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Scotian Shelf, Gulf of Maine, and Georges Bank Pollock Stock Status-1981

by

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SUMMARY

Commercial landings of pollock from the Scotian Shelf and southward have increased more or less continually since the late 1960's and in 1980 were the highest ever reported (55,400 tons) of which 36,000 tons were landed by Canada and 18,300 tons by the USA. This increase may reflect increases in abundance (nos.) and biomass, shifts in directed effort, and misreporting of regulated species (e.g., haddock) as pollock to circumvent catch limitations. USA recreational surveys in 1974 and 1979 provided catch estimates of 500 tons and 3,200 tons, respectively. This increase may reflect differences in methodology rather than an actual increase in biomass or fishing effort.

Stock biomass (age 2+) appears to be relatively high at present. Canadian commercial indices for 1979-1980 were substantially higher than for 1972-1978, although USA commercial catch-effort data suggest relatively constant levels. USA and Canadian research vessel survey data indicate no appreciable change in abundance since the early 1970's, although USA indices in terms of weight for 1977-1981 were higher. Survey catch-at-age data indicate the 1971, 1975, 1976, and 1979 year classes to be strong ones. Estimates of total mortality (Z) from research vessel surveys for 1978-1980 averaged approximately 0.5 implying that fishing mortality (F) was close to $F_{0.1}$ (0.25) assuming natural mortality (M) =0.2.

Virtual population analysis of commercial catch-at-age data indicates an increase in stock size (age 2+) of from 99 million fish (162,000 tons) in 1974 to 133 million fish (210,000 tons) in 1977. Abundance subsequently declined to 100 million fish in 1980, although biomass increased to 233,000 tons. Equilibrium yield calculations indicate that fishing at $F_{0.1}$ would provide a long-term catch of 52,000 tons, while fishing at F_{max} = 0.49 would provide a catch of 57,000 tons. Assuming a stock biomass level of 220,000 tons at the beginning of 1981, a catch of 50,000 tons during 1981 and recruitment levels and partial selection (recruitment) factors equal to the 1973-1977 average, fishing at $F_{0.1}$ would provide a catch of 33,000 tons in 1982 and a biomass of 306,000 tons at the beginning of 1983. Fishing at F_{max} would provide a catch of 58,000 tons in 1982 and a biomass of 274,000 tons at the beginning of 1983. Given relatively high biomass levels and favorable recruitment prospects evidenced by survey catch-at-age data it appears that harvests in the order of 50-55,000 tons during 1981-1983 should at least maintain current stock size levels.

INTRODUCTION

Commercial landings (nominal catches) of pollock from the Scotian Shelf, Gulf of Maine and Georges Bank area have increased substantially in recent years and in 1980 were the highest ever reported (55,400 tons[1]). This primarily reflects increased Canadian and USA landings; Canadian landings more than doubled during the 1970's, while a four-fold increase in USA landings occurred. Landings by distant-water fleets declined by approximately 90% during the same decade. The fishery has been centered primarily on the Scotian Shelf (67% of the 1960-1980 total landings) although the proportion taken on Georges Bank and in the Gulf of Maine has increased since the mid-1970's. Pollock have traditionally been taken as by-catch, although more effort appears to have been directed towards this species in recent years.

Seasonal trends in commercial landings by area, tagging data, and distributions of ripe adults, eggs, and larvae suggest the existence of one major spawning area in the western Gulf of Maine (Clark et al. 1977), although there are also indications of minor spawning on the Scotian Shelf (Steele 1963). Recent larval distribution data collected during Canadian surveys also provide some evidence for pollock spawning on the Scotian Shelf, although no major spawning areas have been documented[2]. Recaptures of pollock tagged in inshore Nova Scotia locations have been primarily confined to the Scotian Shelf region, although small numbers have also been recaptured in the western Gulf of Maine

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[1]Tons in this paper refers to metric tons.

[2]McGlade, pers. comm., August, 1981.

and along the northern edge of Georges Bank[3]. In view of a lack of definitive information concerning stock boundaries, pollock in the Scotian Shelf, Gulf of Maine, and Georges Bank region and areas to the south (NAFO Divisions 4VWX, Subarea 5 and Statistical Area 6, Figure 1) are herein considered as a unit, as in previous assessments.

Pollock landings were unregulated in the Northwest Atlantic prior to 1973. During 1973-1976, the fishery was regulated by total allowable catches (TACs) under the International Commission for the Northwest Atlantic Fisheries (ICNAF). The annual TAC during 1974-1976 was 55,000 tons. Due to evidence for increased fishing mortality and reduced recruitment, the TAC was reduced to 30,000 tons for 1977. The USA withdrew from ICNAF December 31, 1976, however, and the USA fishery has since been unregulated. A Draft Fishery Management Plan was prepared for the USA fishery in 1978 (New England Regional Fishery Management Council 1978) but was not implemented. The 30,000 ton TAC was maintained by Canada for each year during 1977-1979 but was raised to 40,000 tons for 1980 (McGlade et al. MS 1981).

The present document reviews the current status of the Scotian Shelf, Gulf of Maine, and Georges Bank pollock stock and provides catch and stock size projections for 1982-1983.

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[3]Beanlands, pers. comm., August 1981.

COMMERCIAL FISHERY

The Scotian Shelf, Gulf of Maine, and Georges Bank pollock stock has been fished primarily by Canada and the USA. Commercial landings[4] for Canada rose from an average of 5,100 tons from 1920 to 1942 to an average of 29,300 tons from 1960-1964 before declining to 10,800 tons in 1970 (Table 1, Figure 2). Canadian landings then increased to an average of 25,600 tons during 1973-1978; landings for 1979 and 1980 (provisional) were 30,000 and 36,000 tons, respectively (Table 1, Figure 2). USA landings averaged 13,400 tons from 1935-1960, declined to an average of 3,300 tons during 1967-1968, and then increased steadily to 17,700 tons in 1978; landings for 1979 and 1980 (provisional) were 15,500 tons and 18,300 tons, respectively (Table 1, Figure 2). It should be noted that since 1978 data for both countries appear to have been distorted by alleged misreporting of other species, e.g. haddock as pollock to circumvent catch limitations. There is no basis for quantifying amounts involved in either case.

