihood of poor reproduction and recruitment in the years immediately ahead. Equally, since maximum yield per recruit at  $F_{max}$  ( $F = 0.30$ ) and  $F_{0.1}$  ( $F = 0.16$ ) is not attained until ages at first capture of between 6.5-7.5 years (Serchuk et al. 1979), the persistence of older age groups in the population results in potential increases in cohort yield.

### Mortality Estimates

As for Georges Bank cod, estimates of instantaneous total mortality ( $Z$ ) were calculated for Gulf of Maine cod by pooling spring and autumn NEFC offshore survey data for fully recruited age groups (age 4+) over four time periods (1964-1967, 1968-1972, 1973-1977, and 1978-1981). To evaluate mortality over identical year classes within each period, the  $\log_e$  ratio of pooled age 4+/age 5+ data were used in the autumn surveys and pooled age 5+/age 6+ data in the spring surveys, e.g., the 1978-1981 estimates were derived from

Autumn:  $\ln (\Sigma 4 \text{ and older fish for } 1977-1980 / \Sigma 5 \text{ and older fish for } 1978-1981)$

Spring:  $\ln (\Sigma 5 \text{ and older fish for } 1978-1981 / \Sigma 6 \text{ and older fish for } 1979-1982)$

Mortality estimates from the spring and autumn analyses showed close agreement within each time period (Table 6), and hence were averaged. Average  $Z$  values for the four time intervals ranged between 0.50 and 0.64, with mortality in 1964-67 and 1968-72 slightly lower than in subsequent periods. Assuming natural mortality ( $M$ ) = 0.20, average fishing mortality ( $F$ ) approximated  $F_{\max}$  (0.30) during 1964-1972; in subsequent periods  $F$  has been slightly higher than  $F_{\max}$ .

Estimates of  $Z$  from survey catch curve analyses of the strong 1971 and 1973 year classes tend to correspond to those derived from the pooled analyses (Figure 6). For the 1971 year class, a  $Z$  of 0.39 was obtained from averaging the spring and autumn results (Spring:  $Z = 0.408$ ; Autumn:  $Z = 0.367$ ). For the 1973 year class, the survey catch curves produced an average  $Z$  of 0.74 (Spring:  $Z = 0.533$ ; Autumn:  $Z = 0.956$ ). These  $Z$  values reflect mortality during 1973-80 (1971 year class) and 1977-81 (1973 year class) and hence encompass the time periods represented by the pooled  $Z$  estimates for 1973-77 ( $Z = 0.64$ ) and 1978-81 ( $Z = 0.58$ ).

Inspection of the spring and autumn survey catch curves for the 1971 year class suggests that mortality between ages 6-8 (during 1977-1979) was higher than estimated from analysis of the entire set of catch-at-age values (Figure 6). When only the age 6-8 segment of the spring and autumn catch curves are used to estimate total mortality, Z values of 0.86 (spring) and 0.62 (autumn) are obtained. These values are quite similar to the estimates of Z derived for the 1978-1981 period from the pooled analyses ( $Z = 0.58$ ) and the 1973 year class catch curve calculations ( $Z = 0.74$ ). Hence, all of the mortality analyses tend to be consistent in indicating an increase in total mortality (and hence fishing mortality) in the most recent years.

Trends in relative exploitation indices have generally paralleled the trends observed in the mortality analyses (Table 7). Relative exploitation indices (E values) were lowest during the 1964-1967 period and have tended to be sequentially higher in all subsequent time periods. The average E values for the 1973-1977 and 1978-1981 periods are identical (i.e., 1.6) suggesting the same stabilization in fishing mortality rates during the most recent years as shown by the average pooled mortality estimates (Table 6).

As an aggregate, all of the mortality-associated analyses indicate that recent mortality in the Gulf of Maine, although stable, is both higher than  $F_{max}$  and higher than F levels observed in the mid and late 1960's and early 1970's.

### Recreational Fishery

An important recreational fishery for Gulf of Maine cod exists along the coasts of Maine, New Hampshire, and northeastern Massachusetts. An estimated half-million cod were landed by marine recreational anglers from Maine and New Hampshire during 1979 (United States Department of Commerce 1980). A review of the Northwest Atlantic recreational cod fishery, which summarized landings data

from the national and regional marine recreational statistics surveys performed through 1979, was provided in Serchuk and Wood (1981). More recent survey data (i.e., 1980) are not yet available. However, the 1982 summer party boat fishery for Gulf of Maine cod appears to have been a good one, based on weekly port reports in The New England Fisherman. Party boat captains in Massachusetts (Gloucester, Newburyport), New Hampshire (Rye, Hampton Beach), and Maine (Kennebunkport, Portland) reported extremely good landings of "market" cod during late spring and summer.

#### Implications of the Current Gulf of Maine Cod Assessment

Gulf of Maine cod stock biomass has continued to remain at the high levels noted in the past four years. The stock, currently comprised of a number of above average year classes, has sustained annual landings of greater than 12,000 tons during each of the past five years without significant adverse effect to population size or composition. The spring 1982 NEFC offshore survey abundance and biomass indices were among the top quarter of observed values in the survey series. Although recent fishing mortality rates have increased relative to the late 1960's and early 1970's and are presently above  $F_{max}$ , stock stability has been maintained through production of a series of relatively good year classes. Given the robust population size and age composition of the present stock and current management and fishing practices, continued short-term harvests of about 12,000 tons appear sustainable. Potential yield could be increased further, however, if size at first capture were delayed to age 6 and fishing mortality reduced to the  $F_{max}$  level. Total reproductive potential would also be enhanced through these actions.

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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), 1960-1982.

Year	Georges Bank and South <sup>1</sup>					Gulf of Maine					Total				
	USA	Canada	USSR	Other <sup>2</sup>	Total	USA	Canada	USSR	Other <sup>2</sup>	Total	USA	Canada	USSR	Other <sup>2</sup>	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 <sup>3</sup>	32,645	6,011	-	-	38,656	11,680	379	-	-	12,059	44,325	6,390	-	-	50,715
1980 <sup>3</sup>	40,053	8,094	-	-	48,147	13,528	161	-	-	13,689	53,581	8,255	-	-	61,836
1981 <sup>4</sup>	33,849	8,508	-	-	42,357	12,534	599	-	-	13,133	46,383	9,107	-	-	55,490
1982 <sup>5</sup>	18,041	2,389	-	-	20,430	5,717	17	-	-	5,734	23,758	2,406	-	-	26,164

<sup>1</sup> SNK landings have been assigned to the Georges Bank and southward region.

<sup>2</sup> Primarily Spain and Poland.

<sup>3</sup> Provisional.

<sup>4</sup> Preliminary.

<sup>5</sup> January-June only.

SOURCE: ICNAF/NAFO Statistical Bulletins 1960-1979.  
 NAFO SCS Document 81/V1/15 (1980 landings).  
 NAFO SCS Document 82/V1/ 7 (1981 Canadian landings).  
 NEFC Weighout Files and State Canvass Reports (1981 USA landings).  
 NAFO Circular Letter 82/55 (January-June 1982 Canadian landings).  
 NEFC Statistics Branch (January-June 1982 USA landings).

Table 2. Percentage of USA commercial Atlantic cod from Georges Bank and south, and the Gulf of Maine, by market category, 1964-1981.

Year	Georges Bank and South				Gulf of Maine			
	Large	Market	Scrod	Total	Large	Market	Scrod	Total
1964	45	47	8	100	29	59	12	100
1965	56	40	3	99	39	54	7	100
1966	53	37	10	100	42	48	10	100
1967	41	42	16	99	41	41	17	99
1968	34	46	19	99	47	43	9	99
1969	27	57	16	100	35	53	9	99
1970	30	62	8	100	43	52	6	101
1971	40	51	9	100	52	42	6	100
1972	37	53	10	100	53	35	7	100
1973	24	40	36	100	52	36	11	99
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	94 (6%mixed)
1977	26	39	34	99	33	42	22	97 (3%mixed)
1978	29	60	11	100	38	44	17	99
1979	37	55	8	100	37	49	14	100
1980	41	47	12	100	36	45	19	100
1981 <sup>1</sup>	38	48	11	97(3% mixed)	33	47	20	100

<sup>1</sup>January-September only.

