WOODS HOLE LABORATORY REFERENCE DOCUMENT NO. 82-32

GEORGES BANK AND GULF OF MAINE HADDOCK STOCK STATUS-1982

by

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APPROVED FOR DISTRIBUTION

(APPROVING OFFICIAL)

Oct 5, 1982

(DATE)

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SUMMARY

The Georges Bank and Gulf of Maine haddock fishery has increased considerably in importance in recent years. Improved recruitment led to an increase in total nominal catch of from 6,300 metric tons in 1976 to 35,000 tons in 1980; the provisional total for 1981 was 31,100 tons, and preliminary data for 1982 indicate a total of 21,400 tons.

The total nominal catch for Georges Bank increased from an annual average of 4,700 tons during 1974-1976 to 27,600 tons in 1980; the provisional total for 1981 was 24,600 tons, and preliminary data for 1982 indicate a total of 16,000 tons. Total nominal catches for the Gulf of Maine increased from 600 tons in 1973 to 7,500 tons in 1980; the provisional total for 1981 was 6,500 tons, and preliminary data for 1982 indicate a total of 5,400 tons. The Georges Bank fishery has been supported primarily by the 1975 and 1978 year classes since 1977, while the 1975 year class appears to have predominated in the Gulf of Maine.

The fishery has been dominated by the USA and Canada since 1975; since 1978, Canadian nominal catches have fluctuated between 5,400 tons and 10,800 tons, most of which have been taken on Georges Bank. Actual USA catches in recent years have been higher than reported due to discard and/or misreporting to circumvent landings restrictions imposed under the Fishery Management Plan for Atlantic Groundfish. Recent recreational catches have been small (400-500 tons in 1978).

Northeast Fisheries Center (NEFC) bottom-trawl survey data for Georges Bank indicate a sharp increase in abundance and biomass during the mid- to late 1970's. Since 1980, however, all indices have declined substantially. Trends for the Gulf of Maine in recent years as evidenced by NEFC offshore and inshore surveys have been generally similar. Results of Massachusetts inshore surveys are generally consistent with those from NEFC surveys. Estimates of fishing mortality (F) for Georges Bank for 1973-1981 derived from NEFC survey catch per tow have exceeded F_{max}, with mortality being highest on age 2 fish. Estimates for 1977-1981 are clearly incompatible with recruitment estimates for the 1975 and 1978 year classes and known removals at age and may reflect misreporting or unreported discard. Gulf of Maine data suggest lower, but increasing, levels of mortality, although estimates appear to have been biased to some extent by availability changes.

Recruitment for both stocks has fluctuated considerably. The 1975 and 1978 year classes on Georges Bank were strong ones (possibly comparable to some of the very strong year classes produced during the 1950's and early 1960's). The remaining year classes since 1975 appear to be substantially weaker than the long term (1935-1960) average. Recruitment trends for the Gulf of Maine have been generally similar, although the 1976 year class appears to have been relatively stronger and the 1978 year class relatively weaker than on Georges Bank.

Stock size estimates (age 2 and older) for 1982 are in the order of 40-50 million fish (63-70,000 tons), substantially below the long-term (1935-1960) average of 140 million fish or 153,000 tons. Similar results were achieved by applying a modification of the Delury method to commercial catch in numbers and bottom-trawl survey catch-per-tow data. This level compares closely to those observed on Georges Bank in the late 1960's when recruitment was poor and stock size was declining rapidly. Use of the modified Delury method on Gulf of Maine data provided essentially the same result, i.e., an estimated 1982 stock size comparable to that observed in the late 1960's and early 1970's. Catch and stock size projections for Georges Bank indicate continued declines in abundance and biomass for levels of F anticipated in the immediate future. If recruitment remains poor and fishing mortality exceeds F_{max}, a return to the very low levels of abundance observed in the early-to-mid-1970's will occur by the mid-1980's.

INTRODUCTION

The Georges Bank and Gulf of Maine haddock stocks are of major importance to the New England fishing industry. During 1935-1960, USA nominal catches (live weight equivalent of landings excluding discards; subsequently referred to as "landings") averaged 51,900 tons per year; strong recruitment and subsequent increases in exploitation by the USA and foreign nationals resulted in record total landings of 154,700 tons in 1965. Landings for 1966 totalled 127,000 tons. Subsequent poor recruitment, redirection of fishing effort to other stocks, and increasingly restrictive management under the International Commission for the Northwest Atlantic Fisheries or ICNAF resulted in a decline in landings to only 5,100 tons in 1974. In succeeding years recruitment improved and combined Georges Bank and Gulf of Maine haddock landings rose from 6,300 tons in 1976 to 35,000 tons in 1980; provisional statistics for 1981 indicate a total of 31,100 tons.

Recent assessments (Clark and Essig MS 1980; Clark et al. MS 1981) attributed recent increases in Georges Bank landings and stock abundance primarily to recruitment of the strong 1975 and 1978 year classes. The 1976, 1977, and 1979 year classes appeared to be much weaker. Thus, the recent Georges Bank fishery has been characterized by continued dependence on single strong year-classes, which have been heavily exploited upon recruitment at age two.

The present report assesses the current status of the Georges Bank and Gulf of Maine haddock stocks based on commercial and recreational landings data, biological sampling of commercial landings and research vessel survey data.

MANAGEMENT

Haddock in Northwest Atlantic Fisheries Organization (NAFO) Subarea 5 were managed by the New England Fishery Management Council (NEFMC) under the Fishery Management Plan (FMP) for Atlantic Groundfish from March 15, 1977 to March 30, 1982. Haddock management under this Plan for 1977-1980 has been reviewed previously (Clark et al. MS 1981). Final Supplement No. 4 to the FMP (effective September 1981) provided for USA commercial allocations of 17,675 tons for Georges Bank (NAFO Division 5Z[1]) and 7,575 tons for the Gulf of Maine (NAFO Division 5Y), a USA recreational allocation of 2,000 tons, and a Canadian allocation of 5,250 tons, for a total fishing year OY of 32,500 tons. Effective annual (calendar-year) quotas for the USA fishery for 1980 and 1981 were equivalent, since quarterly allocations have corresponded to these figures since October, 1979. Other FMP provisions included seasonal spawning area closures, a minimum codend mesh size regulation of 130 mm (5 1/8 inches), and mandatory data reporting requirements.

Attempts to manage haddock in mixed trawl fisheries led to a complex series of regulations which were frequently ignored or circumvented, resulting in underreporting of catches and seriously reducing the reliability of the commercial data base. As a result of this and other problems, the NEFMC has decided to pursue development of a comprehensive Atlantic Demersal Finfish Plan (ADF) for the groundfish complex. To provide the time necessary to develop the ADF, the Interim Plan for Atlantic Groundfish (NEFMC 1981) was developed and implemented under emergency regulations on March 31, 1982.

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[1]This management unit is considered to include NAFO Subarea 6, although haddock catches in that subarea have usually been negligible.

Under the Interim Plan, OY is defined as the amount of cod, haddock, and yellowtail flounder actually harvested by USA fishermen in accordance with other plan provisions, which include mesh regulations by area, seasonal spawning area closures, minimum possession sizes and a voluntary data reporting system. The Plan calls for an increase in codend mesh size from 130 mm (5 1/8 inches) to 140 mm (5 1/2 inches) (measurements based on synthetic twine or equivalent) after the Plan has been in effect for one year. Minimum sizes (total length) of 43 cm (17 inches) and 38 cm (15 inches) are specified for commercial and recreational haddock landings, respectively, the former corresponding to the 50% retention length of 130 mm trawl codends. Previous spawning area closures are maintained, with slight modifications. The Council recognized that the elimination of quota-based management assumed a certain element of risk, although it was noted that the stocks in question appeared strong enough to withstand the increased levels of fishing mortality expected under the Interim Plan.

COMMERCIAL AND RECREATIONAL FISHERY

Landings (Nominal Catch)

Georges Bank landings increased from an annual average of 4,700 tons during 1974-1976 to 27,600 tons (provisional statistics) in 1980; the provisional total for 1981 was 24,600 tons (Table 1, Figure 1). Preliminary data for 1982 indicate a total of 16,000 tons.

USA landings rose from 3,100 tons (annual average) in 1974-1976 to 18,900 tons in 1981. Canadian landings fluctuated between 5,200 tons and 10,200 tons during 1978-1981. No distant water fleet landings were reported from 1977-1980, but preliminary data for 1981 indicate an incidental Japanese catch of 3 tons on southwest Georges Bank (Window 5) during operations directed towards squid.

Trends for the Gulf of Maine have been generally similar, with total landings increasing from 600 tons in 1973 to 7,500 tons in 1980; the provisional total for 1981 was 6,500 tons (Table 1, Figure 1). Preliminary data for 1982 indicate a total of 5,400 tons. Most of the Gulf of Maine catch has been taken by the USA (94% from 1975-1981). No distant-water fleet landings of Gulf of Maine haddock have been reported since 1975 (Table 1).

It should be stressed that since 1976, actual USA catches have been much higher than reported USA landings (Clark et al. 1982, MS 1981). Interview data (corroborated by other industry sources) indicate that, due to the regulations imposed by the Groundfish FMP, substantial amounts of scrod[2] and snapper[2] haddock were routinely discarded and/or misreported as other species. The total amount involved appears to have been substantial, particularly in 1977 and 1980 when the strong 1975 and 1978 year classes recruited to the fishery (Clark et al. 1982, MS 1981).

Recreational catches of haddock in recent years have been relatively minor. A 1974 survey indicated a recreational catch of only 199 tons (Ridgely and Deuel MS 1976); while in 1978 the catch was in the order of 400-500 tons (Clark et al. 1982). Data are not available for subsequent years. Almost all of the recreational haddock catch is taken in the western Gulf of Maine (Nicholson and Ruais MS 1979).

Age Composition of Commercial Landings

Monthly length frequencies and age samples have generally been available for USA Georges Bank landings since the 1930's, and Canadian landings have also been sampled intensively in recent years. Length frequencies for the two countries have generally corresponded very closely[3], and accordingly USA

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[2]By convention, "large" haddock are those weighing more than 1.1 kg (gutted weight); "scrod" haddock range from 0.5 to 1.1 kg. "Snapper" haddock average 0.5 to 0.8 kg in commercial landings and are often discarded.

[3]Note that both countries have been subject to similar trawl mesh size regulations.

monthly length frequencies and quarterly age-length keys have been used to generate annual age compositions for USA and Canadian landings. Age compositions (percentages) of total landings for 1972-1981 are given in Figure 2 (see also Clark et al. 1982). Data for recent years cannot be taken as representative of total catch due to extensive USA discard, which would impact most heavily on estimates for younger age groups.

The recent fishery has been supported primarily by the 1975 and 1978 year classes. The 1975 year class was the first strong year class to appear since 1963 and accounted for 77% of the total number landed during 1977-1979. The 1978 year class (which appears to have been comparable in size) accounted for 54% of the total by number in 1980 and 63% in 1981 (through September). In contrast, the average maximum percentage contribution of any one year class during 1935-1960 was 44%, with ages 2-4 accounting for 80% of the catch in number (Clark et al. 1982). Since the 1975 year class in now much reduced and recruitment prospects for 1982 (discussed below) appear mediocre at best, the Georges Bank fishery is now primarily dependent on the 1978 year class (Figure 2).

Sampling of the Gulf of Maine landings has been much less extensive although trends in age structure appear to have been generally similar to those for Georges Bank. The 1975 year class was the first strong one to appear since 1963 and predominated in 1977-1979 samples, and the 1978 year class appears to have contributed to some extent in 1980-1981. However, landings by market category (percent by weight of scrod in commercial landings in 1980-1981; not shown) indicate substantially lower recruitment from the 1978 year class in the Gulf of Maine.

RESEARCH VESSEL SURVEYS

The Northeast Fisheries Center (NEFC) has conducted stratified random bottom-trawl surveys in offshore areas (>27 m) on Georges Bank and in the Gulf of Maine since summer of 1963; inshore areas from Cape Cod northward have been sampled since 1977. A "36 Yankee" trawl has been used in all surveys except for spring 1973-1981, when a modified "41 Yankee" trawl was used. Sampling intensity has been variable over time, with increased coverage of key strata in certain years to increase sampling precision. Additional coverage is also available for autumn of 1981 from gear comparison studies on Georges Bank. Indices of relative abundance and biomass (stratified mean catch per tow in numbers and weight in kg) have been developed using offshore spring, summer, and autumn bottom-trawl survey data for both areas (Tables 2 and 3, Figure 3, Appendix A), but as inshore survey catches of haddock have been sporadic south of Cape Cod and spring and autumn survey coverage has been limited, inshore indices have been derived only from Gulf of Maine summer survey data. Grosslein (1969), Azarovitz (1981), Byrne et al. (1981) and Clark (1981) provide detailed information on NEFC survey procedures, available time series of data, and application of these data to assessments (see Appendix B for stratification systems used).