No information exists relative to landings by other nations prior to 1960, as pollock catches by distant-water fleets were usually reported as "mixed" with other species[5]. Landings since that year have fluctuated considerably, ranging from zero in 1962 to 12,300 tons in 1966 (Table 1). Annual landings subsequently declined from an average of 9,600 tons from 1970-1972 to approximately 1,100 tons in 1979-1980 (Table 1). Since 1960, the bulk of the distant water catch has been taken by the USSR (43%), the GDR (22%), Spain (20%) and the FRG (10%).

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[4]Landings data for Canada and the USA are not available by ICNAF division prior to 1960 and were approximated from data reported in "Fisheries Statistics of Canada" and "Fisheries Statistics of the U.S." Subsequent data are as reported to ICNAF/NAFO.

[5]Hodder, pers. comm., July 1978.

Total commercial landings averaged 37,800 tons annually from 1958-1964, declined to 22,800 tons in 1968, and subsequently increased to an average of 39,200 tons from 1973-1977. Landings for 1980 (55,400 tons) were the highest ever reported (Table 1, Figure 2). The bulk of the catch since 1970 (67%) has been taken on the Scotian Shelf, with most of the remainder being about evenly distributed between Georges Bank and the Gulf of Maine (Table 2). The Canadian catch was taken primarily on the western Scotian Shelf (89%); USA landings were more evenly distributed between Georges Bank (47%), the Gulf of Maine (36%), and the Scotian Shelf (18%) during 1960-1971, but have since been taken largely in the western Gulf of Maine (61%). This appears to reflect increases in directed effort and gillnetting in the Gulf of Maine (the percentage of USA commercial landings taken by gillnetting has increased from 7% in 1970-1971 to 45% in 1978-1979 and 38% in 1980). Traditionally, the largest portion of the Canadian catch has been taken by otter trawling, with only 10% being taken by gillnets (McGlade et al. MS 1981). Distinct seasonal differences in landings trends are also evident, i.e., a summer (June-July) peak in Canadian landings on the Scotian Shelf and a winter (November-January) peak in USA landings in the Gulf of Maine (Steele 1963; Clark et al. 1977). The latter trend appears to reflect seasonal spawning movements.

RECREATIONAL FISHERY

Recreational catch data for pollock are limited. No data are available for Canada and it is assumed that Canadian recreational catches are of minor significance[6]. Recreational catch information for New England and the Mid-Atlantic states has been collected in a series of national saltwater angling

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[6]See Footnote 2.

surveys for 1960, 1965, and 1970 (Clark 1962; Deuel and Clark 1968; Deuel 1973), in a regional survey of the northeastern United States in 1974 (Ridgely and Deuel MS 1976), and more recently in the 1979 Marine Recreational Fishery Statistics Survey of the Atlantic and Gulf Coasts (United States Department of Commerce 1980). The 1979 survey represented a significant departure from earlier surveys in that it combined a household telephone survey to identify fishermen and to determine levels of effort over a two-month recall period with an intercept (creel) survey in which trained observers collected data on species and size composition of the catch. The 1979 survey avoided many methodological problems of earlier surveys, e.g. species misidentification and recall inaccuracies of numbers and average weights caught, and due to these differences results are comparable only in a general way.

Recreational catch estimates obtained for 1960, 1965, and 1970 totalled 4.3 million fish (9,800 tons), 3.8 million fish (4,200 tons), and 2.5 million fish (2,500 tons), respectively. These are considered to be overestimates, although the magnitude of the resulting bias is not known (United States Department of Commerce 1980). The 1974 survey indicated a total recreational catch of 0.5 million fish or 500 tons and may not be overestimated (United States Department of Commerce 1980). The 1979 survey indicated a total catch including pollock reportedly caught and released alive of 2.5 million fish or 3,200 tons, of which the harvested (remaining) catch totalled 1.3 million fish or 1,600 tons (Table 3).

The USA recreational fishery has been centered primarily in the Gulf of Maine; smaller amounts have been taken from Connecticut to New Jersey (Ridgely and Deuel MS 1976; United States Department of Commerce 1980). The bulk of the 1978 recreational catch was taken by party and charter boats, although juvenile "harbor" pollock are available year-round along the Maine coast (Nicholson and

Ruais MS 1979). In the 1979 survey, 57% of the total catch by number was reportedly taken in coastal inlets and bays[7], with the remainder being divided almost equally between the territorial sea (21%) and areas further offshore (22%).

The recreational fishery for pollock in the southern New England and Middle Atlantic areas has been described as "poorly defined, highly specialized and nondirected" (Wilk et al. MS 1979); catches tend to peak in late spring and decline sharply during summer, possibly in response to seasonal shifts in distribution and directed effort[8]. Here, pollock are primarily taken by party boats in directed fishing for cod and other species, although sporadic inshore fisheries may develop for harbor pollock during years of high abundance (Wilk et al. MS 1979).

COMMERCIAL CATCH RATES

Commercial indices (tons per hour fished) have been calculated for Canadian Tonnage Class (TC) 4 (150-499 GT) and TC 5 (500-999 GT) otter trawlers based on June-August trip data for which 50% or more of the total landings consisted of pollock (McGlade et al. MS 1981); similar indices (tons per day fished) have also been calculated for USA TC 2 (0-50 GT) and TC 3 and 4 (51-500 GT) otter trawlers, again using the 50% or greater criterion. Use of this criterion was arbitrary, as there is little or no basis at present for defining directed effort in either fishery.

The Canadian index for TC 4 vessels was relatively constant from 1972-1978 and then increased sharply to 1.7 tons in 1979; the 1980 index value was

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[7]In this survey, coastal inlets, bays and similar areas of salt or brackish water were considered as being separate from the territorial sea (0-3 nautical miles from shore).

[8]Wilk, pers. comm., August 1979.

1.0 tons (Table 4, Figure 3). The corresponding index for TC 5 vessels again fluctuated little during 1972-1976 and then rose sharply to 2.3 tons in 1979; the 1980 index value was 1.1 tons (Table 4, Figure 3). Averages for 1979-1980 (1.4 tons and 1.7 tons, respectively) are both substantially higher than observed 1972-1978 values. The USA TC 2 index has generally declined since 1973, while the TC 3 and 4 index has fluctuated without a definite trend (Table 4, Figure 4). The latter index appears to be the more reliable in that it is based on a substantially greater number of trips completed over a wider area.