Table 3. Age composition (percent by number), by market category, of USA 1981 commercial landings of Atlantic cod from Georges Bank (NAFO Subdivision 52a).<sup>1</sup>

Market Category	Age										Total
	1	2	3	4	5	6	7	8	9	10	
Scrod	0.7	58.3	35.2	5.4	0.3	0.1	-	-	-	-	100.0
Market	-	12.2	46.6	35.4	0.6	4.6	0.6	-	-	-	100.0
Large	-	-	-	5.1	0.1	57.0	21.7	5.1	7.3	3.2	100.0
Total	0.2	24.5	36.7	22.1	0.5	10.5	3.3	0.7	1.1	0.4	100.0

<sup>1</sup>January-September only.

Table 4. Distribution of USA commercial landings (metric tons, live) of Atlantic cod from Georges Bank (Area 5Ze), by gear type, 1965-1981. 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.

Year	Landings (metric tons, live)					Percentages of Annual Landings				
	Otter Trawl	Line Trawl	Handline	Other Gear	Total Landings	Otter Trawl	Line Trawl	Handline	Other Gear	Total
1965	1025 <sup>1</sup>	582	505	9	11347	90.3	5.1	4.5	0.1	100.0
1966	10206	787	757	19	11769	86.7	6.7	6.4	0.2	100.0
1967	10915	894	704	9	12522	87.2	7.1	5.6	0.1	100.0
1968	12084	936	524	<1	13544	89.2	6.9	3.9	-	100.0
1969	13194	1371	387	<1	14952	88.2	9.2	2.6	-	100.0
1970	11270	1676	404	<1	13350	84.4	12.6	3.0	-	100.0
1971	12436	2334	230	2	15002	82.9	15.6	1.5	-	100.0
1972	10179	2071	217	10	12477	81.6	16.6	1.7	0.1	100.0
1973	12431	2185	206	24	14846	83.7	14.7	1.4	0.2	100.0
1974	14078	2548	11	12	16649	84.6	15.3	0.1	0.1	100.1
1975	12069	2435	84	4	14592	82.7	16.7	0.6	-	100.0
1976	12257	1519	153	9	13938	87.9	10.9	1.1	0.1	100.0
1977	18529	912	83	52	19576	94.7	4.7	0.4	0.3	100.1
1978	20862	1569	1180	140	23751	87.8	6.6	5.0	0.6	100.0
1979	26562	2707	860	779 <sup>1</sup>	30908	85.9	8.8	2.8	2.5	100.0
1980	32479	1102	0	4764 <sup>2</sup>	38345	84.7	2.9	0.0	12.4	100.0
1981	27505	120	584	3710 <sup>3</sup>	31919	86.2	0.4	1.8	11.6	100.0

<sup>1</sup>Of 779 tons landed, 620 tons were by sinking gill nets.

<sup>2</sup>Of 4704 tons landed, 4491 tons were by sinking gill net and 222 tons were by Danish seine.

<sup>3</sup>Of 3710 tons landed, 3513 tons were by sinking gill net and 162 tons were by Danish seine.

Table 5. Stratified mean catch per tow in numbers and weight (kgs) for Atlantic cod from USA offshore spring, summer, and autumn bottom trawl surveys on Georges Bank (Strata 13-25) and in the Gulf of Maine (Strata 26-30 and 36-40), 1963-1982.

Year	Georges Bank						Gulf of Maine					
	Spring <sup>1</sup>		Summer <sup>2</sup>		Autumn		Spring <sup>1</sup>		Summer <sup>2</sup>		Autumn	
	Nos	Wt (kgs)	Nos	Wt (kgs)	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	8.3	-	-	-	-	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	4.9	2.08	8.2	-	-	1.77	9.5
1970	2.78	9.7	-	-	3.25	7.8	1.41	6.8	-	-	3.14	10.2
1971	2.17	8.8	-	-	2.04	6.1	0.92	4.3	-	-	2.80	10.2
1972	5.74	11.7	-	-	8.39	14.2	1.32	4.9	-	-	5.96	8.0
1973	36.91	58.1	-	-	7.87	19.1	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	7.87	17.6	4.42	11.5	2.48	5.3	2.75	8.8	2.49	9.4
1978 <sup>3</sup>	7.89	19.3	3.62	10.7	6.97	21.5	1.31	4.8	7.55	22.1	4.66	11.9
1979 <sup>4</sup>	3.30	10.4	5.25	12.3	4.82	15.2	2.74	5.9	10.33	20.0	2.23	10.8
1980 <sup>5</sup>	4.96	15.3	10.39	15.0	2.36	6.2	1.74	5.7	3.85	8.3	5.71	13.1
1981	8.47	24.0	7.00	10.2	7.33	17.5	3.94	9.9	20.00	60.2	1.55	4.9
1982	6.44 <sup>6</sup>	14.1 <sup>6</sup>	-	-	-	-	3.20	8.6	-	-	-	-

<sup>1</sup> Spring surveys, 1973-1980, 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.

<sup>2</sup> Summer surveys on Georges Bank only include strata 13, 16, 19-25; summer surveys in the Gulf of Maine only include strata 26-28 and 37-40.

<sup>3</sup> Summer survey on Georges Bank in 1978 only sampled strata 13, 16, 19-20, 23-25.

<sup>4</sup> Summer survey in Gulf of Maine in 1979 only sampled strata 26-28 and 39-40.

<sup>5</sup> Summer survey on Georges Bank in 1981 only sampled strata 13, 16, 19-21, 23, and 25; summer survey in the Gulf of Maine only sampled stratum 26.

<sup>6</sup> Excludes unusually high catch of 1032 cod (4096 kg) at station 323 (strata tow 16-7).

Table 6. Estimates of instantaneous total mortality (Z) and fishing mortality (F)<sup>1</sup> for Georges Bank and Gulf of Maine Atlantic cod for four time periods, 1964-1981, derived from NEFC offshore spring and autumn bottom trawl survey data<sup>2</sup>.

Time period	Georges Bank						Gulf of Maine					
	Spring		Autumn		Average		Spring		Autumn		Average	
	Z	F	Z	F	Z	F	Z	F	Z	F	Z	F
1964-1967	-	-	0.73	0.53	0.73	0.53	-	-	0.51	0.31	0.51	0.31
1968-1972 <sup>3,4</sup>	0.45	0.25	0.49	0.29	0.47	0.27	0.46	0.26	0.53	0.33	0.50	0.30
1973-1977	0.80	0.60	0.57	0.37	0.69	0.49	0.73	0.53	0.55	0.35	0.64	0.44
1978-1981	0.55	0.35	0.63	0.43	0.59	0.39	0.54	0.34	0.61	0.41	0.58	0.38

<sup>1</sup> Instantaneous natural mortality (M) assumed to be 0.20.

<sup>2</sup> Estimates derived from:

Georges Bank spring:  $\ln (\Sigma \text{ age } 4+ \text{ for years } i \text{ to } j / \Sigma \text{ age } 5+ \text{ for years } i+1 \text{ to } j+1)$ .

Georges Bank autumn:  $\ln (\Sigma \text{ age } 3+ \text{ for years } i-1 \text{ to } j-1 / \Sigma \text{ age } 4+ \text{ for years } i \text{ to } j)$ .

Gulf of Maine spring:  $\ln (\Sigma \text{ age } 5+ \text{ for years } i \text{ to } j / \Sigma \text{ age } 6+ \text{ for years } i+1 \text{ to } j+1)$ .

Gulf of Maine autumn:  $\ln (\Sigma \text{ age } 4+ \text{ for years } i-1 \text{ to } j-1 / \Sigma \text{ age } 5+ \text{ for years } i \text{ to } j)$ .