NEFC Offshore Surveys

Data for Georges Bank reveal declines in abundance and biomass of approximately 90% between the mid-1960's and the early 1970's, followed by recovery to or above late-1960's levels (Table 2, Figure 3). The spring survey (weight) index rose from 5.4 kg per tow in 1975 to 35.7 kg in 1980, the highest value observed in the spring survey time series,

while the corresponding autumn survey index rose from 2.6 kg in 1974 to 26.9 kg in 1979, the highest value observed since 1965 (Table 2). Summer survey data, although available only for certain years, reveal similar trends. Stratified mean catch-per-tow-at-age data (Appendix A-1) and distributions of stratified mean catch per tow at length (Appendices B-3 and B-4) reveal that these increases resulted primarily from recruitment and growth of the 1975 and 1978 year classes.

Since 1980, all indices have declined substantially. Inclusion of data for additional stations sampled during autumn 1981 gear comparison tests resulted in no appreciable change in the corresponding survey index values for numbers and weight (10.0 fish and 11.5 kg, respectively, compared to 11.0 fish and 11.8 kg, Table 2). Catch-per-tow values for the 1979, 1980, and 1981 year classes have generally been low (Appendix A-1). Throughout the time series, trends for indices in terms of numbers have closely paralleled those derived in terms of weight (Table 2).

Trends for the Gulf of Maine have been generally similar, with spring and autumn survey indices declining to minimal levels in the early to mid-1970's, followed by increases in abundance and biomass due primarily to recruitment and growth of the 1975 year class (Table 3, Figure 3, Appendices A-2 , B-3 and B-4). Since 1978, the spring survey (weight) index has fluctuated without a definite trend, while the corresponding autumn survey index has declined (Table 3). The 1978 year class has been consistently weaker than the 1975 year class based on catch per tow at age (Appendix A-2). Remaining year classes (with the possible exception of the 1976 year class) again appear to be considerably weaker than the 1975 year class.

Mortality

Estimates of instantaneous total mortality (Z) were calculated from NEFC offshore spring and autumn survey data by pooling over fully recruited ages (age 2 in spring surveys and age 1 in autumn on Georges Bank; see Appendix A for details of calculations). Separate estimates were derived for (1) 1973-1976 and (2) more recent years, as estimates for briefer time intervals were too variable to establish meaningful trends.

Spring estimates for Georges Bank (Appendix A-1) declined in 1977-1980 compared to 1973-1976, while autumn estimates increased. Averages over seasons for age 2 and older fish agreed closely, however (0.79 for 1973-1976 and 0.81 for 1977-1981). Catch-curve analyses for the 1975 and 1978 year classes also indicate high mortality levels in recent years (0.77 and 0.92, respectively). Averages based on data for ages 3 and older were substantially lower than for ages 2 and older (0.47 and 0.60, respectively). These estimates suggest high fishing mortality (substantially above F_{max}=0.55) following recruitment to commercial gear at age 2, followed by a decline to between $F_{0.1}$ (=0.26) and F_{max} at ages 3 and older. These results are incompatible with recruitment estimates and reported rates of removal at age 2 for the 1975 and 1978 year classes and therefore indicate substantial additional mortality from unreported catches at age 2 (Clark et al. 1982). Assuming that instantaneous natural mortality (M)= 0.20, these results indicate that F approximated 0.30 for ages 3 and older in 1973-1976, the average obtained from virtual population analysis (VPA) of commercial catch-at-age data for these years (Clark et al. 1982).

Estimates of Z for the Gulf of Maine (age 2 and older) increased from 0.13 in 1973-1976 to 0.56 in 1977-1981, although the data of Appendix A-2 suggest that results may have been biased downward by availability changes

between years. More definitive conclusions cannot be drawn at present.

NEFC Inshore Surveys

NEFC inshore survey indices for the Gulf of Maine have fluctuated considerably since 1977, although the general trend has again been downward (Appendix A-3). Catch per tow at age 2 for the 1975 year class was the highest in the 1977-1981 time series, as was catch per tow at age zero for the 1980 year class, but remaining data indicate that other year classes since 1975 are relatively weak. These results are generally consistent with those observed for offshore surveys.

Massachusetts Surveys

The State of Massachusetts has conducted stratified random bottom-trawl surveys in inshore areas along the Massachusetts coast (Appendix B-5) during spring and autumn since 1978. Catch per tow and related information are available for these surveys through spring of 1981 (Howe et al. MS 1979; MS 1980; MS 1981; pers. comm.[4]). Indices of relative abundance and biomass have been developed only for the Gulf of Maine, as haddock catches in inshore areas of NAFO Division 5Z have been sporadic.

Results to date suggest recent increases in abundance and biomass during 1979-1980 (Appendix A-3). The 1979 and 1980 year classes appear comparable in size. Final results are currently unavailable for autumn 1981, although catches recorded during survey work were substantially lower than in 1980 and only three young-of-year fish were taken (Howe, pers. comm.[4]). These results agree closely with those obtained in NEFC

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[4]Sandwich, Ma., June, 1982.

inshore surveys (Appendix A-3). Such surveys will be of increasing value for future assessment applications, e.g., evaluation of recruitment (due to the predominance of age zero and 1 haddock in inshore survey catches) as the time series develops.

DISEASES AND PARASITES

Information on diseases and parasites of haddock is limited. Margolis and Arthur (1979) provide a summary of parasites from a variety of taxa (chiefly protozoans, nematodes, and copepods) known to infect haddock, but for most of these little information is available concerning degree of incidence or effects upon the host. The coccidian parasite Eimeria gadi, which infects the swimbladder of larger juveniles and adults, was found in 58% of the haddock examined from Emerald Bank (NAFO Division 4X) during 1973-1974 (Odense and Logan 1976), although a corresponding sample from Georges Bank indicated an incidence of only 4%. More recent data collected during NEFC spring and autumn bottom trawl surveys on Georges Bank also indicate a relatively low incidence (Despres-Patanjo, pers. comm.[5]). Heavy infestations have been found to completely occlude the swimbladder, presumably resulting in loss of buoyancy regulatory capacity and impairment of sound production (Odense and Logan 1976). Based on seasonal trends in incidence (e.g., observed seasonal declines in incidence of heavy infestations), and the degree of incidence observed, these authors inferred that significant mortality could result. Viral erythrocytic necrosis (VEN) has also been documented in haddock

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[5]Woods Hole, Ma., September, 1982.

(Murchelano, pers. comm.[6]) and again appears to be of potential significance. NEFC studies on these and other parasites and pathogens are continuing.

RECRUITMENT

Recruitment estimates for the Georges Bank stock have fluctuated considerably. The 1975 and 1978 year classes have predominated in recent years; the 1975 year class accounted for 85% by number of the total stratified mean catch per tow of age 2 and older fish in 1977-1979 spring and autumn surveys, while the 1978 year class accounted for 79% and 71%, respectively, of the corresponding spring and autumn catches in 1980-1981. Catch-per-tow-at-age data also suggest that these year classes were of comparable size (Appendix A-1).

Clark et al. (1982) estimated the 1975 and 1978 year classes to be strong ones (>75 million fish at age 2, compared to the 1935-1960 average of 61 million fish at age 2), although actual point estimates varied considerably due to differences in data sets and methods used. Recent updates of the virtual population analysis (VPA) by Clark et al. (1982) and industry sources have corroborated the relative strength of these year classes (e.g., the VPA estimate for the 1975 year class was 62 million fish at age 2 based on reported landings data for 1977-1981). Since large quantities are known to have been discarded and/or misreported since 1977 (see COMMERCIAL FISHERY), the implication is that both were at least equal to 75 million fish at age 2 and quite likely were larger. There is no basis for quantifying estimates for these year classes more precisely at present.

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[6]Oxford Laboratory, Oxford, Md., March, 1982.

The remaining year classes since 1975 appear to be substantially weaker than the long-term average. NEFC survey catch-per-tow values have been generally comparable to those observed for the very weak year classes during the late 1960's and early 1970's (Appendices A-1 and A-4). Catch per tow for the 1980 year class at age zero was among the highest observed in the 1953-1981 time series[7], and the calculated young-of-year index value (Grosslein MS 1969) of 2.8 was comparable to the observed average of 3.1 for 1975 and 1978 (Appendix A-4). Subsequent survey catches for this year class have been low, however (Appendices A-1, B-3, and B-4). Linear regressions between VPA year-class size estimates at age 2 for 1964-1974 (Clark et al. 1982) and NEFC spring survey catch per tow (age 1 and 2 combined) and autumn survey catch per tow (age 1) provide widely differing estimates (5 and 24 million fish, respectively, Figures 4 and 5). The distributions of data points in these regressions provide little basis for choice between either estimate, although the observed range appears realistic for predictive purposes (e.g., 10-20 million fish). In any case, this year class appears to be substantially weaker than the long-term average of 61 million fish. This result is supported by recent interview data collected at major ports.

The above results were unexpected given the initial apparent strength of the 1980 year class. Since 1953, young-of-year survey catches of the magnitude observed in 1980 have consistently been indicative of average to strong recruitment, and consequently there was previously no

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[7]Bottom-trawl surveys for young-of-year haddock have been conducted on Georges Bank since 1953; the present NEFC survey was initiated in 1963. Gear configuration and calculations of young-of-year index values have been standard throughout the time series although survey design has varied somewhat.

reason to suppose that recruitment would not be at least average in 1982 (see Clark et al. 1981). However, juvenile haddock do not appear to recruit fully to the survey gear until age 1 at the earliest (Appendix A-1) suggesting that young-of-year index values may be more subject to year-to-year availability changes than those for older fish. In the present case, the 1979-1980 winter on Georges Bank appears to have been moderate and spawning began much earlier than usual (early January). Also, larval abundance in the 1980 winter MARMAP survey was the highest observed since the time series began in 1973 (Smith et al. 1981). This implies that juvenile development could have been more rapid than usual, in turn resulting in increased availability and proportionally higher catches during the autumn 1980 survey. There is no supporting evidence from other sources to corroborate this hypothesis, e.g., mean lengths at age zero and 1 for this year class do not differ appreciably from values observed for other year classes.

Information on the strength of the 1981 year class is provided by NEFC summer and autumn 1981 and spring 1982 surveys. In each case, catch per tow for this year class was among the lowest in the time series (Appendices A-1, B-3 and B-4). Values were comparable to the observed 1967-1971 year-class averages (for which the average VPA year-class size estimate was 2 million fish). It is consequently anticipated that recruitment of age 2 fish (the 1981 year class) in 1983 will be poor. Similarly, there are preliminary indications from 1982 MARMAP ichthyoplankton surveys that the 1982 year class may also be poor.

Recent recruitment trends for the Gulf of Maine have been generally similar, although the 1976 year class appears to have been relatively stronger and the 1978 year class relatively weaker than on Georges Bank.

Catch per tow for the 1980 year class at age zero in the 1980 autumn survey was the highest observed since 1963, but subsequent catches have again been low (Appendix A-2). Since no young-of-year haddock were taken in the Gulf of Maine in autumn of 1981, it is concluded that recruitment for the Gulf of Maine in 1983 will be poor.

STOCK ABUNDANCE AND BIOMASS

Trends in stock abundance and biomass for Georges Bank for 1931-1981 have been reviewed by Clark et al. (1982, MS 1981). Stock size (age 2 and older) declined precipitously into the early to mid-1970's, but subsequently increased sharply with recruitment of the strong 1975 and 1978 year classes. Since 1980, stock size has again declined substantially as evidenced by NEFC spring and autumn survey catch per tow. Current values in terms of numbers and weight for autumn 1981 and spring 1982 are comparable to those observed in the late 1960's (Table 2), and the outlook appears analogous to those years as the fishery is being supported primarily by a single year class and recruitment prospects are poor.