RESEARCH VESSEL SURVEYS

Canada has conducted stratified random bottom trawl surveys on the Scotian Shelf in summer since 1970 (Figure 5); the Northeast Fisheries Center (NEFC) has conducted similar surveys in autumn (since 1963) and spring (since 1968) in offshore areas (>27 m) from Hudson Canyon to the southwestern Scotian Shelf (Figure 6). A summer survey has also been run intermittently (1963-1965, 1969, and 1977-1980). The NEFC has also conducted inshore surveys (<27 m) from Cape Hatteras northward since 1972; however, the Gulf of Maine was not surveyed in spring and autumn prior to 1979, and while a summer survey time series is available for 1977-1980 coverage and/or pollock catches have tended to be sporadic. Consequently, only a limited number of inshore strata between Nantucket Shoals and Rockland have been considered (Figure 7).

The Massachusetts Division of Marine Fisheries (DMF) has conducted similar inshore surveys along the Massachusetts coast during spring and autumn since 1978 (Figure 7). Areas sampled, sampling procedures and catch-per-tow data for 1978 and 1979 are given in annual completion reports (Howe et al. MS 1979, MS

1980) and preliminary data are available for 1980[9]). Autumn survey catches of pollock in these surveys have been sporadic, and consequently only spring survey data have been utilized.

Abundance indices (stratified mean catch per tow in numbers) have been calculated for all of the above data sets; corresponding indices in terms of weight (kg) have also been calculated for all USA surveys (Tables 5-8, Figures 8 and 9). To compensate for the effects of anomalously high catches in certain strata (e.g., in autumn of 1976, Table 6), NEFC survey data were also transformed to logarithms (x+1) and retransformed estimates in original units calculated as suggested by Bliss (1967:128) according to the relation

$$E\bar{y}_{st} = \exp\left(\bar{y}_{st} + \frac{S^2}{2}\right) - 1$$

where $E\bar{y}_{st}$ represents the estimated (retransformed) stratified mean catch per tow and $\bar{y}_{st}$ and S^2 represent the stratified mean and the estimated population variance, respectively, in logarithmic units. Additional information concerning NEFC sampling designs and survey procedures and applications of resulting data to assessments is provided elsewhere (Grosslein 1969; Clark 1979).

Offshore survey indices have fluctuated considerably but generally appear to indicate no consistent trends in abundance since the early to mid-1970's. The Canadian summer survey index rose sharply in 1977 and 1980 (Table 5, Figure 8) but has otherwise been relatively constant. Peak index values for 1977 and 1980 resulted from unusually high catch-per-tow values in two survey strata and may not reflect actual changes in stock abundance (McGlade et al. MS 1981). USA (retransformed) spring and autumn survey data likewise indicate no consistent trends in abundance since the early 1970's (Table 6, Figure 9). Peak index

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[9]Howe, pers. comm., August 1980.

values in spring of 1972 and autumn of 1972 and 1973 result primarily from recruitment of 1971 year-class fish, while the autumn 1976 peak reflects unusually high catches of 1971 year-class fish in one or two survey strata. An upward trend in biomass is evidenced by USA indices in terms of weight, both of which increased from the late 1960's to 1976; subsequent values have been comparable to or above those observed in the early 1970's (Table 6, Figure 9). The observed increase in the early to mid-1970's appears largely attributable to recruitment and growth of the 1971 year class, while the observed 1981 increase in the USA spring survey index appears to reflect recruitment and growth of the 1975 and 1976 year classes.

Stratified mean catch-per-tow-at-age data for Canadian and USA offshore surveys (Tables 5 and 7) although variable, reveal some consistencies in year-class strength. The 1968, 1969, and 1971 year classes have been relatively strong in Canadian summer surveys and catches of 1974, 1975, and 1976 year-class pollock were also high in 1980. The 1971 year class has been the strongest observed during NEFC spring and autumn surveys. No consistently strong year classes have appeared in NEFC surveys in subsequent years, although recent (1980-81) NEFC spring survey data agree with results of Canadian surveys in indicating the 1975 and 1976 year classes to be strong ones. Data from all three NEFC surveys also suggest that the 1979 year class may be a strong one (Table 7).

Index values for inshore surveys have fluctuated considerably and trends have not been consistent. NEFC summer survey data suggest a decline in abundance in recent years, although Massachusetts spring survey data suggest an increase (Table 8). Given the limited area involved (Figure 7) compared to the distribution of the stock as a whole, it is doubtful whether such indices would in fact accurately reflect trends in stock abundance or biomass over time, although the proximity of this region to major known spawning areas implies that such data may

eventually prove valuable for future recruitment predictions. It may be noted here that the 1979 year class was the strongest observed at ages 0 and 1 in the Massachusetts spring survey and was also the strongest observed at age 0 in the NEFC summer survey.

Mortality

Research vessel survey catch-at-age data suggest that mortality has been low since the early 1970's, although there are indications that it may be increasing. Calculations for fully recruited fish (age 5+ in Canadian summer and USA spring surveys and age 4+ in the USA autumn survey) provide instantaneous total mortality (Z) estimates of 0.39, 0.23, and 0.17, respectively, since 1970; for 1978-1980, corresponding estimates were 0.62, 0.35, and 0.55 (Tables 5 and 7). Assuming instantaneous natural mortality (M) = 0.20, this implies that F has averaged around 0.3 in recent years, relatively close to $F_{0.1}$ as estimated from yield-per-recruit modeling (discussed below). Average estimates of Z for 1978-1980 calculated from Canadian commercial removals at age were 0.84 and 0.69, respectively (McGlade et al. MS 1981).

COMMERCIAL CATCH AGE COMPOSITION

Length-frequency data are available for Canadian catches for nearly all months since the beginning of 1973; also, Canadian age-length keys are available at least by quarter for 1973-1975 and for most months thereafter. USA commercial length frequencies are generally available at least by quarter for 1973-1976 although commercial age data are not available prior to 1977. Commercial sampling of USA pollock landings was intensified in 1977 and monthly length frequencies have generally been available for USA trawl landings since January of that year, although sampling of the USA gillnet catch has been limited. Sampling of catches

by distant water fleets has also been minor.

No length frequencies or age samples are available for the USA recreational catch, although mean weights at age for 1974 (1.03 kg) and 1979 (1.26 kg) are substantially lower than corresponding USA commercial averages (2.19 and 2.72 kg). This discrepancy, and the observed distribution of recreational catch by area in the 1979 survey, indicate the USA recreational catch at age distribution to be substantially different from that of USA commercial landings (note also that almost 50% of this catch was discarded live, a substantially greater proportion than for most other species considered). Accordingly, commercial length frequencies were not applied to recreational landings data in this assessment.