<sup>3</sup> Georges Bank estimates for the 1968-1972 period did not include autumn 1971-1972 data (3+/4+) and spring 1972-1973 data (4+/5+) since these data gave negative Z values.

<sup>4</sup> Gulf of Maine estimates for the 1968-1972 period did not include autumn 1967-1968 data (4+/5+) and spring 1968-1969 and 1972-1973 (5+/6+) data since these data gave negative Z values.

Table 7. Relative average exploitation indices for Georges Bank and Gulf of Maine Atlantic cod derived from average annual total commercial landings (thousands of tons, live weight) and average annual spring and autumn NEFC offshore bottom-trawl survey catch (kg) per tow indices for four time periods, 1964-1981.

Time period	Georges Bank						Gulf of Maine					
	Commercial landings	Spring catch per tow <sup>1</sup>	Autumn catch per tow <sup>2</sup>	Relative Exploitation Index			Commercial landings	Spring catch per tow <sup>1</sup>	Autumn catch per tow <sup>2</sup>	Relative Exploitation Index		
	(A)	(B)	(C)	A/B	A/C	Mean	(D)	(E)	(F)	D/E	D/F	Mean
1964-1967	38.3	-	7.6	-	5.0	5.0	4.4	-	10.2	-	0.4	0.4
1968-1972	32.0	9.8	6.5	3.3	4.9	4.1	7.5	7.1	9.5	1.1	0.8	1.0
1973-1977	25.7	16.8 <sup>3</sup>	11.6	1.5	2.2	1.9	9.1	6.0	5.7	1.5	1.6	1.6
1978-1981	41.1	17.3	13.6	2.4	3.0	2.7	12.9	6.6	11.3	2.0	1.1	1.6

<sup>1</sup> Average spring values calculated for years  $i$  to  $j$ , viz.  $\sum_{i=1}^j \text{catch per tow}/n$  where  $n$  = number of years in time period

<sup>2</sup> Average autumn values calculated for years  $i-1$  to  $j-1$ , viz.  $\sum_{i=1}^{j-1} \text{catch per tow}/n$

<sup>3</sup> Spring 1973 stratified mean catch per tow of 24.5 kg was used (i.e. excluding strata tow 20-4 which had an anomalously high catch of 1894 fish weighing 2.56 tons).

Table 8. Percentage age composition (by number), by market category, of USA 1981 commercial length frequency samples of Atlantic cod from the Gulf of Maine (NAFO Division 5Y).

Market Category	No. of length frequency samples	No. of Fish Measured	Age										Total
			1	2	3	4	5	6	7	8	9	10	
Scrod	7	426	8.2	67.6	17.8	5.9	0.5	-	-	-	-	-	100.0
Market	6	553	-	13.4	36.5	35.1	11.0	2.7	0.9	0.4	-	-	100.0
Large	2	210	-	2.9	11.4	38.1	7.1	21.9	2.4	5.2	-	11.0	100.0

Table 9. Distribution of USA commercial landings (metric tons, live) of Atlantic cod from the Gulf of Maine (Area 5Y), by gear type, 1965-1981. 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.

Year	Landings (metric tons, live)						Percentage of Annual Landings					
	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	4.7	-	100.1
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	0.1	100.1
1969	6553	851	258	162	4	7828	83.7	10.9	3.3	2.1	0.1	100.1
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	0.1	99.9
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	-	0.4	99.9
1977	8415	2872	534	6	166 <sup>1</sup>	11993	70.2	23.9	4.5	0.1	1.4	100.1
1978	7958	3438	393	10	91 <sup>2</sup>	11890	66.9	28.9	3.3	0.1	0.8	100.0
1979	7567	2900	334	19	167 <sup>3</sup>	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	7710	3611	276	12	44	11653	66.2	31.0	2.4	0.1	0.4	100.1

<sup>1</sup>Of 166 tons landed, 107 tons were by mid-water pair trawl and 42 tons were by drifting gill nets.

<sup>2</sup>Of 91 tons landed, 56 tons were by Danish seine and 27 tons were by drifting gill nets.

<sup>3</sup>Of 167 tons landed, 119 tons were by drifting gill nets and 38 tons were by Danish seine.

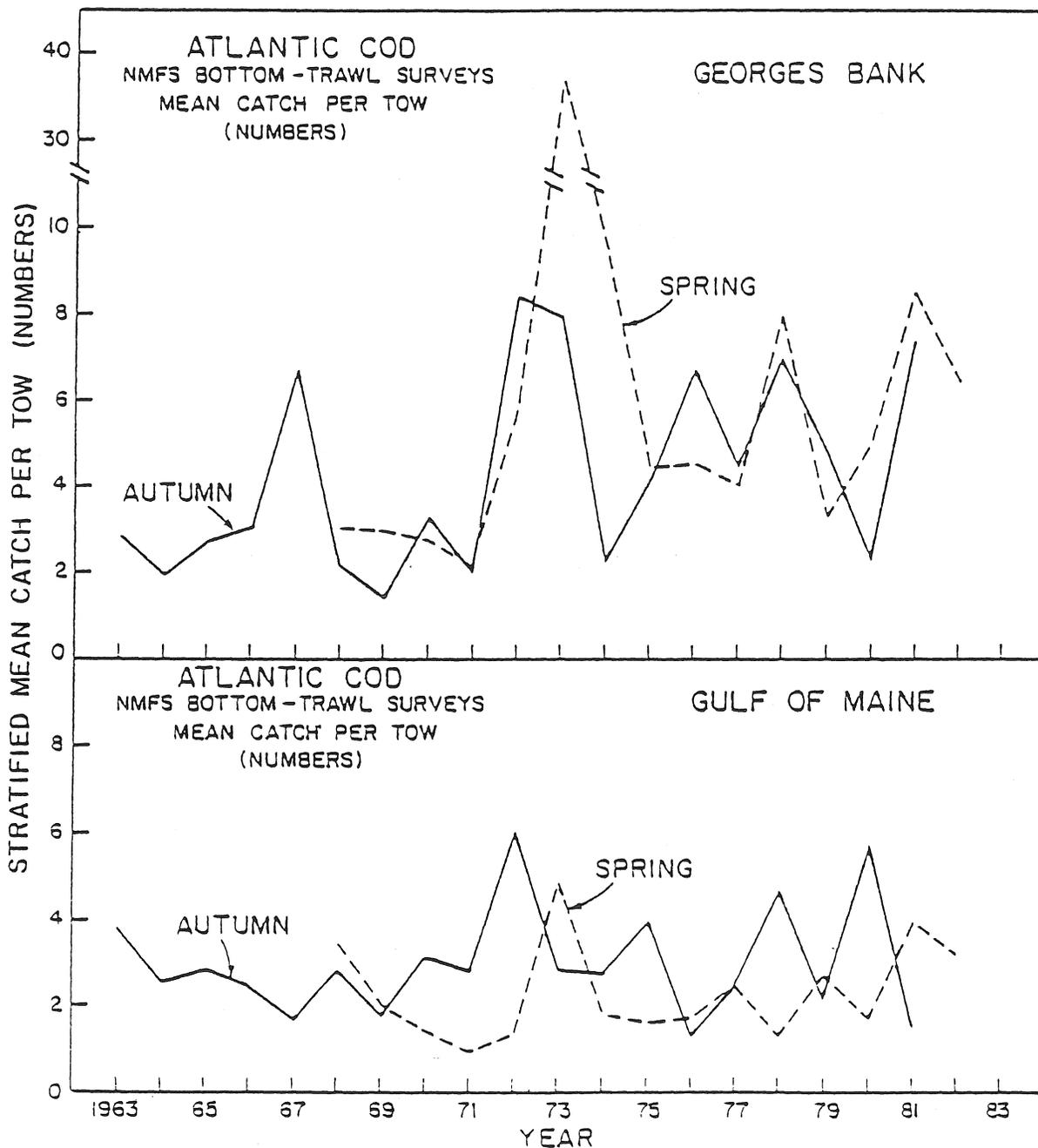


Figure 2. Stratified mean catch(number)per tow of Atlantic cod in NEFC spring and autumn off-shore bottom-trawl surveys on Georges Bank (strata 13-25) and in the Gulf of Maine (strata 26-30 and 36-40), 1963-1982.