As noted above, little reliance can be placed on commercial landings-at-age data for 1977-1981 needed for virtual population analysis. Since VPA stock size estimates for 1964-1974 and NEFC autumn survey indices correspond closely (Clark et al. MS 1981), stock size for 1982 was predicted based on a linear regression between VPA estimates in numbers (age 3 and older) and NEFC autumn survey catch per tow (age 2 and older) (Figure 6). An estimate of 30 million fish was obtained, which, using the above range of 10-20 million fish for the 1980 year class at age 2, implies a 1982 stock size of 40-50 million fish. Similar relationships (not shown) between VPA stock size estimates for age 2 and older

fish and corresponding NEFC spring and autumn survey catch per tow values provide estimates of 46 and 54 million fish, respectively.

An alternative calculation was also made using a modification of Delury's (1947) method (Collie and Sissenwine MS 1982). This method utilizes commercial catch in numbers and survey catch per tow at age to develop estimates of the survey catchability coefficient (q) and population size. The technique is based on the equation:

$$N(t+1)=(N(t)-C(t)+R(t))e^{(-M)} \quad (1)$$

which relates population size (N) in year t+1 to population size and recruitment (R), minus catch (C), in year t, all discounted by instantaneous natural mortality (M). By substituting n(t+1)/q for N(t+1), n(t)/q for N(t), and r(t)/q for R(t) where n and r are the survey catch per tow in numbers of fully recruited fish and recruits, respectively, and multiplying by q, the model:

$$n(t+1)=(n(t)-qC(t)+r(t))e^{-M}+\varepsilon(t) \quad (2)$$

is obtained ($\varepsilon(t)$ being an error term) from which q and stock size in numbers may be estimated. Stock size estimates (age 2 and older) obtained for Georges Bank for 1964-1976 (omitting recent years for which commercial catch in numbers is uncertain) correspond very well to VPA results reported by Clark et al. 1982 (Sissenwine and Collie MS 1982; see Figure 7). The 1982 estimated stock size of 46 million fish (obtained by applying the fitted value of q to 1981 autumn survey catch per tow) agrees well with the above estimates obtained by standard linear regression techniques.

It is concluded that stock abundance and biomass have declined to levels comparable to those observed in the late 1960's, substantially below the long-term (1935-1960) average of 140 million fish or 153,000

tons. Since recruitment from the 1980 year class appears mediocre at best and the 1981 year class appears to be poor, continued declines are anticipated in the foreseeable future. Current USA landings trends for Georges Bank appear to reflect this situation to some extent as landings for the first two quarters of 1982 (7,000 tons) were considerably lower than for the same period in 1981 (11,000 tons). Preliminary projections indicate a USA total of 12,000-13,000 tons for Georges Bank compared to 19,000 tons in 1981. Canadian landings data suggest a comparable decline, indicating a total 1982 harvest in the order of 16,000 tons.

Table 4 provides catch and stock size projections for Georges Bank for 1982-1985 for three recruitment options in 1982 (1980 year class assumed equal to 10, 15, and 20 million fish) assuming a catch of 16,000 tons in 1982 and exploitation at F_{max}=0.55 and $F_{0.1}$=0.26 in subsequent years. The 1982 estimate of 30 million fish was apportioned to ages based on autumn survey catch per tow at age in 1981. Recruitment in subsequent years was assumed equal to the 1967-1971 year class average of 2 million fish. Mean weights at age were taken as the observed 1979-1980 average in USA landings, and a partial selection coefficient of 0.75 was assumed for age 2 fish. Under this set of assumptions (which include all reasonable levels of F that might be expected) stock size declines substantially. It is concluded that if recruitment remains poor and F should remain near or above F_{max}, a return to minimal levels of abundance and biomass comparable to the mid-1970's situation would occur by the mid-1980's.

A VPA has not been performed for the Gulf of Maine, although in the present assessment stock size estimates for 1964-1976 have been derived based on Collie and Sissenwine's (MS 1982) approach. Total catch in numbers for 1964-1968 was estimated by dividing annual landings by USA

mean weights derived from commercial sampling. Sampling of Gulf of Maine landings was limited in 1969-1976 and accordingly USA mean weights for Georges Bank were used (a reasonable approximation since recruitment patterns were similar between these areas during 1964-1976). Although Gulf of Maine mean weights have generally been somewhat higher, the overall impact of this bias appears to be slight.

Results (Figure 7) are comparable to those obtained for Georges Bank, i.e., a precipitous decline in abundance to an apparent all-time low in the early 1970's followed by increased abundance in subsequent years. Application of the calculated value of q to 1981 autumn survey catch per tow provides a 1982 estimate of 9 million fish (or 14,000 tons, assuming an average weight of 1.5 kg per fish), comparable to levels observed in the late 1960's and early 1970's. It is concluded that, as for Georges Bank, abundance and biomass have declined to relatively low levels and, given poor recruitment prospects, these trends will continue at least until 1984.

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Table 1. Commercial landings[1] of haddock (metric tons, live) from Georges Bank and the Gulf of Maine, 1960-1981.

	Georges Bank					Gulf of Maine					Total				
Year	USA	Canada	USSR	Other[2]	Total	USA	Canada	USSR	Other[2]	Total	USA	Canada	USSR	Other[2]	Total
1960	40,800	77	--	--	40,877	4,541	383	--	--	4,924	45,341	460	--	--	45,801
1961	46,384	266	--	--	46,650	5,297	112	--	--	5,409	51,681	378	--	--	52,059
1962	49,409	3,461	1,134	--	54,004	5,003	107	--	--	5,110	54,412	3,568	1,134	--	59,114
1963	44,150	8,379	2,317	--	54,846	4,742	3	44	--	4,789	48,892	8,382	2,361	--	59,635
1964	46,512	11,625	5,483	466	64,086	5,383	70	--	--	5,453	51,895	11,695	5,483	466	69,539
1965	52,823	14,889	81,882	768	150,362	4,204	159	--	--	4,363	57,027	15,048	81,882	768	154,725
1966	52,918	18,292	48,409	1,655	121,274	4,579	1,125	--	--	5,704	57,497	19,417	48,409	1,655	126,978
1967	34,728	13,040	2,316	1,385	51,469	4,907	589	--	--	5,496	39,635	13,629	2,316	1,385	56,965
1968	25,469	9,323	1,397	4,734	40,923	3,437	120	--	--	3,557	28,906	9,443	1,397	4,734	44,480
1969	16,456	3,990	65	1,741	22,252	2,423	59	--	231	2,713	18,879	4,049	65	1,972	24,965
1970	8,415	1,978	103	804	11,300	1,457	38	--	67	1,562	9,872	2,016	103	871	12,862
1971	7,306	1,630	374	1,552	10,862	1,194	85	--	27	1,306	8,500	1,715	374	1,579	12,168
1972	3,869	609	137	1,118	5,733	909	23	4	--	936	4,778	632	141	1,118	6,669
1973	2,777	1,563	602	389	5,331	509	49	--	--	558	3,286	1,612	602	389	5,889
1974	2,396	462	109	1,323	4,290	622	198	--	9	829	3,018	660	109	1,332	5,119
1975	3,989	1,358	8	55	5,420	1,180	79	--	4	1,263	5,169	1,437	8	69	6,683
1976	2,904	1,361	4	--	4,324	1,865	91	--	--	1,956	4,769	1,452	--	59	6,280
1977	7,934	2,909	--	--	10,843	3,296	26	--	--	3,322	11,230	2,935	--	--	14,165
1978	12,160	10,179	--	--	22,339	4,538	641	--	--	5,179	16,698	10,820	--	--	27,518
1979	14,279	5,182	--	--	19,461	4,622	257	--	--	4,879	18,901	5,439	--	--	24,340
1980[3]	17,470	10,101	--	--	27,571	7,270	203	--	--	7,473	24,740	10,304	--	--	35,044
1981[3]	18,891	5,662	--	3	24,556	5,987	514	--	--	6,501	24,878	6,176	--	3	31,057

[1]As reported to ICNAF/NAFO for Divisions 5Z and 5Y, respectively (5 NK landings have been assigned to Division 5Z).

[2]Primarily Spain, Poland, and Romania.

[3]Provisional (incomplete).

Table 2. Stratified mean catch per tow in numbers and weight (kg) for haddock in NEFC offshore spring, summer, and autumn[1] bottom trawl surveys on Georges Bank, 1963-1982.

	Spring[2]		Summer[3]		Autumn	
	Nos.	Wt. (kg)	Nos.	Wt. (kg)	Nos.	Wt. (kg)
1963	--	--	76.65	29.49	97.34	52.83
1964	--	--	387.74	119.45	129.70	64.07
1965	--	--	261.65	156.05	68.26	48.20
1966	--	--	--	--	22.32	19.78
1967	--	--	--	--	11.88	16.87
1968	15.56	23.13	--	--	5.06	10.20
1969	8.26	19.05	6.46	12.95	2.28	5.59
1970	6.84	19.28	--	--	5.17	8.94
1971	3.18	5.62	--	--	2.83	3.70
1972	7.26	8.30	--	--	7.62	5.61
1973	25.23	10.18	--	--	9.98	6.48
1974	12.77	11.72	--	--	2.71	2.64
1975	4.18	5.44	--	--	20.78	10.00
1976	55.83	10.41	--	--	47.68	23.68
1977	24.74	17.60	49.29	42.90	19.02	23.13
1978	13.03	20.71	26.43	1.89	20.70	15.18
1979	30.53	13.09	55.56	25.28	42.74	26.87
1980	40.32	35.71	48.54	39.12	24.98	18.47
1981	25.53	31.95	14.00	13.12	11.01	11.77
1982[4]	12.53	18.70	--	--	--	--

[1]Spring and autumn, strata 13-25, 29, and 30; summer, strata 13, 16, and 19-25 (Appendix B-1).

[2]Data for 1968-1972 and 1982 adjusted by a factor of 1.7 to account for differences in surface area between the "36 Yankee" and the modified "41 Yankee" trawls (the "41 Yankee" was used in spring during 1973-1981).

[3]Sampling incomplete in 1978 and 1981 (7 strata sampled).

[4]Preliminary.

le 3. Stratified mean catch per tow in numbers and weight (kg) for haddock in NEFC offshore spring, summer, and autumn[1] bottom trawl surveys in the Gulf of Maine, 1963- 1982.

r	Spring[2]		Summer[3]		Autumn	
	Nos.	Wt (kg)	Nos.	Wt (kg)	Nos.	Wt (kg)
3	-	-	16.81	25.79	46.68	33.57
4	-	-	82.68	28.58	9.51	12.47
5	-	-	15.62	9.62	11.70	11.72
6	-	-	-	-	7.82	9.18
7	-	-	-	-	8.18	11.16
8	6.99	9.17	-	-	5.75	11.42
9	4.32	8.30	3.47	7.34	3.66	8.51
0	1.03	1.94	-	-	1.96	4.87
1	1.00	2.84	-	-	1.93	5.39
2	0.98	0.98	-	-	1.33	2.01
3	0.88	1.06	-	-	2.80	5.68
4	0.96	0.70	-	-	1.80	2.21
5	1.86	2.30	-	-	3.71	5.71
6	5.59	4.21	-	-	4.05	5.32
7	4.56	4.45	7.42	10.99	6.79	7.34
8	0.91	0.95	4.31	9.14	8.00	18.16
9	2.32	3.17	7.07	17.67	4.52	11.50
0	1.81	2.24	5.95	10.48	5.85	8.24
1	2.96	3.00	-	-	3.17	7.83
2[4]	3.13	4.08	-	-	-	-

ring and autumn, strata 26-28 and 36-40; summer, strata 26-28, 37, and 38 (Appendix B-1).

ta for 1968-1972 and 1982 adjusted by a factor of 1.7 to account for differences in rface area between the "36 Yankee" and the modified "41 Yankee" trawls (the modified 1 Yankee" was used in spring during 1973-1981).

mpling incomplete in 1979, and only one stratum (26) was sampled in 1981.

eliminary.

Table 4. Catch and stock size projections (000's tons) for Georges Bank haddock for 1983-1985 under differing mortality and recruitment options, assuming a catch of 16,000 tons in 1982 and F equal to $F_{0.1}$[1] and F_{max}[1] in subsequent years.

1982			1983			1984			1985
Stock[2] Biomass (000's tons)	F[3]	Catch (000's tons)	Stock Biomass (000's tons)	F[3]	Catch (000's tons)	Stock Biomass (000's tons)	F[3]	Catch (000's tons)	Stock Biomass (000's tons)
62.8 R_2=10	.31	16	52.2	$F_{0.1}$	11.5	44.4	$F_{0.1}$	9.7	36.4
				F_{max}	21.3	33.7	F_{max}	13.6	21.4
66.5 R_2=15	.29	16	56.6	$F_{0.1}$	12.6	49.1	$F_{0.1}$	10.7	40.1
				F_{max}	23.3	37.2	F_{max}	15.0	23.5
70.1 R_2=20	.27	16	60.9	$F_{0.1}$	13.6	53.8	$F_{0.1}$	11.7	43.8
				F_{max}	25.3	40.7	F_{max}	16.4	25.6

[1] $F_{0.1}$ = 0.26; F_{max} = 0.55.