Substantial length-frequency differences were evident for the USA and Canadian fisheries in 1973 and 1974 (USA samples usually included a higher proportion of smaller fish), but length frequencies for 1975 and 1976 were found to be in relatively close agreement. USA commercial landings at age distributions for 1973-74 were obtained by applying USA length frequencies and Canadian age-length keys on a quarterly basis, while Canadian length-frequency data and age-length keys were applied to Canadian landings. For 1975 and 1976, numbers landed at age were derived by applying USA and Canadian length frequencies and Canadian age-length keys to respective monthly landings for each country; Canadian length frequencies were applied to USA landings for months for which USA data were unavailable. For 1977-1980, Canadian and USA data have been applied independently, with the exception that Canadian gillnet samples were applied to USA 1980 gillnet landings (no USA gillnet samples were available for that year). This is believed appropriate, as gillnet mesh sizes used in Canada appear similar to those used

by USA fishermen[10] and the resulting distribution appears similar to those observed for the USA fishery for 1977-1979 (Figure 10). Canadian length-frequency samples and age-length keys have been applied routinely to catches by distant water fleets, as the bulk of the distant-water catch since 1973 has been taken on the Scotian Shelf.

Summarized data for all countries (Table 9) reveal that the catch has been dominated by age 3-5 fish (73% of the 1973-1980 total). The 1969, 1971, and 1975 year classes have shown up well in commercial landings, although catches of 1974 and 1976 year-class fish have also been reasonably high. Increased catches of older (12+) fish in recent years have been taken primarily in the USA fishery.

Mean weights at age for this stock appear in Table 10. Values for 1973-1976 are as reported by Cleary (MS 1980); values for 1977-1980 represent averages for the USA and Canadian fisheries, weighted by numbers landed at age. Values fluctuate to some extent but no consistent trends appear evident.

STOCK ABUNDANCE AND RECRUITMENT

A virtual population analysis or VPA was performed on the commercial catch at age data in Table 9 to derive fishing mortality and stock size estimates for 1973-1980. No estimates of instantaneous natural mortality (M) are currently available, and M has therefore been assumed equal to 0.2 as in recent Canadian and European assessments (McGlade et al. MS 1981; ICES MS 1981). There is no evidence to suggest significant natual mortality in recent years from disease

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[10]The most commonly used gillnet mesh size in the Canadian fishery is 140 mm or 5.5 inches (Beck, pers. comm., June 1981), the current USA legal minimum.

or other natural causes[11,12]. Pollock appear to be fully recruited to the commercial fishery at ages 5-6 as evidenced by age-specific fishing mortality (Table 11); full recruitment at age 5 has been assumed in the present assessment. The sharp increase in USA gillnet landings in recent years implies a potential shift in recruitment patterns, although this trend has been largely offset by recent declines in Canadian gillnet landings.

The limited commercial catch-effort and survey catch-at-age data bases available, and uncertainty in reported landings data for recent years, rendered determination of a terminal or starting F value difficult. In this assessment a procedure was adopted in which F_{1980} for fully recruited year classes was obtained from predictive regressions of catch-at-age data upon time; data were transformed to logarithms (ln) and linear regressions run to project catch at age by cohort (age 5+) several additional years. A VPA analysis was then run using observed catches for 1980 and projected catches for later years with a starting F of 0.35, which corresponded approximately to the 1980 catch level based upon projected stock size estimates from an earlier assessment (Clark et al. MS 1978). The average F estimate obtained for 1980 based upon the observed catch data (0.403) was used as the starting F in the final VPA analysis. This procedure was used in that it appeared to provide a reasonable approximation based on recent trends in abundance and fishing effort whereas other methods (e.g., development of empirical relationships between F and commercial effort data or catch and stock size in numbers and research vessel survey catch per tow) did not appear to provide reliable estimates. F_{1980} for incompletely recruited ages (2-4) was determined by applying average partial selection (recruitment) factors obtained from 1973-1977 data (0.04,

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[11]McGlade, pers. comm., November, 1981.

[12]Murchelano, pers. comm., December, 1981.

age 2; 0.34, age 3, and 0.76, age 4).

Results of this analysis (Table 11) indicate a steady increase in stock size (age 2+) of from 99 million fish or 162,100 tons in 1974 to 133 million fish or 210,400 tons in 1977. (Stock size estimates in terms of weight were obtained by applying mean weights at age in Table 10, adjusted by the observed/calculated ratios given in Table 9). Stock size in terms of numbers subsequently declined to 100 million fish in 1980 (the approximate 1973-1975 level), although stock biomass increased to the highest level observed in the time series (233,100 tons). There was generally little or no correlation between stock size estimates from VPA and corresponding indices derived from research vessel surveys, although the association tended to be somewhat better between VPA biomass estimates and Canadian commercial abundance indices for TC 4 and 5 trawlers ($r = 0.50$ and 0.62, respectively). McGlade et al. (MS 1981) determined $F_{1980} = 0.275$ based on relationships between Canadian commercial abundance indices and VPA stock biomass estimates, which implies a greater increase in stock biomass in recent years than evidenced by the above VPA.

YIELD PER RECRUIT AND EQUILIBRIUM YIELD

Yield per recruit calculations were performed by the Thompson-Bell method (Rivard 1980) using average commercial mean weights-at-age for 1979-1980 (Table 10) and partial selection (recruitment) factors of 0.04 (age 2), 0.34 (age 3), and 0.76 (age 4) determined from age specific fishing mortality rates for 1973-1977. Results indicate $F_{0.1} = 0.25$ and $F_{max} = 0.49$. The latter value is substantially higher than that obtained in earlier assessments from "knife-edge" modeling with von Bertalanffy growth parameters (0.37, Clark et al. MS 1978), assuming a mean age at recruitment (t_c) of 3.5 years.

Equilibrium yield calculations under the same set of assumptions and assuming constant recruitment of 42.4 million fish at age 2 (the 1973-1977 average) indicates that fishing at $F_{0.1}$ would provide a long-term equilibrium yield of 52,400 tons (from a stock biomass of 340,900 tons); fishing at F_{max} would provide a long-term equilibrium yield of 56,600 tons (from a stock biomass of 237,600 tons). Potential long-term yields are seen to be nearly equal, although a 44% increase in stock size could be achieved by fishing at $F_{0.1}$ as opposed to fishing at F_{max} (Figure 11).