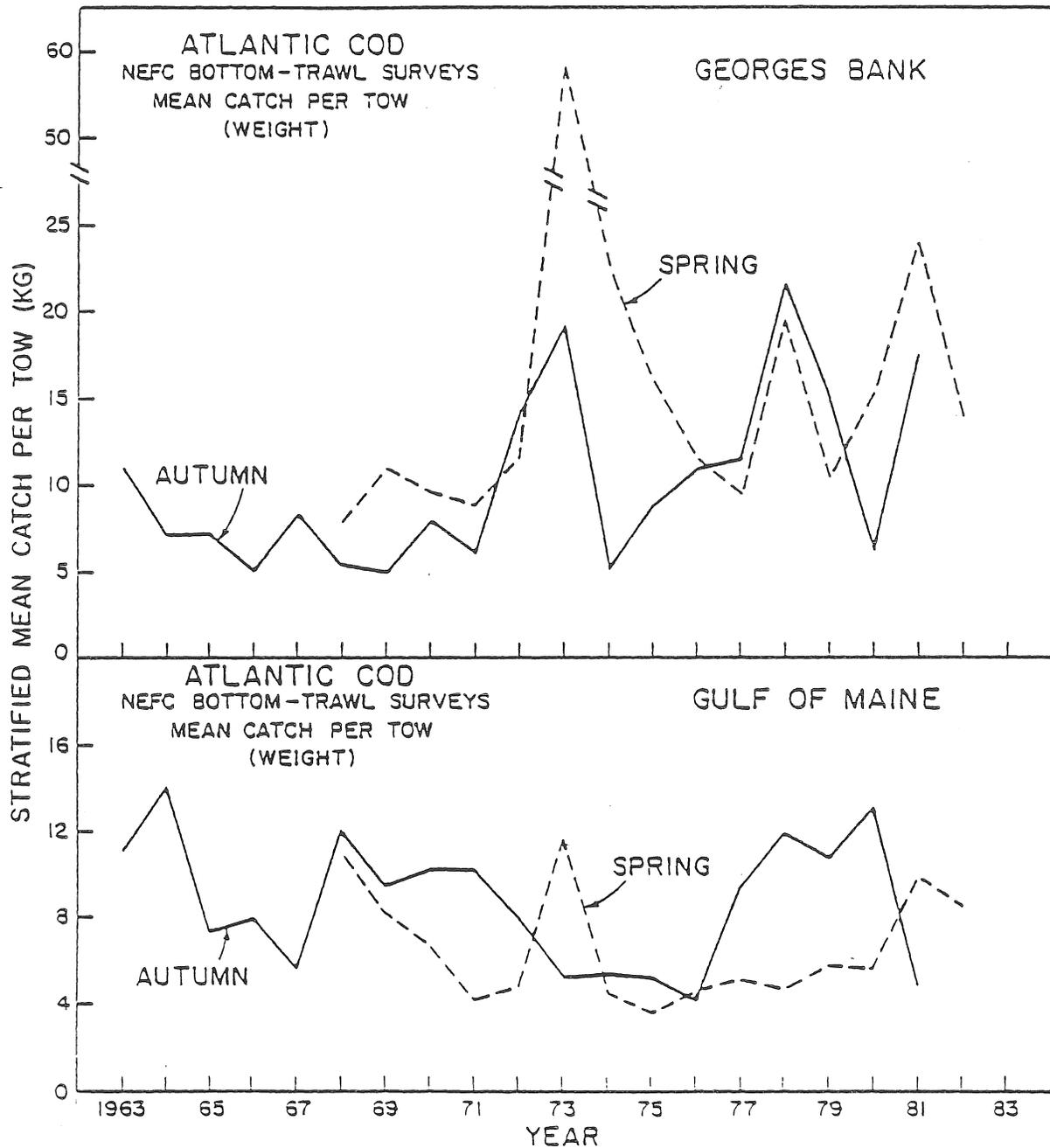


Figure 3. Stratified mean catch (weight in kilograms) per tow of Atlantic cod in NEFC spring and autumn offshore bottom-trawl surveys on Georges Bank (strata 13-25) and in the Gulf of Maine (strata 26-30 and 36-40), 1963-1982.

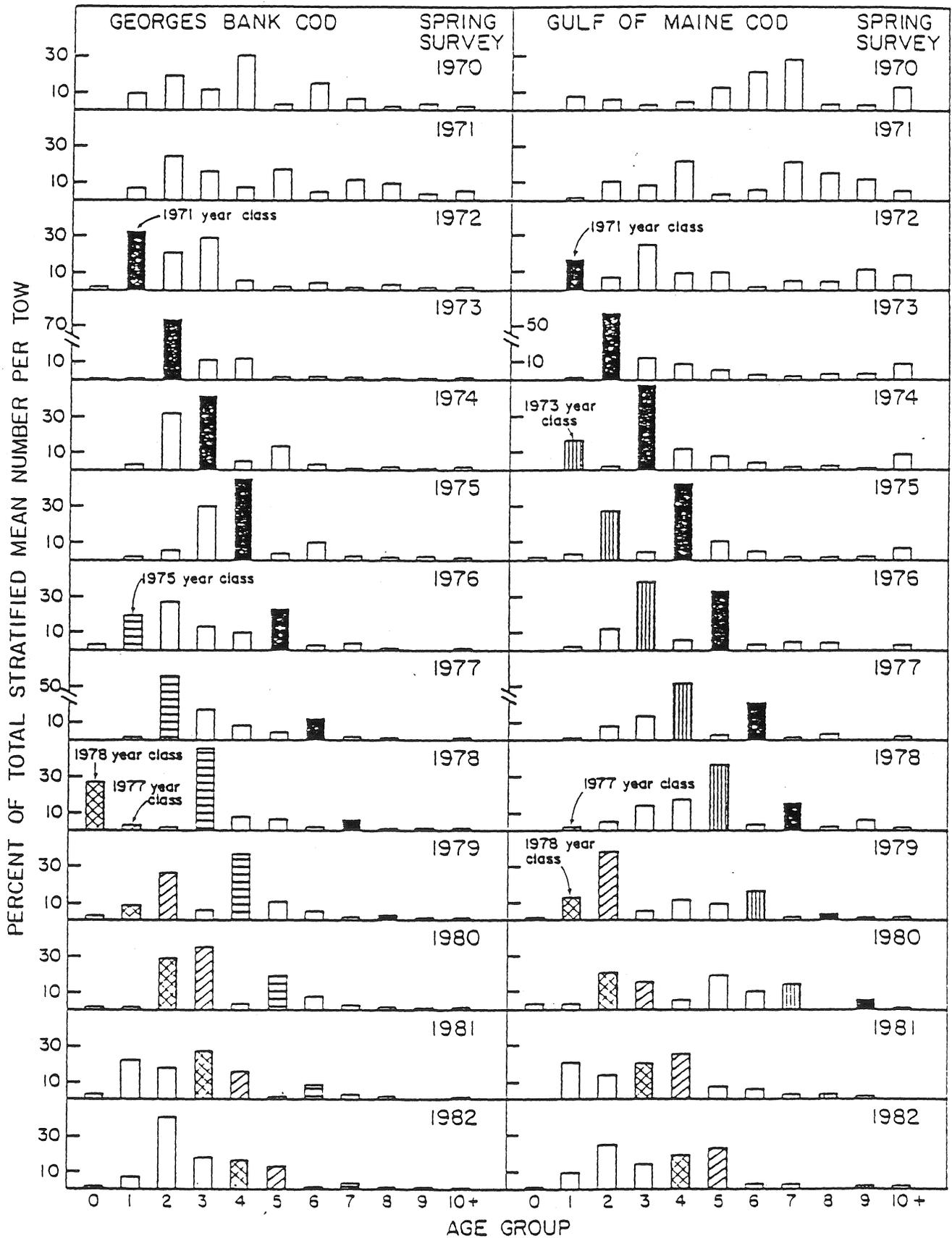


Figure 4. Relative age composition (percent by number) of Atlantic cod in NEFC spring offshore bottom-trawl surveys on Georges Bank (strata 13-25) and in the Gulf of Maine (strata 26-30 and 36-40), 1970-1982.