[2] As predicted from linear regressions between VPA stock size and year-class size estimates in numbers and research vessel survey catch per tow (R_2 estimates refer to recruitment from the 1980 year class in millions of fish at age 2).

[3] At full recruitment.

LANDINGS (000's TONS)

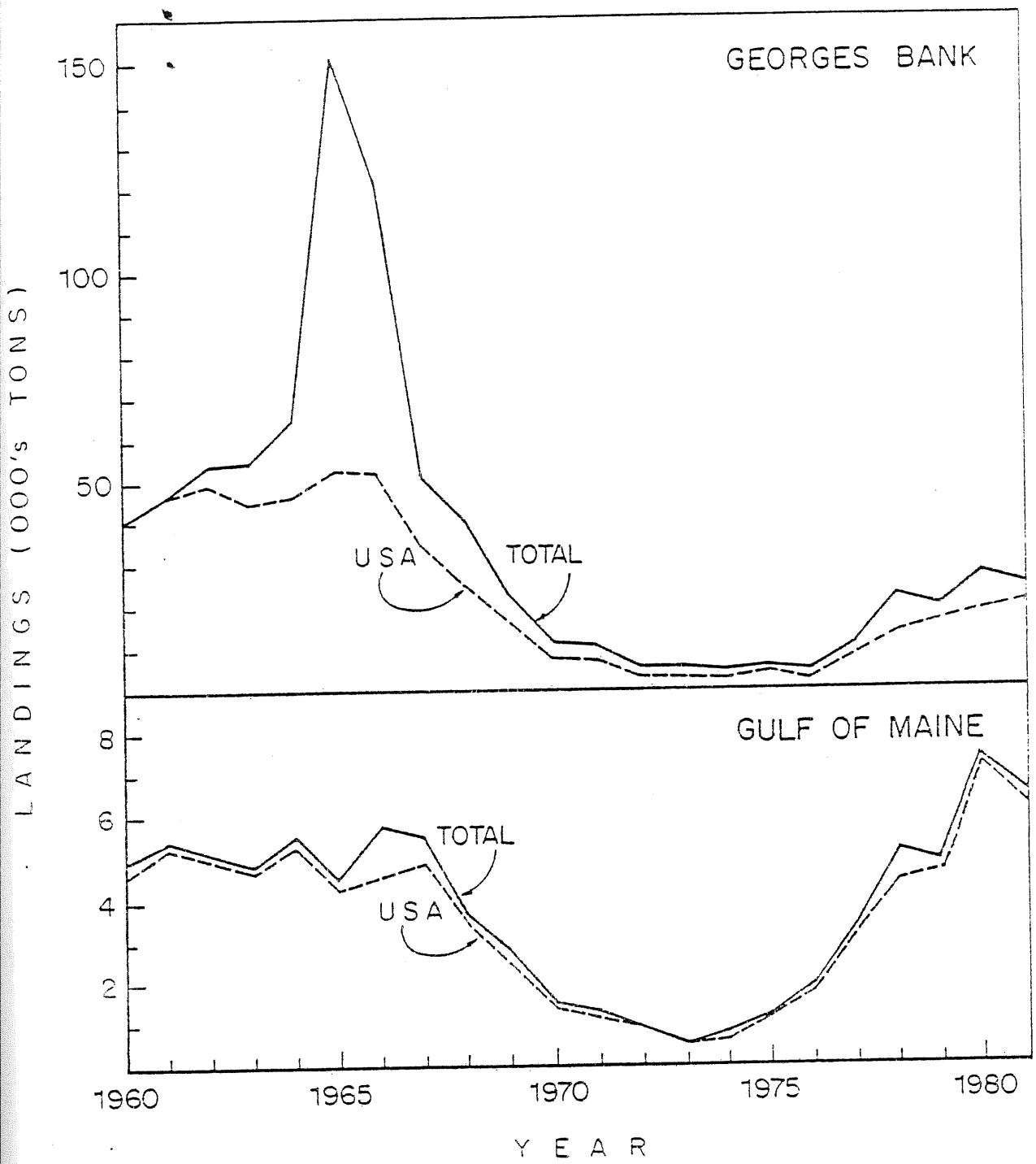


Figure 1. Commercial landings of haddock for Georges Bank and the Gulf of Maine, 1960-1981.

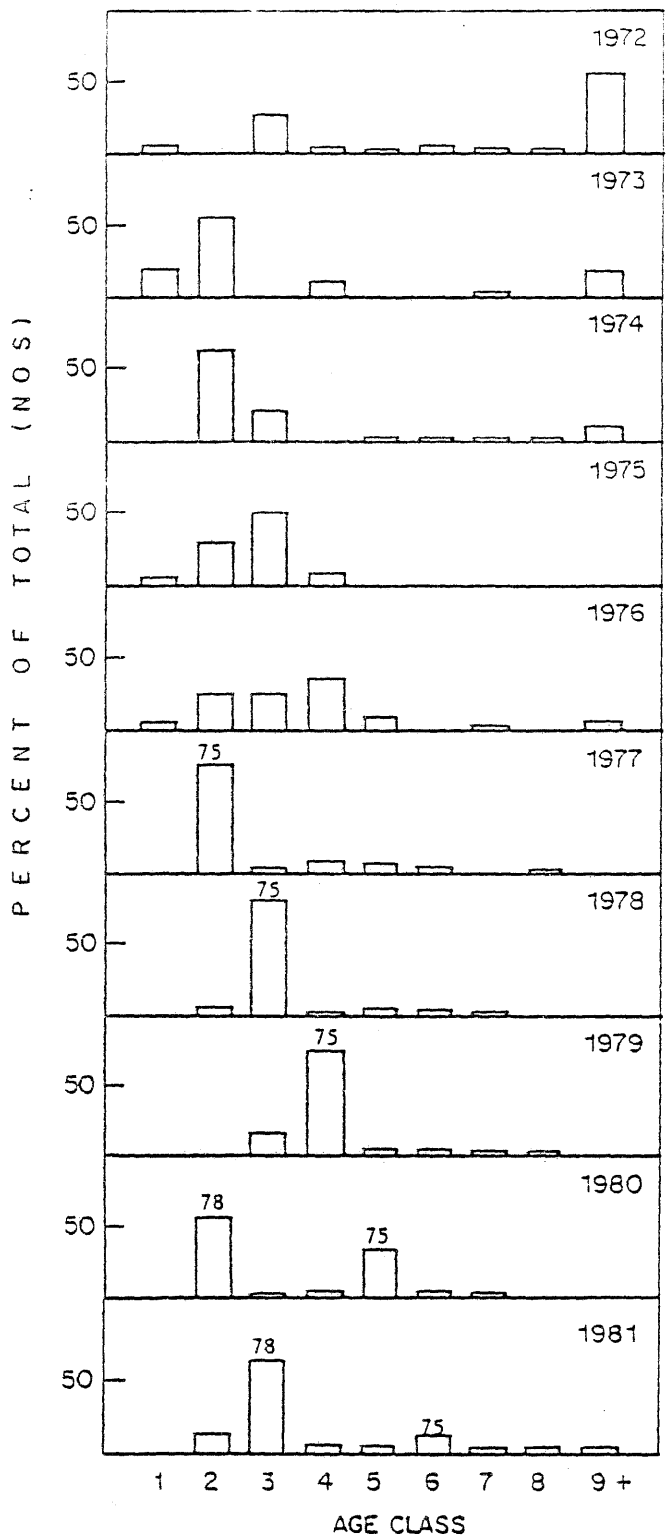


Figure 2. Age composition of commercial landings (percent by number) for Georges Bank haddock for 1972-1981.

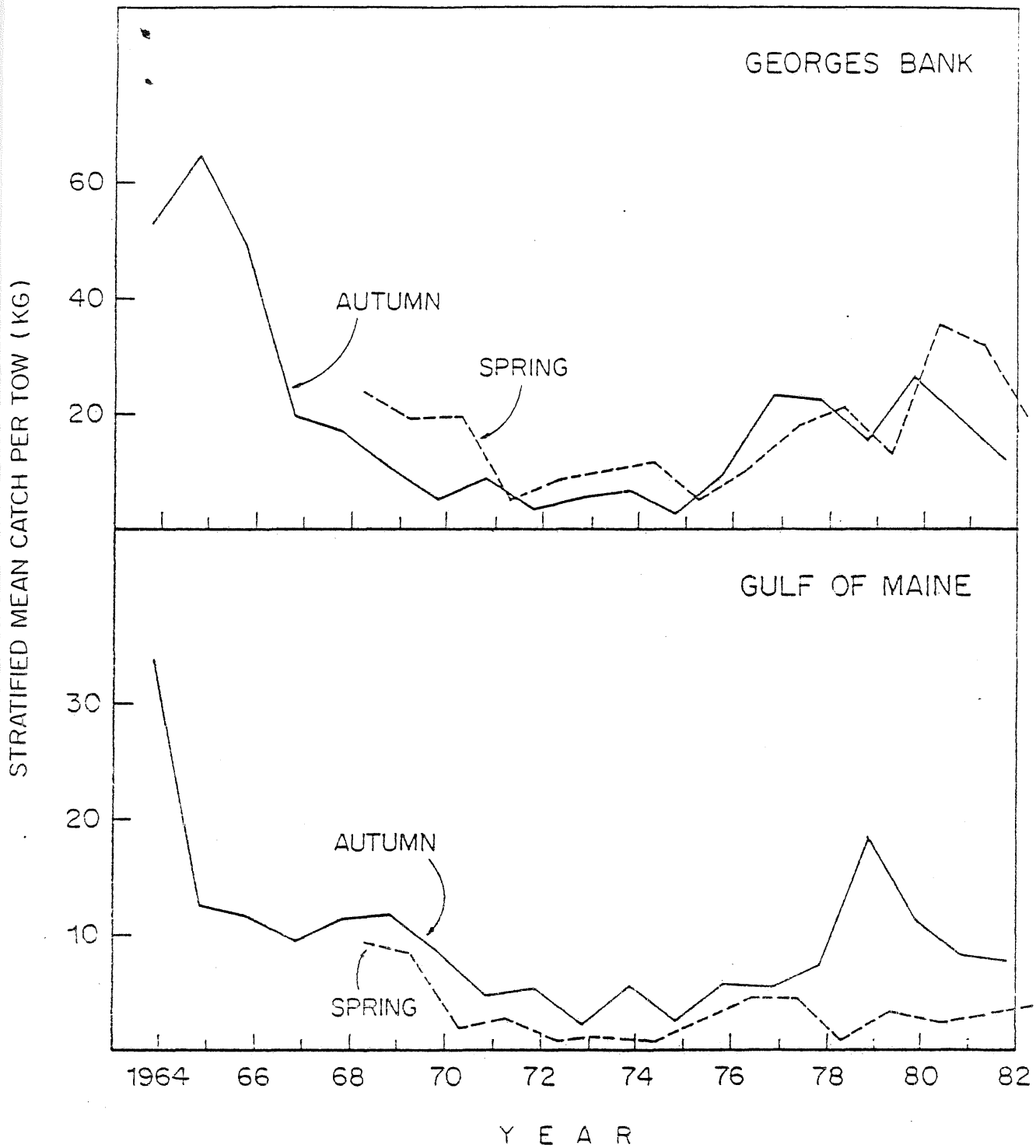


Figure 3. Stratified mean catch per tow (kg) of haddock in NEFC spring and autumn bottom trawl surveys on Georges Bank and in the Gulf of Maine, 1963-1982.