CATCH AND STOCK SIZE PROJECTIONS

The above assumptions relative to F_{1980}, full recruitment at ages 5 and older, partial recruitment factors of 0.04, 0.34, and 0.76 for ages 2, 3, and 4, respectively, and recruitment of 42.4 million fish at age 2 (the 1973-1977 average) in 1981 imply a total stock size (age 2 and older) of 107 million fish or 219,600 tons at the beginning of 1981. Information concerning 1981 harvest levels is of course incomplete, but projections based on Canadian and USA landings to date suggest that total 1981 landings will be in the order of 50,000 tons.

Assuming a total stock size (age 2+) of 107 million fish or 219,600 tons in 1981, a total 1981 catch of 50,000 tons, and recruitment and partial recruitment factors equal to the 1973-1977 average, fishing at $F_{0.1} = 0.25$ would provide a total 1982 catch of 32,600 tons, with a stock size of 306,100 tons at the beginning of 1983; fishing at $F_{max} = 0.49$ would provide a 1982 catch of 57,900 tons, with a stock size of 273,900 tons at the beginning of 1983. Given current evidence that recruitment and biomass levels have been above average in recent years, it appears that harvests in the order of 50-55,000 tons should be sustainable in the foreseeable future.

DISCUSSION

Available evidence suggests relatively constant abundance and increased biomass in recent years. Increased commercial (and USA recreational) landings (tons) may reflect the latter trend, although misreporting of catches of other species as pollock to circumvent regulations and increased effort may also be involved. No consistent trends in abundance are evident from research vessel survey data; occasional sharp increases in Canadian and USA survey indices may reflect factors other than an actual increase (Clark et al. (MS 1978) attributed high USA autumn survey index values for 1976 to distributional differences between years). Canadian commercial and USA survey (weight) indices agree in suggesting recent increases in biomass, apparently due in large part to growth of two or three relatively strong year classes appearing in the mid-1970's (the 1974-1976 year classes). Mortality appears to have increased somewhat, although research vessel survey data indicate levels of F relatively close to $F_{0.1}$ in recent years. Recruitment appears to have been above average during the mid to late 1970's and there are preliminary indications that the 1979 year class is a strong one.

VPA results reported in this assessment are subject to a number of limitations, e.g. the time series of commercial landings-at-age data used (only 8 years available) and uncertainty concerning recent levels of harvest and fishing mortality in 1980. Nevertheless, results appear generally consistent with those obtained from analysis of commercial catch-effort and research vessel survey data; stock size in numbers increased to a peak in 1977-78 before declining to the approximate 1973-1975 level in 1980, and stock biomass has increased substantially since the mid-1970's. Mortality was generally higher than evidenced by research vessel survey data but since 1974 has generally fallen between the $F_{0.1}$ and F_{max} levels. The method used to derive F_{1980} implies a certain amount

of upward bias (due to probable upward bias in reported landings data) and thus results obtained are probably conservative. Projections for 1981-1982 are consistent with recent commercial and survey indices revealing no appreciable decline in stock size from harvests in the order of 50,000 tons.

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Table 1. Commercial landings and estimated recreational catches of pollock (metric tons, live) for the Scotian Shelf, Gulf of Maine, Georges Bank, and Southern New England-Middle Atlantic areas[1] by country, 1960-1980.

Year	Country							Total commercial	Estimated USA recreational[2]	Grand total
	Canada	USA	FRG	GDR	Spain	USSR	Other			
1960	29,470	10,132	-	-	783	-	1	40,386	9,834	50,220
1961	26,323	10,265	-	-	982	-	1	37,571	9,963	47,534
1962	31,721	7,391	-	-	-	-	-	39,112	7,174	46,286
1963	28,999	6,653	126	-	-	906	28	36,712	5,319	42,031
1964	30,007	6,006	208	-	-	4,603	429	41,253	4,802	46,055
1965	27,316	5,303	71	-	1,361	2,667	11	36,729	4,240	40,969
1966	18,271	3,791	-	-	2,384	9,865	12	34,323	3,031	37,354
1967	17,567	3,312	-	-	1,779	644	10	23,312	2,648	25,960
1968	18,062	3,280	-	-	1,128	372	7	22,849	2,088	24,937
1969	15,968	3,945	1,188	2,195	1,515	227	7	25,045	2,511	27,556
1970	10,753	3,979	3,233	4,317	532	527	40	23,381	2,533	25,914
1971	11,757	4,890	633	6,849	912	2,216	18	27,275	3,113	30,388
1972	18,022	5,729	475	4,816	616	3,495	66	33,219	3,647	36,866
1973	26,990	6,303	1,124	948	3,113	3,092	1,606	43,176	358	43,534
1974	24,975	8,726	149	2	1,500	2,348	102	37,802	496	38,298
1975	26,548	9,318	236	96	709	2,004	124	39,035	530	39,565
1976	23,568	10,863	994	24	303	1,466	390	37,608	618	38,226
1977	24,654	13,056	368	-	2	268	54	38,402	2,694	41,096
1978	26,801	17,714	-	-	-	502	290	45,307	3,656	48,963
1979	29,967	15,541	-	-	-	1,025	99	46,632	3,207	49,831
1980[3]	35,986	18,278	-	-	-	950	212	55,426	3,772	59,198

[1]As reported to ICNAF-NAFO for Divisions 4VWX, Subarea 5, and Statistical Area 6.

[2]Data for 1960, 1965, 1970, 1974, and 1979 as provided by recreational fishery surveys: remaining points estimated.

[3]Provisional (incomplete).

Table 2. Commercial pollock landings (metric tons, live) for the Scotian Shelf, Gulf of Maine, Georges Bank, and Southern New England - Middle Atlantic areas[1], 1960-1980.