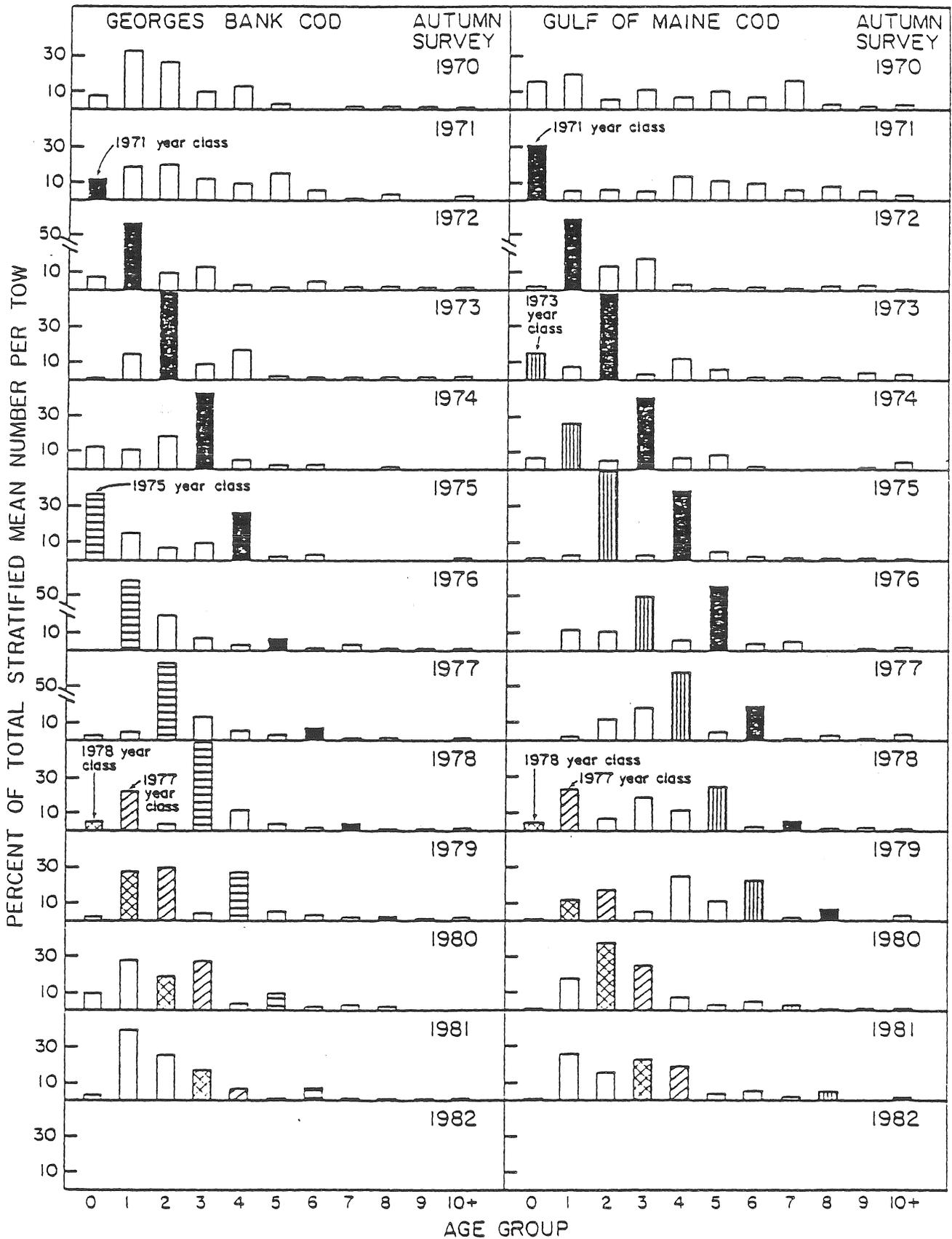


Figure 5. Relative age composition (percent by number) of Atlantic cod in NEFC autumn offshore bottom-trawl surveys on Georges Bank (strata 13-25) and in the Gulf of Maine (strata 26-30 and 36-40), 1970-1981.

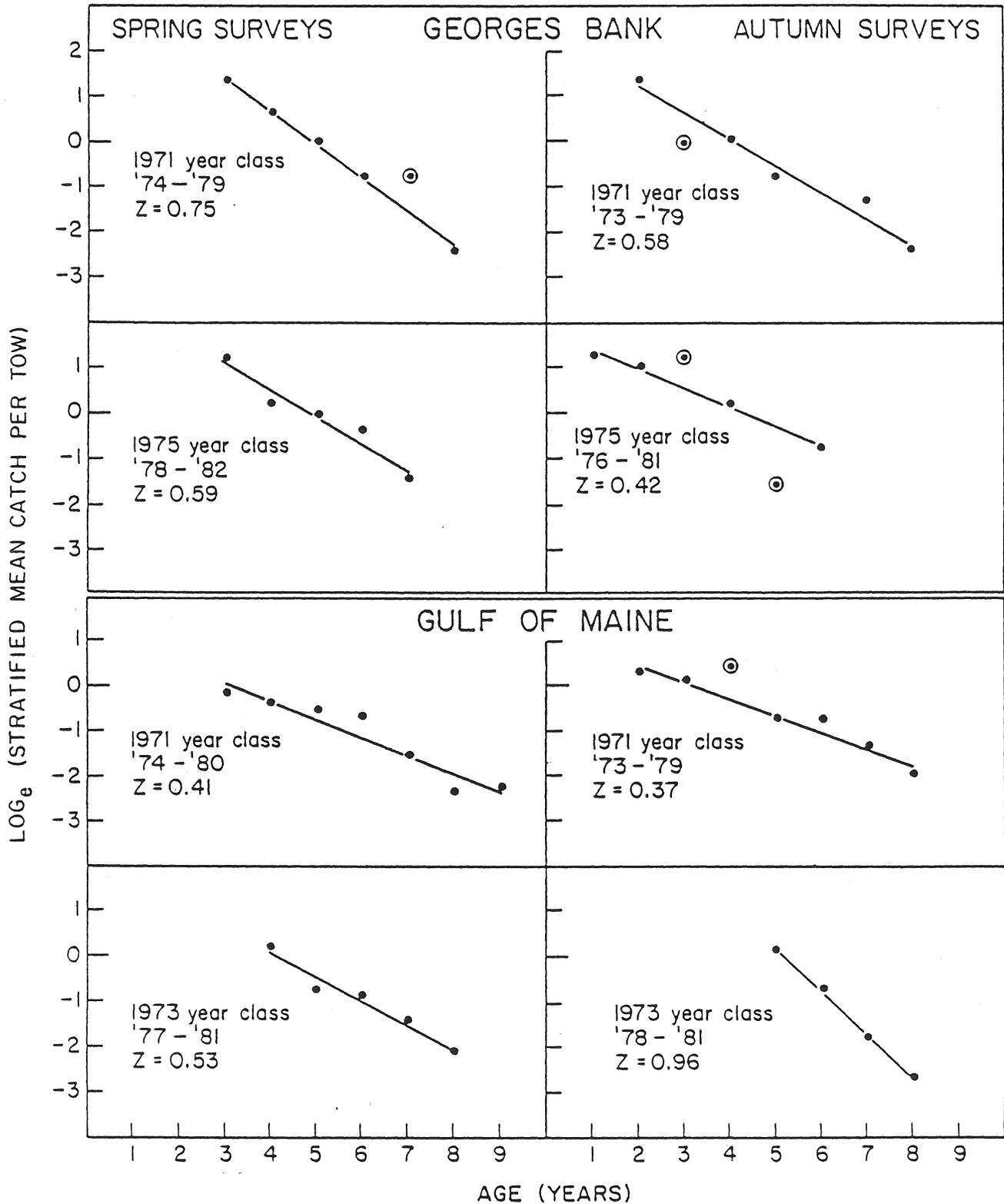


Figure 6. Catch curves for 1971 and 1975 year classes of Atlantic cod from Georges Bank and 1971 and 1973 year classes of Atlantic cod from the Gulf of Maine derived from analyses of NEFC spring and autumn offshore bottom-trawl survey data. (Circled points not used in calculations).