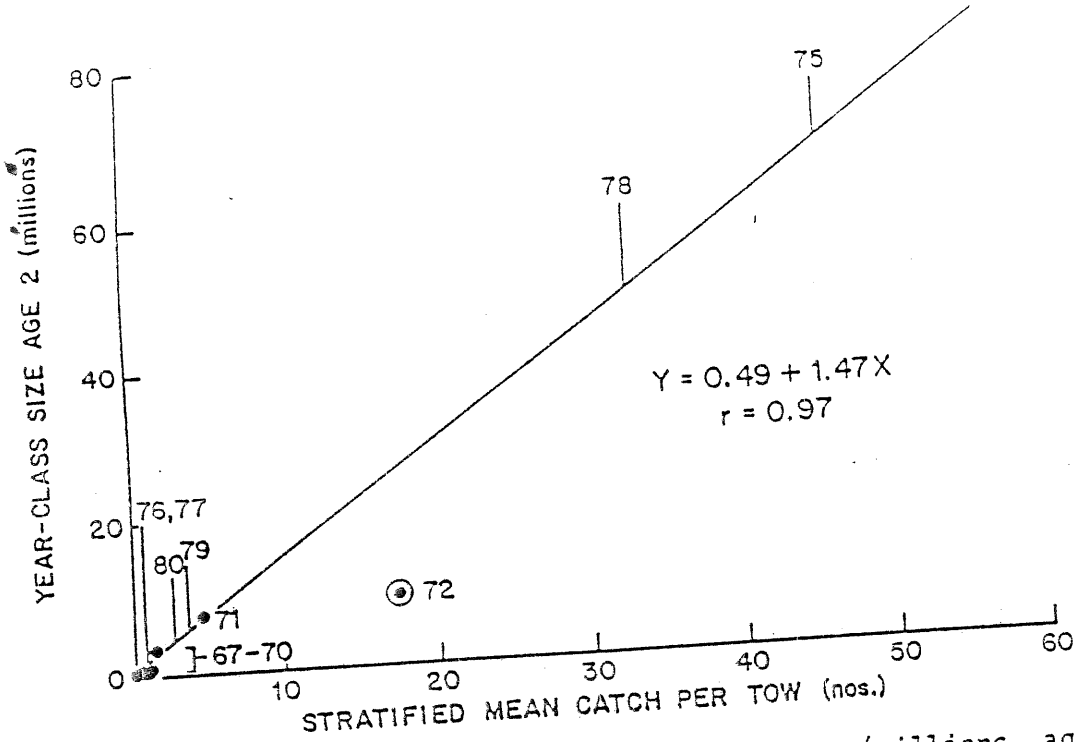


Figure 4. Relationship between year-class size (millions, age 2) calculated from virtual population analysis or VPA and NEFC spring survey catch per tow (numbers, age 1 and 2) for Georges Bank haddock. The 1972 point was not used in calculating the regression line. Survey data points were not adjusted to compensate for gear differences.

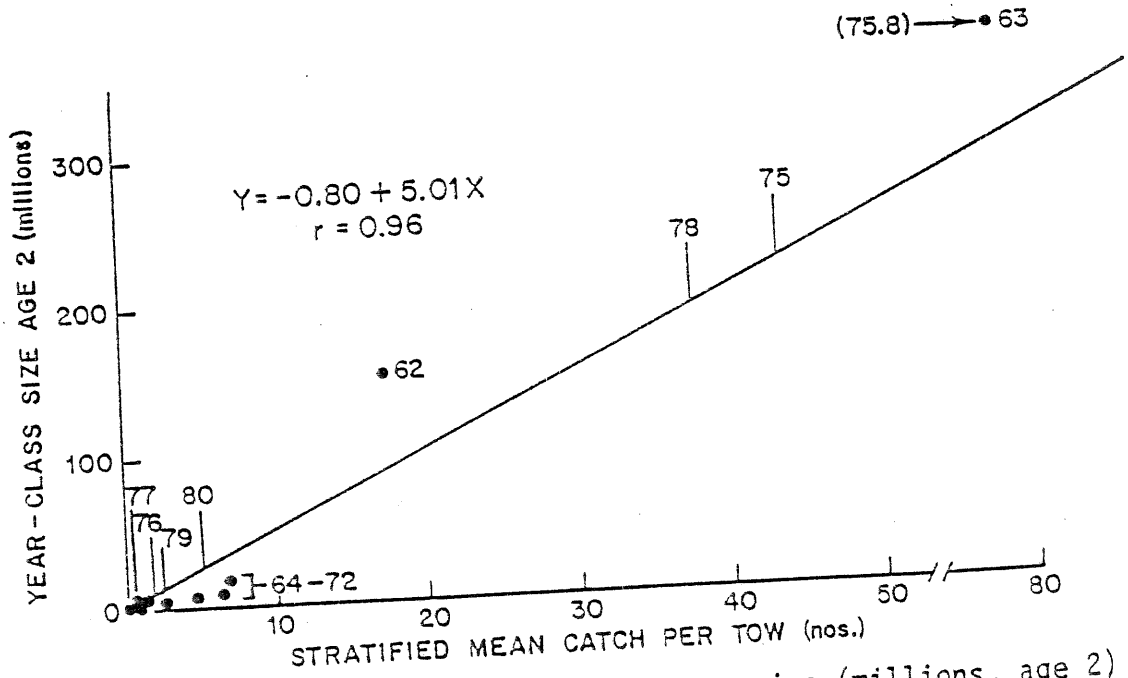


Figure 5. Relationship between year-class size (millions, age 2) calculated from virtual population analysis or VPA and NEFC autumn survey catch per tow (numbers, age 1) for Georges Bank haddock. Survey data are lagged one year.

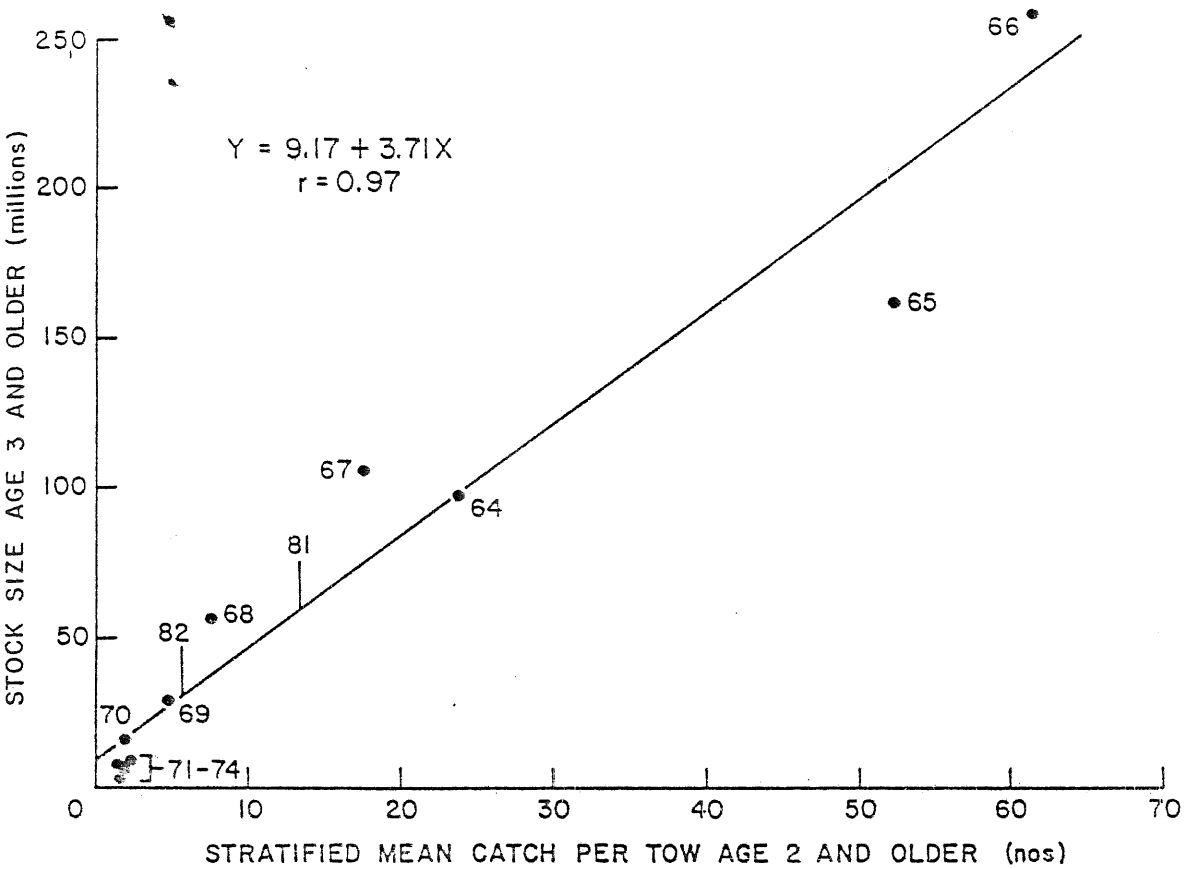


Figure 6. Relationship between stock size age 3 and older (millions) calculated from virtual population analysis or VPA and NEFC autumn survey catch per tow (numbers, age 2 and older) for Georges Bank haddock.

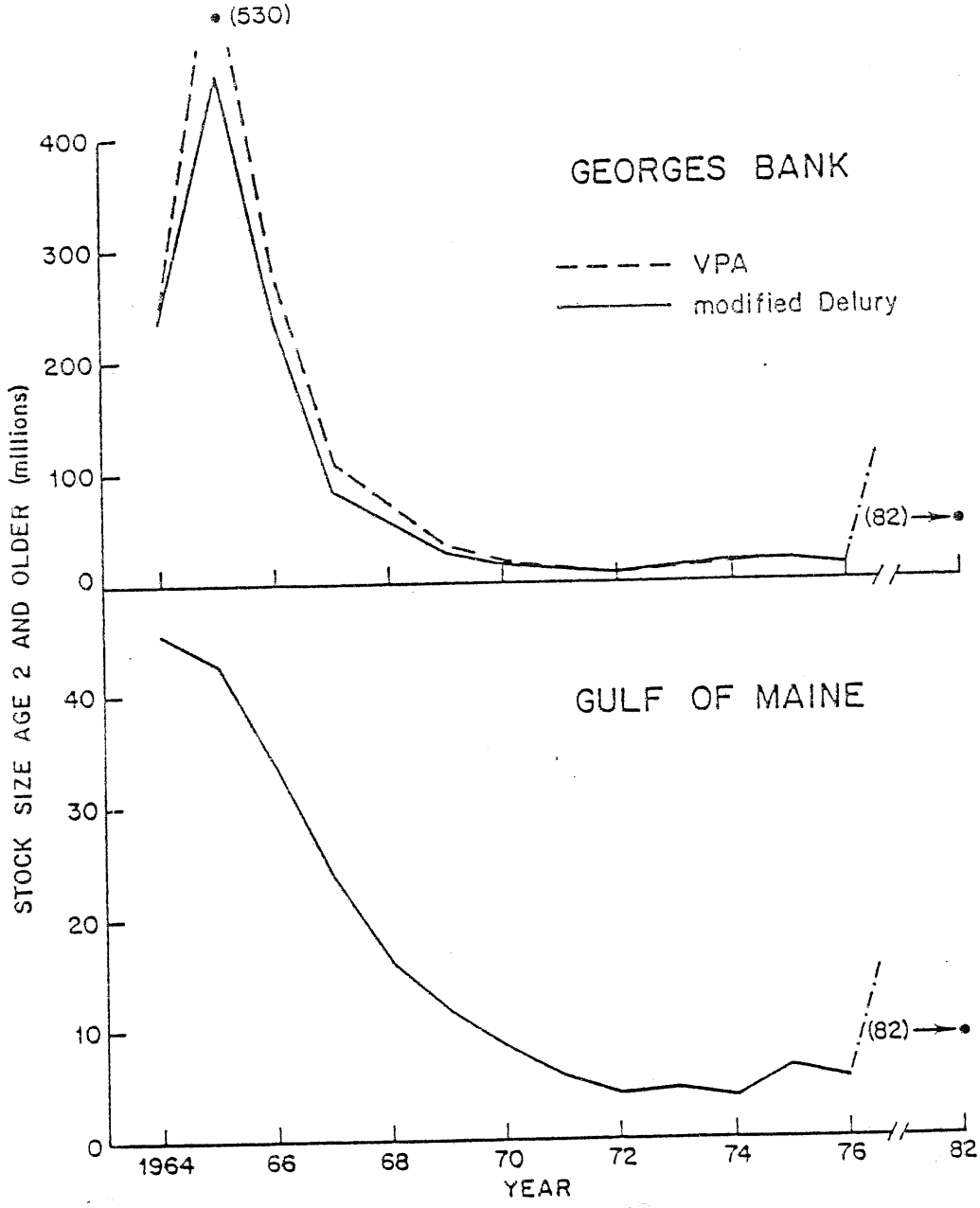


Figure 7. Stock size age 2 and older (millions) for Georges Bank and the Gulf of Maine calculated from the modified Delury method, 1964-1976 and 1982.