	Area				
Year	Scotian Shelf	Gulf of[2] Maine	Georges[3] Bank	Southern New England-Middle Atlantic	Total
1960	29,989	6,563	3,834	-	40,386
1961	29,352	5,042	3,177	-	37,571
1962	32,961	2,575	3,576	-	39,112
1963	30,471	2,178	3,947	116	36,712
1964	32,245	1,754	7,250	4	41,253
1965	27,729	1,933	7,065	2	36,729
1966	24,476	953	8,846	48	34,323
1967	14,787	1,733	6,790	2	23,312
1968	17,623	1,416	3,724	86	22,849
1969	15,221	4,635	5,025	164	25,045
1970	11,402	6,281	5,157	541	23,381
1971	12,072	7,074	7,096	1,033	27,275
1972	20,206	6,419	6,519	75	33,219
1973	30,100	5,202	6,235	1,639	43,176
1974	25,409	6,106	6,233	54	37,802
1975	25,164	6,015	7,848	8	39,035
1976	24,226	6,453	6,915	14	37,608
1977	22,129	8,314	7,846	113	38,402
1978	23,002	12,329	9,943	33	45,307
1979	28,180	10,077	8,356	19	46,632
1980[4]	31,889	11,635	11,879	23	55,426

[1]As reported to ICNAF-NAFO for Divisions 4VWX, Division 5Y, Subdivision 5Ze, and Subdivision 5Zw and Statistical Area 6, respectively.

[2]Subarea 5 NK landings assigned to the Gulf of Maine.

[3]As reported for Division 5Z prior to 1968; landings by subdivision not available for 1960-1967.

[4]Provisional; incomplete.

Table 3. Numbers, total weight, and estimated mean weight(kg) of pollock taken by USA recreational fishermen by area, 1960-1979.

Year	Area: Maine	New Hamoshire	Massa-chusetts	Connecticut-New Jersey	Totals: Number (000's)	Weight (tons)	Mean weight (kg)
1960	-	-	-	-	4,335	9,834	2.27
1965	-	-	-	-	3,756	4,240	1.13
1970	-	-	-	-	2,451	2,533	1.03
1974	146	81	211	43	481	496	1.03
1979[1]	276	419	1,510	342	2,547	3,207[2]	
	(124)	(189)	(681)	(303)	(1,297)	(1,633)[2]	1.26

[1]Numbers in parentheses exclude data for pollock caught and released alive.

[2]Calculated by multiplying numbers caught by mean weight of pollock available for identification in intercept (creel) survey work.

Table 4. Commercial abundance indices for pollock for the Canadian and USA fisheries, 1964-1980.

Year	Canada: Tons per hour fished TC4[1]	TC5[1]	USA: Tons per day fished TC2[2]	TC 3&4[2]
1964	-	-	8.33	6.27
1965	-	-	10.62	7.09
1966	-	-	11.30	7.88
1967	-	-	3.09	6.60
1968	-	-	6.94	5.81
1969	-	-	3.66	6.47
1970	-	-	5.72	5.86
1971	-	-	8.36	5.97
1972	0.52	0.78	8.44	7.68
1973	0.70	0.67	11.59	7.77
1974	0.51	0.67	8.76	7.61
1975	0.48	0.69	5.25	6.27
1976	0.47	0.55	4.67	6.56
1977	0.50	1.05	6.87	8.15
1978	0.25	0.85	7.19	7.28
1979	1.73	2.32	4.69	6.36
1980	1.00	1.07	4.36	7.59

[1]Calculated based on trip data for June, July, and August for side and stern otter trawlers of 150-499 GT and 500-999 GT, respectively, for which 50% or more of the total catch consisted of pollock.

[2]Calculated based on trip data for side and stern otter trawlers of 0-50 GT and 51-500 GT, respectively, for which 50% or more of the catch consisted of pollock.

Table 5. Stratified mean catch per tow at age (numbers) for pollock in Canadian offshore summer bottom trawl surveys on the Scotian Shelf[1], 1970-1980.

	Age													Totals by age[2]				
Year	0	1	2	3	4	5	6	7	8	9	10	11	12+	1+	2+	3+	4+	5+
1970	-	0.01	2.50	0.61	0.37	0.27	0.27	0.22	0.13	0.05	0.00	0.06	0.02	4.51	4.50	2.00	1.39	1.02
1971	-	0.00	1.01	0.75	0.23	0.06	0.03	0.04	0.02	0.01	0.03	0.00	0.00	2.17	2.17	1.16	0.41	0.18
1972	-	0.02	0.14	0.26	1.74	0.52	0.16	0.05	0.08	0.07	0.04	0.02	0.04	3.14	3.12	2.99	2.72	0.98
1973	-	0.00	0.54	0.52	1.61	0.56	0.08	0.03	0.06	0.07	0.01	0.04	0.02	3.53	3.53	2.99	2.47	0.86
1974	-	0.01	0.06	1.32	0.33	0.43	0.23	0.27	0.15	0.12	0.07	0.17	0.06	3.23	3.22	3.16	1.84	1.51
1975	-	0.00	0.01	0.03	0.43	0.39	0.51	0.08	0.13	0.04	0.01	0.01	0.00	1.64	1.64	1.63	1.60	1.17
1976	-	0.00	0.05	0.28	0.79	1.40	0.34	0.56	0.20	0.06	0.06	0.03	0.06	3.83	3.83	3.78	3.50	2.71
1977	-	0.00	0.36	1.05	1.37	2.83	1.99	0.28	0.50	0.17	0.09	0.05	0.02	8.71	8.71	8.35	7.30	5.93
1978	-	0.00	0.01	0.24	0.88	1.28	0.47	0.43	0.14	0.06	0.00	0.00	0.04	3.55	3.55	3.54	3.30	2.42
1979	-	0.00	0.00	0.15	0.87	0.99	0.75	0.33	0.21	0.02	0.05	0.00	0.00	3.37	3.37	3.37	3.22	2.35
1980	-	0.02	0.80	0.94	2.68	4.75	1.65	0.99	0.38	0.14	0.09	0.00	0.00	12.44	12.42	11.62	10.68	8.00

$Z^{3}_{1970-80} = 0.39$; $Z^{4}_{1978-80} = 0.62$

[1]Strata 53-95.

[2]Do not include data for which ages are unknown.

[3]Calculated as $\ln(\frac{\Sigma \text{ age } 5+1970-79}{\Sigma \text{ age } 6+1971-80})$.

[4]Calculated as $\ln(\frac{\Sigma \text{ age } 5+1977-79}{\Sigma \text{ age } 6+1978-80})$.

Table 6. Stratified mean catch per tow in weight (kg) and numbers for Scotian Shelf, Gulf of Maine, and Georges Bank pollock in NEFC offshore spring[1], summer[2], and autumn[1] bottom trawl surveys, 1963-1981.