APPENDIX

Appendix Table 1. Stratified mean catch per tow at age (numbers) of Atlantic cod in NEFC offshore spring, summer, and autumn bottom trawl surveys on Georges Bank<sup>1</sup>, 1963-1982<sup>2</sup>.

Year	Age											Totals					
	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+
<b>Spring<sup>3</sup></b>																	
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	.153	.525	.322	.143	.575	.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	.036	.334	27.000	4.035	4.117	.418	.325	.244	.032	.126	.246	36.913	36.877	36.543	9.543	5.508	1.391
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	3.859	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	1.556
1981	.244	1.869	1.555	2.255	1.353	.081	.706	.218	.117	.000	.069	8.467	8.223	6.354	4.799	2.544	1.191
1982	.018	.407	2.620	1.146	1.059	.847	.013	.242	.053	.013	.028	6.446	6.428	6.021	3.401	2.255	1.196
<b>Summer<sup>4</sup></b>																	
1977	.131	.195	5.121	1.111	.660	.164	.326	.051	.081	.000	.026	7.866	7.735	7.540	2.419	1.308	.648
1978	.753	.350	.266	1.542	.369	.149	.057	.109	.000	.028	.000	3.625	2.870	2.520	2.254	.712	.343
1979	.236	1.459	1.767	.373	.943	.234	.050	.053	.115	.000	.031	5.261	5.025	3.566	1.799	1.426	.483
1980	2.646	.640	4.135	2.371	.064	.415	.092	.000	.031	.000	.000	10.394	7.748	7.108	2.973	.602	.538
1981	.024	3.347	1.657	1.224	.568	.035	.098	.048	.000	.000	.000	7.001	6.977	3.630	1.973	.749	.181
<b>Autumn</b>																	
1963	.012	.461	.499	.590	.575	.227	.209	.112	.066	.009	.044	2.804	2.792	2.331	1.832	1.242	.667
1964	.006	.410	.448	.377	.345	.093	.087	.040	.032	.109	.053	1.910	1.904	1.494	1.046	.669	.324
1965	.111	.833	.640	.453	.310	.107	.115	.072	.052	.015	.015	2.723	2.612	1.779	1.139	.686	.376
1966	.657	1.085	.641	.330	.169	.064	.061	.040	.025	.001	.011	3.084	2.427	1.342	.701	.371	.202
1967	.046	4.869	.855	.335	.260	.085	.085	.035	.033	.008	.045	6.656	6.610	1.741	.886	.551	.291
1968	.045	.201	1.033	.502	.174	.047	.043	.017	.015	.005	.031	2.113	2.068	1.867	.834	.332	.158
1969	.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	2.153	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																	

<sup>1</sup>Spring and autumn: Strata 13-25; summer: Strata 13, 16, 19-25.

<sup>2</sup>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.

<sup>3</sup>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.

<sup>4</sup>Summer survey in 1978 only sampled strata 13, 16, 19-20, 23-25. Summer survey in 1981 only sampled strata 13, 16, 19-21, 23 and 25.

Appendix Table 2. Stratified mean catch per tow at age (numbers) of Atlantic cod in NEFC offshore spring, summer, and autumn bottom trawl surveys in the Gulf of Maine<sup>1</sup>, 1963-1982<sup>2</sup>.

Year	Age											Totals					
	0	1	2	3	4	5	6	7	8	9	10+	0-	1+	2+	3+	4+	5+
<b>Spring<sup>3</sup></b>																	
1968	.082	.393	.791	.902	.542	.345	.133	.083	.071	.038	.106	3.486	3.404	3.011	2.220	1.518	.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	.685	.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	.307	.805	.446	.611	.760	.099	.094	.000	.035	.035	3.204	3.192	2.885	2.080	1.634	1.023
<b>Summer<sup>4</sup></b>																	
1977	.117	.090	.379	.275	.883	.108	.666	.039	.132	.000	.061	2.750	2.633	2.543	2.164	1.889	1.006
1978	.153	1.047	.718	1.216	1.455	2.054	.076	.687	.022	.074	.054	7.556	7.403	6.356	5.638	4.422	2.967
1979	.690	3.438	2.851	.441	.907	.609	1.073	.063	.145	.037	.074	10.328	9.638	6.200	3.349	2.908	2.001
1980	.350	.319	.715	1.419	.193	.384	.109	.233	.000	.066	.063	3.851	3.501	3.182	2.467	1.048	.855
1981	.000	3.031	6.253	3.368	4.148	.035	.400	.600	.000	.200	1.200	20.000	20.000	16.969	10.716	7.348	3.200
<b>Autumn</b>																	
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	1.535	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																	

<sup>1</sup>Spring and autumn: Strata 26-30 and 36-40; summer: Strata 26-28 and 37-40.

<sup>2</sup>Catch per tow at age values for 1965-1969 obtained by applying combined 1970-1981 age length keys to stratified mean tow at length distributions from each survey.

<sup>3</sup>Spring surveys during 1975-1981 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.

<sup>4</sup>Summer survey in 1979 only sampled strata 26-28, 39-40. Summer survey in 1981 only sampled stratum 26.

Appendix Table 3. 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, 1978-1982.

Year	Age											Totals				Stratified Mean Weight Per Tow (kg)
	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	
<u>Inshore of Georges Bank</u> <sup>1</sup>																
<u>Spring</u>																
1978 <sup>2</sup>	.000	.000	.000	.308	.000	.000	.000	.000	.000	.000	.000	.308	.308	.308	.308	0.37
1979 <sup>3</sup>	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 <sup>3</sup>	1.598	.363	.401	.683	.050	.605	.479	.092	.000	.000	.000	4.271	2.673	2.310	1.909	10.33
1981 <sup>3</sup>	5.653	.164	.593	.706	.379	.050	.264	.036	.018	.000	.000	7.863	2.210	2.046	1.453	8.18
1982	1.847	.832	4.514	.399	.201	.360	.008	.050	.008	.000	.000	8.219	6.372	5.540	1.026	7.90
<u>Autumn</u>																
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	.000	.364	.124	.878	.240	.954	.145	.042	.083	.000	.000	2.830	2.830	2.466	2.342	20.99
1981 <sup>3</sup>	.000	.484	.586	1.838	.817	.043	.647	.075	.123	.044	.094	4.751	4.751	4.267	3.681	24.98
1982																
<u>Lower Gulf of Maine</u> <sup>1</sup>																
<u>Spring</u>																
1978						Not Sampled							Not Sampled			
1979 <sup>4</sup>	.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 <sup>5</sup>	.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	7.524	20.154	6.592	2.599	.649	.235	.038	.000	.007	.000	37.528	37.528	30.274	10.120	28.18
<u>Autumn</u>																
1979 <sup>6</sup>	.189	8.319	1.417	.110	.349	.062	.015	.000	.000	.000	.000	10.461	10.272	1.953	.536	3.82
1980 <sup>6</sup>	.000	4.256	4.594	.434	.047	.032	.203	.000	.000	.000	.000	9.566	9.566	5.310	.716	9.88
1981 <sup>7</sup>	.200	.807	1.769	.501	.528	.022	.000	.000	.000	.000	.000	3.827	3.627	2.820	1.051	4.68
1982																

<sup>1</sup> Inshore of Georges Bank: Inshore strata 45-46, 55-56; Lower Gulf of Maine: Inshore strata 58-61, 63-66.