APPENDICES

Appendix A-1. Stratified mean catch per tow at age (numbers) for haddock in NEFC offshore spring, summer, and autumn[1] bottom trawl surveys on Georges Bank, 1963-1981.

Year	Age 0	1	2	3	4	5	6	7	8	9+	Totals 0+[2]	1+[2]	2+
Spring[3]													
1968	-	0.27	3.23	0.53	0.80	7.62	1.92	0.29	0.51	0.37	-	15.54	15.27
1969	-	0.02	0.05	0.66	0.17	0.48	4.83	1.17	0.32	0.52	-	8.22	8.20
1970	-	0.77	0.29	0.00	0.37	0.53	0.53	2.28	1.12	0.97	-	6.86	6.09
1971	-	0.00	1.33	0.29	0.00	0.14	0.14	0.10	0.94	0.26	-	3.20	3.20
1972	-	4.61	0.10	0.70	0.14	0.03	0.05	0.15	0.03	1.48	-	7.29	2.68
1973	-	20.59	3.25	0.00	0.36	0.06	0.00	0.12	0.01	0.86	-	25.25	4.66
1974	-	1.43	8.92	1.92	0.00	0.16	0.00	0.01	0.07	0.25	-	12.76	11.33
1975	-	0.63	0.65	2.23	0.42	0.00	0.09	0.06	0.01	0.10	-	4.19	3.56
1976	-	54.22	0.20	0.40	0.62	0.29	0.00	0.03	0.00	0.07	-	55.83	1.61
1977	-	0.41	22.42	0.28	0.82	0.40	0.30	0.00	0.03	0.08	-	24.74	24.33
1978	-	0.05	0.65	10.69	0.24	0.63	0.55	0.11	0.04	0.07	-	13.03	12.98
1979	-	24.24	1.06	0.76	3.83	0.22	0.11	0.25	0.04	0.03	-	30.54	6.30
1980	-	3.49	31.34	0.34	0.70	3.27	0.45	0.25	0.31	0.16	-	40.31	36.82
1981	-	2.70	2.69	15.95	1.79	0.62	1.46	0.20	0.09	0.04	-	25.53	22.83
Summer[4]													
1963	12.72	53.04	4.22	2.15	2.08	1.41	0.40	0.33	0.04	0.25	76.64	63.92	10.88
1964	24.89	320.27	36.61	1.31	0.89	2.02	1.29	0.18	0.13	0.15	387.74	362.85	42.58
1965	0.00	27.38	207.90	19.51	1.65	1.19	1.91	1.34	0.24	0.53	261.65	261.65	234.27
1969	0.74	0.31	0.02	0.51	0.08	0.17	3.40	0.89	0.09	0.25	6.46	5.72	5.41
1977	0.04	3.80	44.41	0.00	0.48	0.23	0.24	0.04	0.00	0.06	49.30	49.26	45.46
1978	25.16	0.11	0.40	0.69	0.01	0.01	0.01	0.01	0.00	0.02	26.42	1.26	1.15
1979	3.35	49.89	0.07	0.54	1.37	0.21	0.08	0.01	0.03	0.03	55.58	52.23	2.34
1980	1.09	5.93	40.23	0.22	0.15	0.87	0.01	0.02	0.00	0.01	48.53	47.44	41.51
1981	2.03	1.77	2.45	7.51	0.14	0.00	0.11	0.00	0.00	0.00	14.01	11.98	10.21
Autumn													
1963	56.33	17.04	6.19	4.57	5.60	3.99	1.37	1.13	0.79	0.31	97.32	40.99	23.95
1964	1.59	75.75	42.78	3.91	1.20	2.56	1.05	0.46	0.17	0.22	129.69	128.10	52.35
1965	0.22	6.82	51.94	6.51	0.72	0.54	0.61	0.54	0.17	0.18	68.25	68.03	61.21
1966	4.12	0.64	1.94	12.34	2.25	0.35	0.33	0.22	0.08	0.05	22.32	18.20	17.56
1967	0.02	4.51	0.24	0.67	4.54	1.09	0.33	0.14	0.22	0.12	11.88	11.86	7.35
1968	0.06	0.04	0.64	0.09	0.22	2.59	0.85	0.18	0.11	0.26	5.04	4.98	4.94
1969	0.26	0.02	0.00	0.19	0.09	0.11	1.02	0.34	0.06	0.18	2.27	2.01	1.99
1970	0.03	2.77	0.14	0.01	0.19	0.18	0.34	0.92	0.32	0.27	5.17	5.14	2.37
1971	1.63	0.00	0.21	0.05	0.01	0.15	0.02	0.06	0.50	0.19	2.82	1.19	1.19
1972	4.53	1.69	0.00	0.35	0.06	0.00	0.06	0.04	0.02	0.87	7.62	3.09	1.40
1973	2.17	6.04	1.08	0.00	0.13	0.03	0.00	0.05	0.01	0.48	9.99	7.82	1.78
1974	0.50	1.19	0.66	0.21	0.00	0.01	0.00	0.00	0.00	0.15	2.72	2.22	1.03
1975	15.76	0.42	0.48	3.26	0.62	0.00	0.02	0.00	0.01	0.20	20.77	5.01	4.59
1976	2.90	43.07	0.35	0.36	0.55	0.20	0.00	0.03	0.07	0.17	47.70	44.80	1.73
1977	0.11	1.75	15.33	0.46	0.47	0.52	0.28	0.03	0.01	0.07	19.03	18.92	17.17
1978	10.82	0.69	0.85	7.59	0.15	0.21	0.37	0.01	0.00	0.01	20.70	9.88	9.19
1979	1.08	37.29	0.03	0.74	3.12	0.21	0.23	0.04	0.01	0.00	42.75	41.67	4.38
1980[5]	9.56	2.22	10.41	0.37	0.15	1.39	0.39	0.38	0.07	0.05	24.99	15.43	13.21
1981	0.31	5.02	1.70	3.03	0.17	0.34	0.43	0.00	0.00	0.01	11.01	10.70	5.68

	Spring			Autumn			Means	
	Years	Age 2+	Age 3+	Years	Age 2+	Age 3+	Age 2+	Age 3+
Instantaneous[6] Total Mortality (Z)	1973-1976	0.90	0.76	1973-1976	0.69	0.29	0.79	0.47
	1977-1980	0.67	0.48	1977-1981	0.97	0.76	0.81	0.60

[1]Spring and autumn, strata 13-25, 29, and 30; summer, strata 13, 16, and 19-25.

[2]May not agree exactly with data in Table 2 due to rounding errors.

[3]Data for 1968-1972 adjusted by a factor of 1.7 to account for differences in surface area between the "36 Yankee" and the modified "41 Yankee" trawls (the modified "41 Yankee" has been used in spring since 1973).

[4]Sampling incomplete in 1978 and 1981 (7 strata sampled).

[5]Preliminary.

[6]Calculated by pooling over age groups, e.g. the spring 1973-1976 value for age 2 and older fish was calculated as $\ln\left(\frac{\Sigma \text{ age 2 and older for 1973-1976}}{\Sigma \text{ age 3 and older for 1974-1977}}\right)$, and the corresponding autumn value was calculated as $\ln\left(\frac{\Sigma \text{ age 1 and older for 1972-1975}}{\Sigma \text{ age 2 and older for 1973-1976}}\right)$.

ıdix 1. Stratified mean catch per tow at age (numbers) for haddock in NEFC offshore spring, summer, and autumn[1] bottom trawl surveys in the Gulf of Maine, 1963-1981.

	Age										Totals		
	0	1	2	3	4	5	6	7	8	9+	0+[2]	1+[2]	2+
ing[3]													
8	-	0.00	0.00	0.00	0.39	5.15	1.09	0.09	0.03	0.24	-	6.99	6.99
9	-	0.00	0.00	0.09	0.02	0.22	3.04	0.80	0.05	0.09	-	4.31	4.31
0	-	0.00	0.00	0.00	0.00	0.00	0.17	0.70	0.10	0.07	-	1.04	1.04
1	-	0.00	0.00	0.00	0.00	0.00	0.03	0.03	0.73	0.20	-	0.99	0.99
2	-	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31	-	0.97	0.31
3	-	0.09	0.53	0.00	0.04	0.00	0.00	0.00	0.00	0.23	-	0.89	0.80
4	-	0.60	0.06	0.22	0.00	0.00	0.00	0.00	0.00	0.09	-	0.97	0.37
5	-	0.01	1.32	0.10	0.25	0.00	0.01	0.00	0.00	0.17	-	1.86	1.85
6	-	3.46	0.05	1.24	0.12	0.61	0.00	0.02	0.00	0.09	-	5.59	2.13
7	-	0.59	2.39	0.02	0.90	0.27	0.39	0.00	0.00	0.00	-	4.56	3.97
8	-	0.06	0.47	0.21	0.04	0.10	0.03	0.00	0.00	0.00	-	0.91	0.85
9	-	0.25	0.00	1.08	0.80	0.06	0.08	0.06	0.00	0.00	-	2.33	2.08
0	-	0.87	0.12	0.14	0.36	0.28	0.02	0.00	0.00	0.03	-	1.82	0.95
1	-	0.89	1.07	0.40	0.13	0.26	0.07	0.05	0.02	0.08	-	2.97	2.08
mmer[4]													
63	0.71	2.51	1.72	1.70	4.41	3.16	1.28	0.64	0.42	0.79	17.34	16.63	14.12
64	0.06	57.27	14.63	3.91	1.37	2.62	0.90	0.91	0.19	0.31	82.67	82.61	25.34
65	0.00	5.12	7.17	0.86	0.15	0.67	0.66	0.48	0.07	0.46	15.64	15.64	10.52
69	0.00	0.00	0.00	0.00	0.00	0.06	2.23	0.56	0.22	0.40	3.47	3.47	3.47
77	0.00	1.32	3.50	0.35	1.13	0.49	0.33	0.04	0.00	0.25	7.41	7.41	6.09
78	0.00	0.00	1.05	1.49	0.70	0.36	0.57	0.07	0.00	0.08	4.32	4.32	4.32
79	0.92	0.76	0.10	1.00	2.56	0.46	0.53	0.18	0.00	0.56	7.07	6.15	5.39
980	0.18	1.04	1.93	0.42	1.20	0.83	0.13	0.11	0.00	0.11	5.95	5.77	4.73
981	-	-	-	-	-	-	-	-	-	-	-	-	-
utumn													
1963	23.90	8.18	1.14	2.02	4.66	3.31	1.12	0.88	0.70	0.74	46.65	22.75	14.57
1964	0.02	2.99	1.87	0.48	0.82	1.62	0.96	0.32	0.22	0.21	9.51	9.49	6.50
1965	0.04	0.25	5.39	3.40	0.17	0.98	0.77	0.44	0.21	0.04	11.69	11.65	11.40
1966	0.01	0.03	0.37	4.86	1.60	0.18	0.41	0.29	0.04	0.02	7.31	7.80	7.77
1967	0.00	0.00	0.20	0.83	5.37	1.21	0.33	0.08	0.12	0.03	8.17	8.17	8.17
1968	0.00	0.00	0.00	0.06	0.13	4.13	0.95	0.17	0.22	0.09	5.75	5.75	5.75
1969	0.00	0.00	0.00	0.02	0.02	0.02	2.78	0.57	0.09	0.14	3.64	3.64	3.64
1970	0.00	0.03	0.00	0.00	0.00	0.03	0.06	1.41	0.41	0.03	1.97	1.97	1.94
1971	0.18	0.00	0.04	0.00	0.01	0.00	0.07	0.11	1.34	0.19	1.94	1.76	1.76
1972	0.00	0.80	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.52	1.34	1.34	0.54
1973	0.76	0.01	0.64	0.00	0.24	0.02	0.01	0.03	0.01	1.08	2.80	2.04	2.03
1974	0.01	1.13	0.13	0.29	0.00	0.00	0.00	0.00	0.01	0.23	1.80	1.79	0.66
1975	0.60	0.15	1.29	0.37	0.93	0.00	0.03	0.03	0.00	0.32	3.72	3.12	2.97
1976	1.10	1.18	0.05	0.86	0.11	0.52	0.00	0.10	0.00	0.12	4.04	2.94	1.76
1977	0.03	2.74	2.65	0.10	0.85	0.13	0.21	0.00	0.00	0.07	6.78	6.75	4.01
1978	0.14	0.01	1.65	3.78	0.38	0.94	0.77	0.12	0.00	0.21	8.00	7.86	7.85
1979	0.59	0.30	0.01	0.79	1.97	0.41	0.30	0.09	0.05	0.02	4.53	3.94	3.64
1980	3.25	0.41	0.26	0.00	0.24	0.88	0.55	0.11	0.08	0.08	5.86	2.61	2.20
1981[5]	0.00	0.41	0.45	0.60	0.33	0.69	0.56	0.02	0.06	0.05	3.17	3.17	2.76

	Spring			Autumn			Means	
	Years	Age 2+	Age 3+	Years	Age 2+	Age 3+	Age 2+	Age 3+
Instantaneous[6] Total Mortality (Z)	1973-1976	0.13	0.09	1973-1976	-[7]	0.15	0.13	0.12
	1977-1980	0.56	0.68	1977-1981	-[7]	0.23	0.56	0.40

[1]Spring and autumn, strata 26-28 and 36-40; summer, strata 26-28, 37, and 38.