	Spring[3]				Summer				Autumn			
	Weight		Numbers		Weight		Numbers		Weight		Numbers	
Year	Linear	Retrans-formed	Linear	Retrans-formed	Linear	Retrans-formed	Linear	Retrans-formed	Linear	Retrans-formed	Linear	Retrans-formed
1963	-	-	-	-	10.28	3.45	2.31	1.07	5.79	4.63	1.46	1.27
1964	-	-	-	-	5.27	2.32	2.06	0.96	4.40	2.15	1.64	0.96
1965	-	-	-	-	2.56	1.05	1.72	0.63	2.74	1.85	0.83	0.72
1966	-	-	-	-	-	-	-	-	2.35	1.43	0.97	0.55
1967	-	-	-	-	-	-	-	-	1.80	1.05	0.52	0.41
1968	4.47	2.45	1.09	0.84	-	-	-	-	3.17	2.09	0.69	0.59
1969	2.66	2.22	1.12	0.94	1.75	1.19	0.70	0.47	6.58	2.67	1.31	0.79
1970	4.91	3.04	1.67	1.35	-	-	-	-	2.59	1.80	0.64	0.59
1971	4.39	2.97	1.18	0.99	-	-	-	-	3.96	1.69	1.09	0.65
1972	5.67	3.78	4.43	2.52	-	-	-	-	4.37	2.83	1.41	1.11
1973	4.82	3.33	4.00	1.47	-	-	-	-	4.71	3.59	1.64	1.17
1974	4.10	4.13	1.39	1.20	-	-	-	-	3.17	1.35	0.90	0.51
1975	5.90	4.52	1.67	1.19	-	-	-	-	2.04	1.38	0.70	0.48
1976	6.84	6.51	1.59	1.43	-	-	-	-	16.66	6.69	3.69	1.64
1977	3.44	2.80	1.63	1.18	9.98	8.35	2.07	1.67	8.78	4.81	2.14	1.19
1978	6.56	3.29	2.48	0.98	4.05	3.80	1.29	0.92	5.83	3.31	0.98	0.65
1979	4.75	3.68	1.06	0.93	17.57	4.14	2.96	1.19	5.81	4.29	1.28	0.86
1980	4.40	3.40	1.52	1.09	9.83	6.61	12.21	2.25	4.63	2.99	0.83	0.64
1981	6.30	4.87	2.00	1.34	-	-	-	-	-	-	-	-

[1]Strata 13-40.

[2]Strata 21-28 and 37-40.

[3]The "36 Yankee" trawl was used from 1968-1972, and the "41 Yankee" trawl was used from 1973-1981. No gear conversion factors are available to adjust for differences in fishing power.

Table 7. Stratified mean catch per tow at age (numbers) for Scotian Shelf, Gulf of Maine, and Georges Bank pollock in NEFC offshore spring[1], summer[2], and autumn[1] bottom trawl surveys, 1963-1981.

	Age													Totals				
Year	0	1	2	3	4	5	6	7	8	9	10	11	12+	1+	2+	3+	4+	5+
Spring[3]																		
1970	0.01	0.52	0.05	0.17	0.20	0.05	0.07	0.09	0.12	0.08	0.04	0.04	0.23	1.66	1.14	1.09	0.92	0.72
1971	0.01	0.15	0.13	0.13	0.09	0.07	0.08	0.04	0.09	0.06	0.07	0.07	0.20	1.18	1.03	0.90	0.77	0.68
1972	-	1.20	1.49	0.90	0.20	0.05	0.05	0.07	0.12	0.04	0.07	0.04	0.17	4.40	3.20	1.71	0.81	0.61
1973	-	0.01	2.80	0.51	0.15	0.14	0.04	0.03	0.10	0.04	0.09	0.02	0.09	4.02	4.01	1.21	0.70	0.55
1974	-	0.01	0.10	0.53	0.14	0.08	0.16	0.07	0.03	0.00	0.01	0.10	0.16	1.39	1.38	1.28	0.75	0.61
1975	-	0.01	0.33	0.20	0.34	0.08	0.09	0.10	0.08	0.05	0.06	0.02	0.29	1.65	1.64	1.31	1.11	0.77
1976	-	0.08	0.11	0.14	0.15	0.24	0.13	0.15	0.17	0.11	0.03	0.04	0.24	1.59	1.51	1.40	1.26	1.11
1977	-	0.14	0.38	0.23	0.06	0.16	0.32	0.13	0.11	0.02	0.02	0.01	0.04	1.62	1.48	1.10	0.87	0.81
1978	-	0.00	0.22	0.42	0.65	0.63	0.15	0.11	0.08	0.07	0.05	0.04	0.07	2.49	2.49	2.27	1.85	1.20
1979	-	0.10	0.05	0.07	0.08	0.15	0.14	0.08	0.16	0.08	0.03	0.03	0.08	1.05	0.95	0.90	0.83	0.75
1980	-	0.15	0.15	0.09	0.28	0.25	0.20	0.23	0.08	0.04	0.02	0.00	0.05	1.54	1.39	1.24	1.15	0.87
1981[4]	-	0.02	0.70	0.13	0.15	0.21	0.22	0.09	0.07	0.06	0.08	0.06	0.19	1.98	1.96	1.26	1.13	0.98
Summer																		
1977	-	0.05	0.23	0.09	0.26	0.29	0.32	0.15	0.23	0.07	0.08	0.07	0.23	2.07	2.02	1.79	1.70	1.44
1978	-	0.00	0.57	0.17	0.09	0.08	0.08	0.05	0.09	0.03	0.01	0.05	0.08	1.30	1.30	0.73	0.56	0.47
1979	-	0.05	0.00	0.38	0.26	0.36	0.55	0.36	0.49	0.06	0.21	0.00	0.23	2.95	2.90	2.90	2.52	2.26
1980	-	10.67	0.11	0.06	0.29	0.25	0.30	0.22	0.03	0.02	0.07	0.05	0.13	12.20	1.53	1.42	1.36	1.07
Autumn																		
1970	0.01	0.13	0.08	0.01	0.09	0.08	0.08	0.04	0.02	0.01	0.02	0.01	0.07	0.64	0.51	0.43	0.42	0.33
1971	0.02	0.11	0.38	0.16	0.02	0.06	0.09	0.04	0.08	0.03	0.01	0.01	0.09	1.08	0.97	0.59	0.43	0.41
1972	0.00	0.38	0.27	0.20	0.08	0.07	0.08	0.07	0.05	0.04	0.03	0.03	0.10	1.40	1.02	0.75	0.55	0.47
1973	0.00	0.03	0.71	0.12	0.17	0.11	0.11	0.09	0.07	0.00	0.12	0.02	0.10	1.65	1.62	0.91	0.79	0.62
1974	0.00	0.00	0.08	0.28	0.20	0.11	0.08	0.09	0.01	0.02	0.00	0.02	0.02	0.91	0.91	0.83	0.55	0.35
1975	0.01	0.22	0.06	0.03	0.11	0.07	0.04	0.09	0.01	0.01	0.01	0.01	0.03	0.68	0.46	0.40	0.37	0.26
1976	0.00	0.03	0.03	0.15	0.55	1.63	0.50	0.31	0.14	0.05	0.01	0.01	0.29	3.70	3.67	3.64	3.49	2.94
1977	0.00	0.06	0.17	0.24	0.29	0.42	0.38	0.22	0.11	0.09	0.02	0.00	0.14	2.14	2.08	1.91	1.67	1.38
1978	0.00	0.03	0.19	0.04	0.04	0.09	0.09	0.15	0.08	0.06	0.04	0.03	0.12	0.96	0.93	0.74	0.70	0.66
1979	0.00	0.01	0.02	0.26	0.33	0.19	0.13	0.08	0.09	0.05	0.04	0.01	0.06	1.27	1.26	1.24	0.98	0.65
1980	0.01	0.13	0.01	0.01	0.05	0.11	0.06	0.07	0.13	0.08	0.06	0.04	0.07	0.82	0.69	0.68	0.67	0.62