<sup>2</sup> Only strata 45-46 sampled.

<sup>3</sup> Only strata 45-46 and 55 sampled.

<sup>4</sup> Only strata 58-60, 64 and 66 sampled.

<sup>5</sup> Only strata 58-61, 64-66 sampled.

<sup>6</sup> Only strata 58-61, 65-66 sampled.

<sup>7</sup> Only strata 61 and 64-66 sampled.

Appendix Table 4. 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), 1978-1982.

Year	Age											Totals				Stratified mean weight per tow (kg)
	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	
<u>Georges Bank Area (Mass. Regions 1-3)<sup>1</sup></u>																
<u>Spring</u>																
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 <sup>3</sup>	31.453	.127	.047	.114	.011	.000	.000	.000	.011	.000	.000	31.763	.310	.183	.136	0.59
1982 <sup>3</sup>	13.303	.639	.201	.145	.131	.107	.002	.022	.002	.000	.019	14.571	1.268	.629	.428	2.17
<u>Autumn</u>																
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																
<u>Gulf of Maine area (Mass. Regions 4-5)<sup>2</sup></u>																
<u>Spring</u>																
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
<u>Autumn</u>																
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																

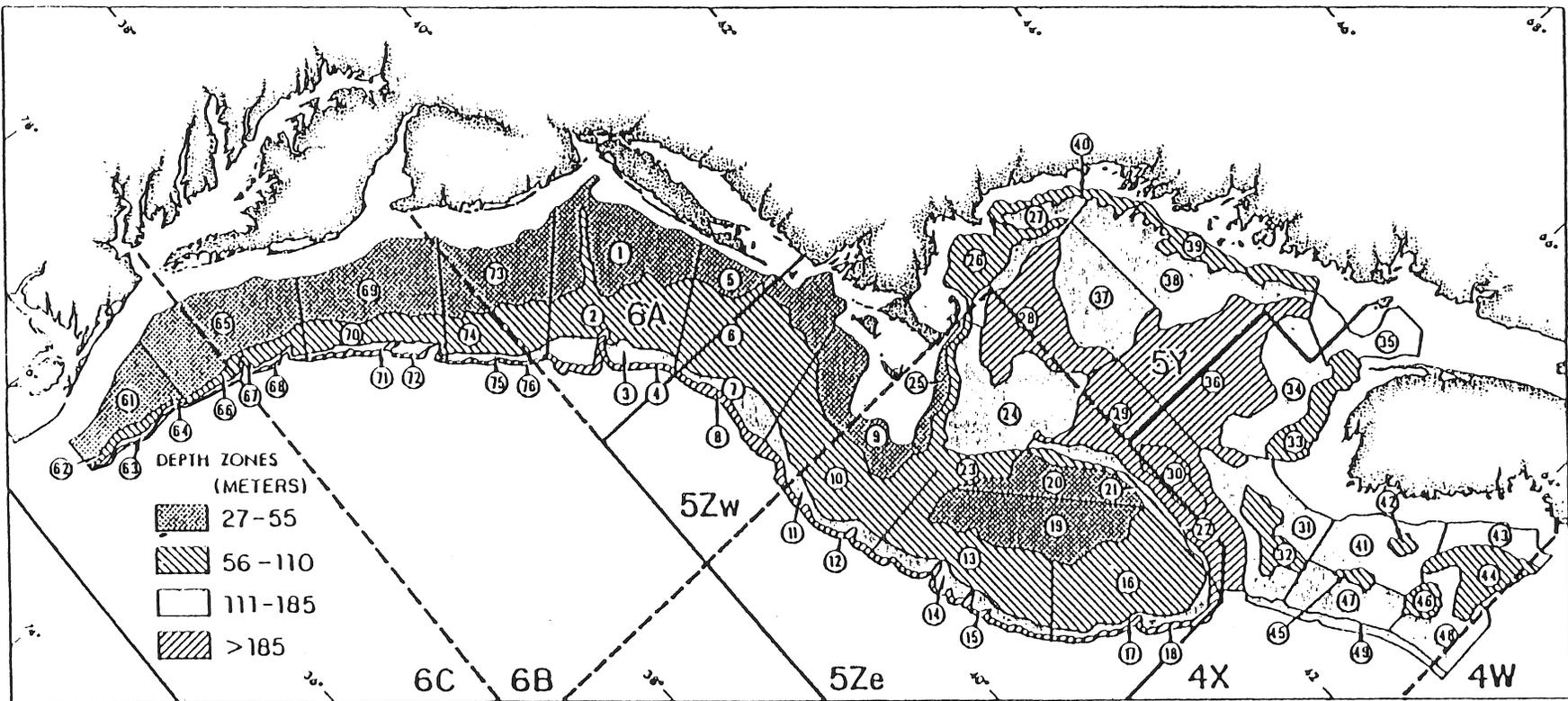
<sup>1</sup>Massachusetts strata 11-21.

<sup>2</sup>Massachusetts strata 25-36.

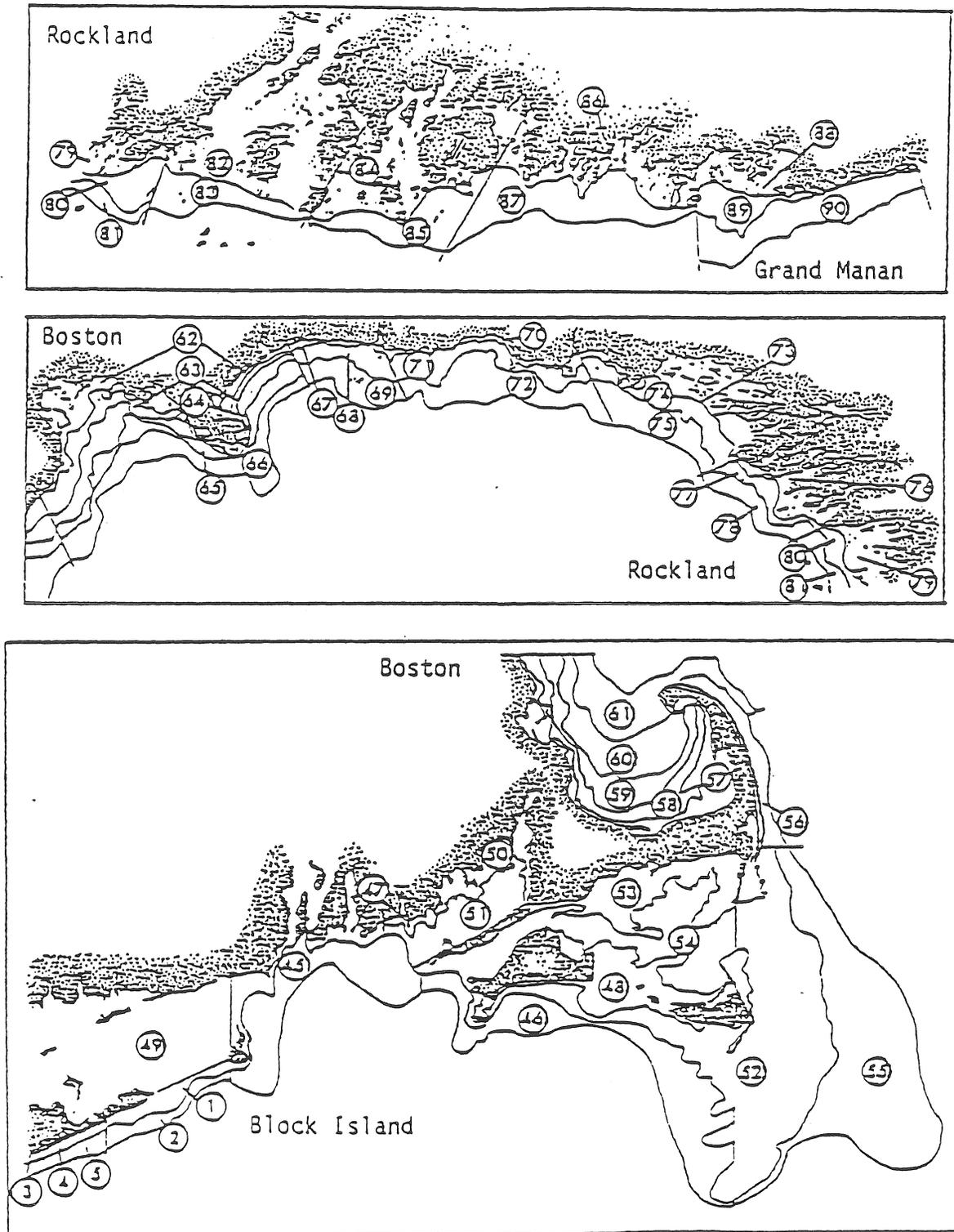
<sup>3</sup>Derived by applying NEFC spring 1982 age length key from Georges Bank to stratified mean number per tow at length.