[2]May not agree exactly with data in Table 3 due to rounding errors.

[3]Data for 1968-1972 adjusted by a factor of 1.7 to account for differences in surface area between the "36 Yankee" and the modified "41 Yankee" trawls (the modified "41 Yankee" trawl has been used in spring since 1973).

[4]Sampling incomplete in 1979, and only one stratum (26) was sampled in 1981.

[5]Preliminary.

[6]Calculated by pooling over age groups, e.g. the spring 1973-1976 value for age 2 and older fish was calculated as $\ln\left(\frac{\Sigma \text{ age 2 and older for 1973-1976}}{\Sigma \text{ age 3 and older for 1974-1977}}\right)$, and the corresponding autumn value for age 3 and older fish was calculated as $\ln\left(\frac{\Sigma \text{ age 2 and older for 1972-1975}}{\Sigma \text{ age 3 and older for 1973-1976}}\right)$.

[7]Age 2 incompletely recruited to the survey gear.

ndix A-3. Stratified mean catch per tow in numbers and weight (kg) for haddock in NEFC and Massachusetts inshore surveys[1] in the Gulf of Maine.

	Stratified mean catch per tow at age[2] (numbers)								Stratified mean catch per tow in weight (kg)
	0	1	2	3	4	5	6+	Total	
(Summer)[3]									
	0.00	13.46	11.49	0.49	0.00	0.00	0.00	25.44	9.57
4	0.05	0.00	1.04	1.36	0.10	0.00	0.00	2.55	2.72
	1.13	9.07	0.34	0.53	0.04	0.00	0.00	11.11	2.71
	5.27	11.73	0.52	0.41	0.76	0.29	0.01	18.99	6.60
4	0.00	4.19	0.13	0.00	0.00	0.00	0.11	4.32	1.00
achusetts (Spring)									
3	0.00	0.00	0.90	0.09	0.00	0.00	0.00	0.99	0.62
9	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.03	0.03
0	0.34	3.00	0.03	0.00	0.03	0.05	0.00	3.45	0.46
1	0.00	4.00	0.12	0.04	0.02	0.00	0.00	4.18	0.52
sachusetts (Autumn)									
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	15.32	0.00	0.00	0.00	0.00	0.00	0.00	15.32	0.11
0	15.64	0.78	0.00	0.00	0.00	0.00	0.00	16.42	0.35

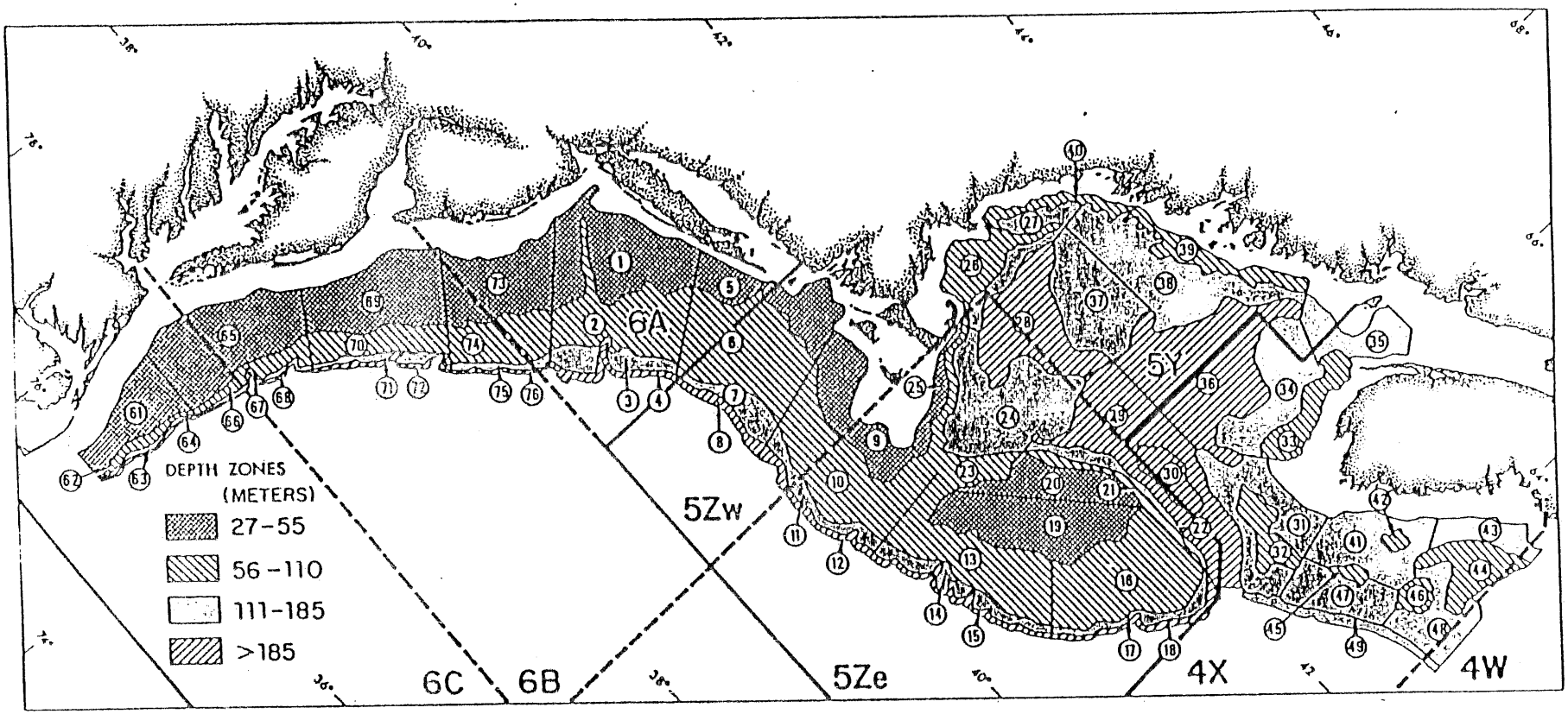
FC: Inshore survey strata 58-61, 63-66, 72, 74-75, 80-81, 83, and 85;
ssachusetts: Regions 4 and 5 (strata 25-36). See Appendices B-2 and B-5.
tained by applying combined NEFC age-length keys from offshore and inshore strata.
ta for spring and autumn not included due to reduced sample coverage.
npling incomplete in 1978 (10 strata sampled) and in 1981 (4 strata sampled).

A-4. Catch per tow and calculated index values for young-of-year haddock in selected juvenile concentration areas on Georges Bank, 1953- 1981.

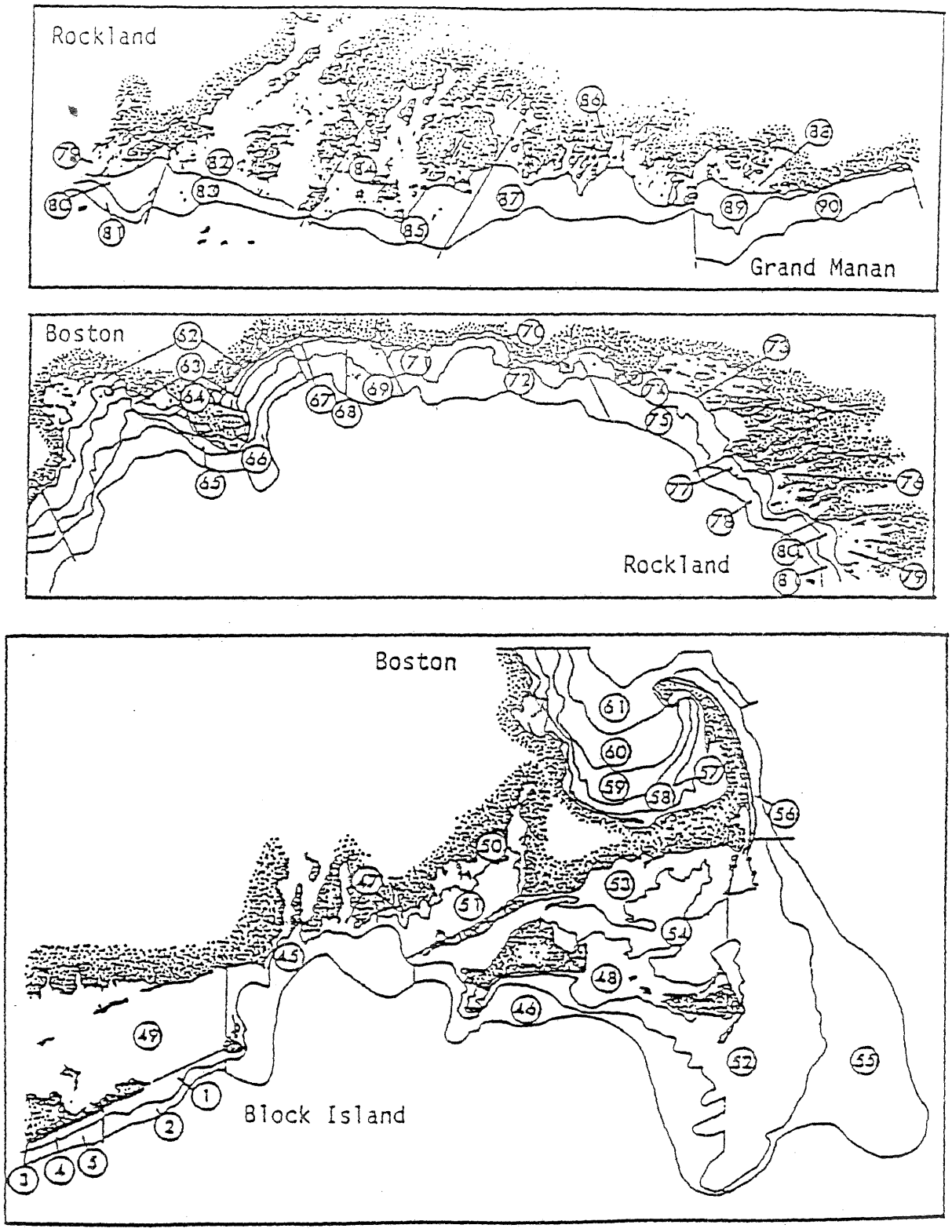
/ -class	Number of Tows	Number caught	Mean Number per tow linear	Mean Number per tow $\log_{10}(x+1)$	Young of year index[1]	VPA[2] stock size age 2 (millions)
953	15	35	2.33	0.31	3.6	43.1
955	34	533	15.68	0.64	3.5	50.0
956	11	12	1.09	0.23	2.0	51.1
958	24	841	35.04	0.99	8.5	104.8
959	57	1535	26.93	1.02	9.6	100.9
960	50	221	4.42	0.43	2.4	44.4
961	48	56	1.17	0.14	1.4	31.8
962	44	206	4.68	0.43	2.6	150.3
963	38	3832	100.84	1.05	12.6	368.3
1964	46	261	5.67	0.36	2.0	17.9
1965	43	18	0.42	0.06	1.2	3.2
1966	44	246	5.59	0.20	1.7	8.6
1967	42	0	0.00	0.00	1.0	0.3
1968	41	4	0.10	0.02	1.0	0.8
1969	39	7	0.18	0.04	1.1	3.5
1970	42	1	0.70	0.01	1.0	0.1
1971	45	84	1.87	0.17	1.5	7.0
1972	45	218	4.84	0.31	2.1	9.3
1973	46	151	3.28	0.24	1.8	-
1974	38	36	0.95	0.13	1.3	-
1975	48	1062	22.13	0.60	3.8	-
1976	40	200	5.00	0.27	1.7	-
1977	58	10	0.17	0.03	1.1	-
1978	110	1541	14.01	0.35	2.3	-
1979	101	234	2.32	0.24	1.6	-
1980	51	1765	34.61	0.47	2.8	-
1981	48	14	0.29	0.07	1.2	

ee Grosslein (MS 1969). Values calculated as averaged means of individual $\log_{10}(x+1)$ bservations by time and depth zone, antilogged; 1953-1968 values as reported by rosslein.

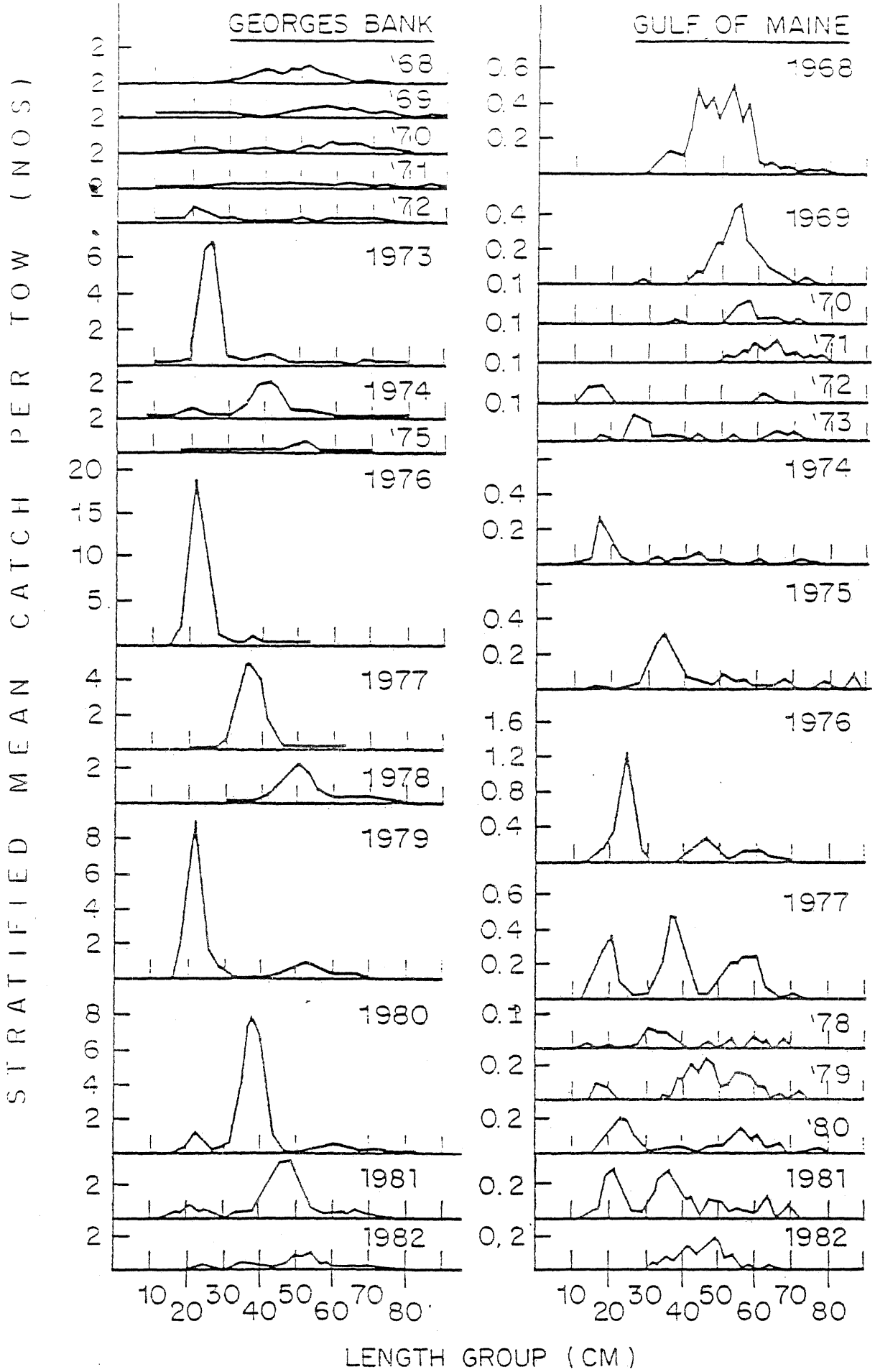
lark et al. (1982).



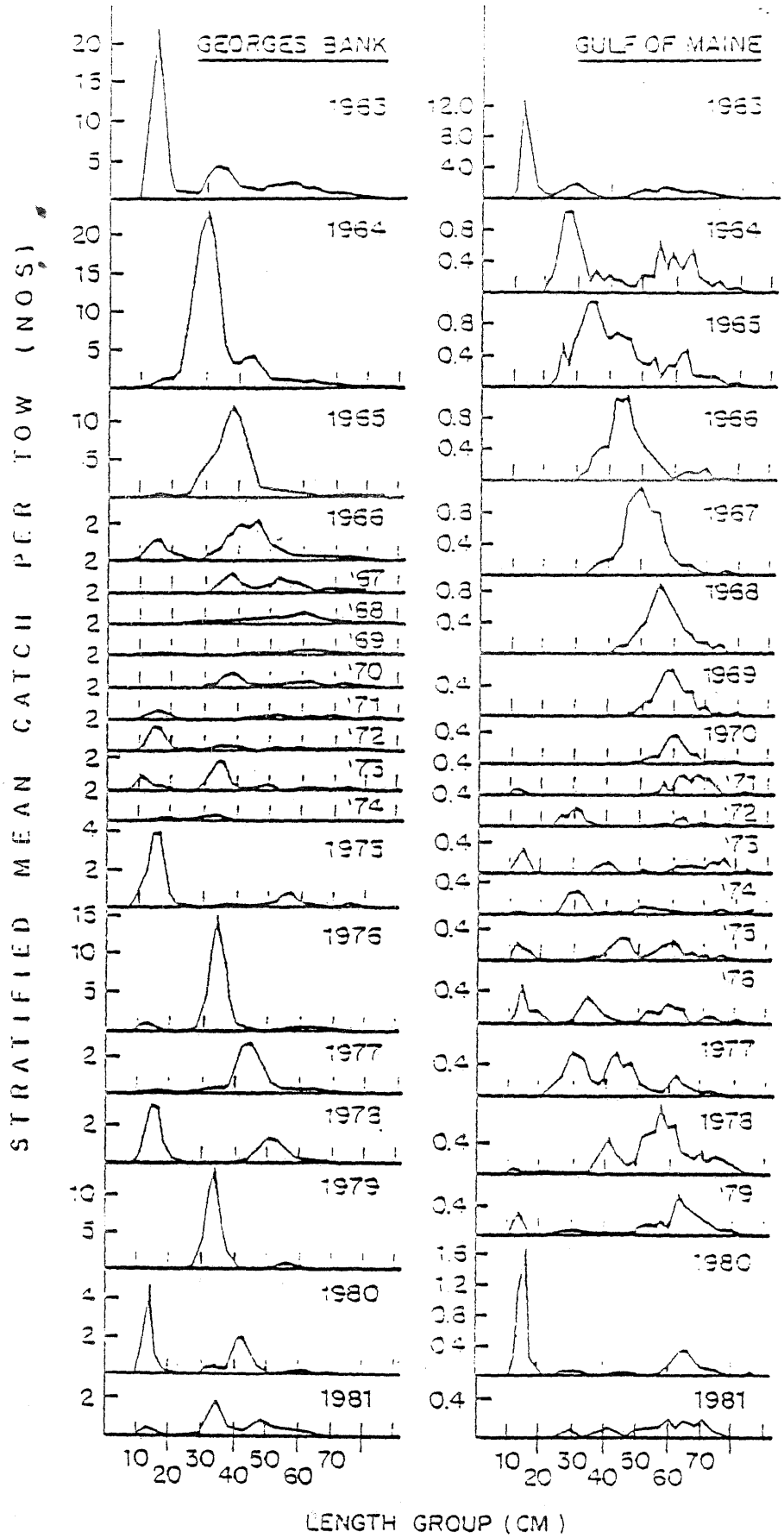
Appendix B-1. Strata used in NEFC offshore (>27m) bottom trawl surveys.



Appendix B-2. Strata used in NEFC inshore (<27m) bottom trawl surveys.

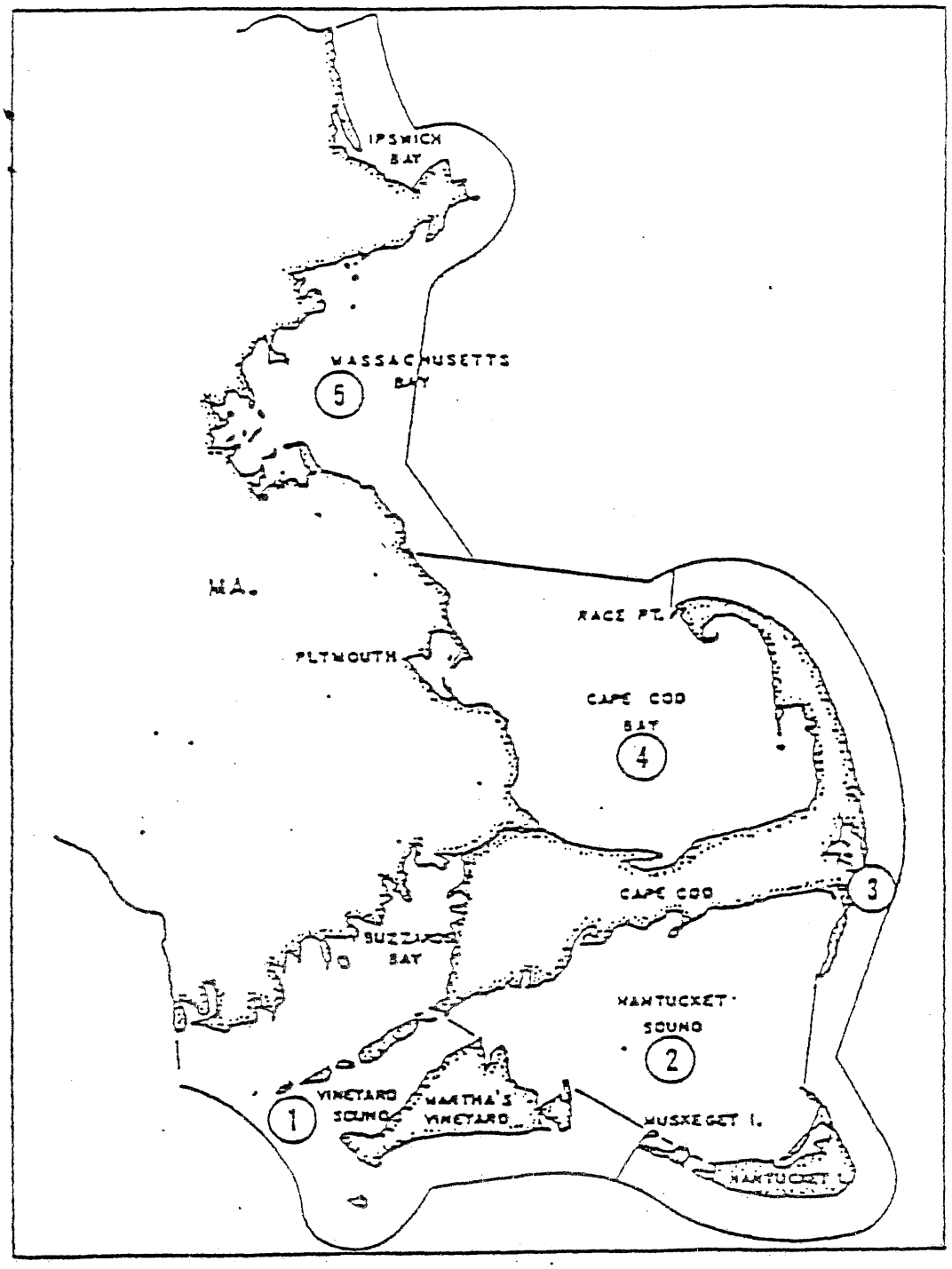


Appendix B-3. Length-frequency distribution of Georges Bank and Gulf of Maine haddock in NEFC spring bottom trawl surveys, 1968-1982.



Appendix B-4. Length-frequency distribution of Georges Bank and Gulf of Maine haddock in NEFC autumn bottom trawl surveys, 1963-1981.

Appendix



Appendix B-5. Massachusetts inshore survey area delineated by regions.