App. Table 5. Stratified mean catch per tow at age (numbers) of Atlantic cod from USA summer inshore bottom trawl surveys in inshore waters adjacent to Georges Bank (Strata 45-56), in the lower Gulf of Maine (Strata 58-66), and in the middle and northern Gulf of Maine (Strata 68-90), 1977-1981.

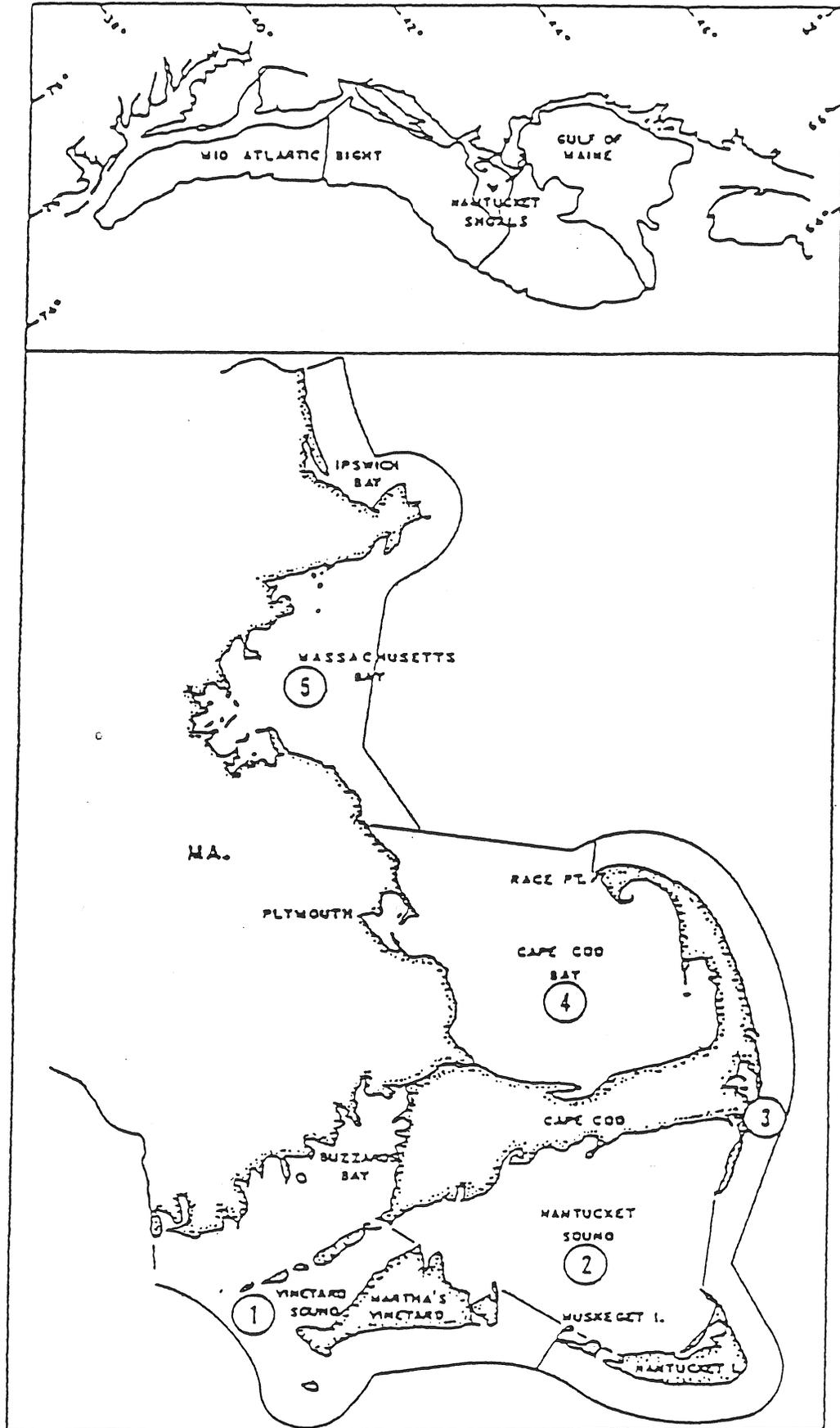
Year	Age											Totals						
	0	1	2	3	4	5	6	7	8	9	10+	0+	1+	2+	3+	4+	5+	
<u>Inshore of Georges Bank</u>																		
1977	.000	.695	1.580	.488	.291	.052	.128	.018	.007	.000	.000	3.259	3.259	2.564	.984	.496	.205	
1978	.164	.324	.507	.549	.002	.035	.000	.000	.000	.000	.000	1.581	1.417	1.093	.586	.037	.035	
1979	.000	.000	.000	.000	.000	.000	.000	.160	.000	.000	.000	.160	.160	.160	.160	.160	.160	
1980	.124	.719	.379	.425	.062	.281	.000	.000	.124	.000	.000	2.114	1.990	1.271	.892	.467	.405	
1981	No Cod Taken											.000	.000	.000	.000	.000	.000	.000
<u>Lower Gulf of Maine</u>																		
1977	.030	1.685	1.994	.627	.378	.056	.186	.004	.000	.000	.000	4.960	4.930	3.245	1.251	.624	.246	
1978	1.674	1.163	.938	.758	.400	.677	.010	.128	.019	.000	.000	5.767	4.093	2.930	1.992	1.234	.834	
1979	.598	1.369	1.027	.175	.779	.347	.416	.000	.000	.000	.000	4.711	4.113	2.744	1.717	1.542	.763	
1980	.510	9.298	3.042	.579	.033	.134	.011	.051	.000	.000	.080	13.738	13.228	3.930	.888	.309	.276	
1981	.626	2.087	.800	.509	.404	.000	.000	.000	.000	.000	.000	4.426	3.800	1.713	.913	.404	.000	
<u>Middle and Northern Gulf of Maine</u>																		
1977	1.106	1.329	2.809	1.393	1.919	.258	.711	.065	.065	.000	.000	9.655	8.549	7.220	4.411	3.018	1.099	
1978	1.133	.871	.249	.932	.791	1.195	.077	.419	.023	.008	.000	5.698	4.565	3.694	3.445	2.513	1.722	
1979	.121	1.334	1.433	.218	.136	.026	.102	.026	.000	.000	.000	3.396	3.275	1.941	.508	.290	.154	
1980	.986	4.216	2.949	1.579	.400	.651	.143	.465	.000	.086	.000	11.475	10.489	6.273	3.324	1.745	1.345	
1981	Not Sampled											Not Sampled						



Appendix Figure 1. Northeast Fisheries Center offshore ( $\geq 27\text{m}$ ) 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) are located in Region 4-5.