Spring: $Z^{5}_{1970-80} = 0.23$; $Z_{1978-80} = 0.35$

Autumn: $Z^{6}_{1971-80} = 0.17$; $Z_{1978-80} = 0.55$

[1]Strata 13-40.

[2]Strata 21-28 and 37-40.

[3]The "36 Yankee" trawl was used from 1970-1972, and the "41 Yankee" trawl was used from 1973-1981. No gear coversion factors are available to adjust for differences in fishing power.

[4]Preliminary

[5]Calculated as $\ln\left(\frac{\Sigma \text{ age } 5+ \ 1970-80}{\Sigma \text{ age } 6+ \ 1971-81}\right)$.

[6]Calculated as $\ln\left(\frac{\Sigma \text{ age } 4+ \ 1970-79}{\Sigma \text{ age } 5+ \ 1971-80}\right)$.

Table 8. Stratified mean catch per tow in numbers and weight (kg) for Scotian Shelf, Gulf of Maine and Georges Bank pollock in Massachusetts inshore spring surveys[1] and NEFC inshore summer surveys[2], 1977-1980.

Year	Age 0	1	2	3	4+	Total	Stratified mean catch per tow in weight (kg)
NEFC (summer)							
1977	0.00	1.11	0.82	0.00	0.00	1.92	0.61
1978	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1979	1.17	0.35	0.00	0.00	0.00	1.52	0.18
1980	0.17	0.33	0.00	0.00	0.00	0.50	0.06
Massachusetts (spring)							
1978	2.07	0.01	0.13	0.06	0.00	2.27	0.11
1979	4.34	0.04	0.01	0.06	0.00	4.45	0.07
1980	0.30	8.37	0.20	0.02	0.00	8.89	0.72

[1]Regions 1-5 (strata 11-21 and 25-36).

[2]Inshore strata 52, 55, 56, 58-61, 63-66, 72, 74, and 75.

Table 9. Commercial landings at age (000's) for the Scotian Shelf, Gulf of Maine, and Georges Bank pollock stock, 1973-1980.

	Age															
Year	1	2	3	4	5	6	7	8	9	10	11	12+	Total	Obs.	Cal.	Obs./Cal.
1973	-	1,856	1,595	5,684	4,341	1,049	795	363	457	421	79	31	16,671	43,176	46,003	0.94
1974	-	617	7,281	2,899	3,626	1,327	511	415	112	123	103	56	17,070	37,802	41,954	0.90
1975	-	372	3,346	8,434	1,890	1,655	555	137	55	70	46	38	16,598	39,035	40,350	0.97
1976	-	514	2,952	3,583	4,453	1,233	960	258	28	32	34	70	14,117	37,608	37,637	1.00
1977	-	170	2,526	3,972	2,431	2,937	1,101	609	174	83	44	260	14,307	38,402	38,442	1.00
1978	-	196	3,023	4,686	3,665	1,824	2,071	660	366	152	111	242	16,996	45,307	45,094	1.00
1979	9	233	3,628	6,348	3,922	2,323	717	448	191	74	38	112	18,043	46,632	46,553	1.00
1980	45	368	1,694	4,971	6,370	3,495	1,203	356	259	99	47	74	18,981	55,421	55,466	1.00

Table 10. Mean weights at age (kg)[1] observed in commercial landings for the Scotian Shelf, Gulf of Maine, and Georges Bank pollock stock, 1973-1980.

	Age											
Year	1	2	3	4	5	6	7	8	9	10	11	12+
1973	-	0.78	1.58	2.38	3.12	3.67	4.42	4.96	5.70	5.64	7.40	7.59
1974	-	0.81	1.44	2.18	3.07	4.10	5.10	6.11	6.68	7.27	8.01	8.36
1975	-	0.89	1.47	2.10	2.97	3.95	5.00	6.24	7.07	7.29	7.83	9.19
1976	-	0.81	1.55	2.20	2.97	3.76	4.51	5.18	6.14	7.64	7.66	7.97
1977	-	0.93	1.12	1.62	2.58	3.42	4.43	5.78	6.74	7.06	7.84	8.47
1978	-	0.82	1.11	1.59	2.39	3.58	4.37	5.54	6.45	6.74	7.54	7.89
1979	0.24	0.74	1.32	1.94	2.91	3.77	4.75	5.96	6.48	7.49	7.91	8.35
1980	0.37	1.04	1.70	2.10	3.01	3.43	4.25	5.83	6.38	7.32	7.92	8.77

[1]Calculated by weighting Canadian and USA values by numbers landed at age.

Table 11. Estimates of instantaneous fishing mortality (F) and stock size (000's) at age for the Scotian Shelf, Gulf of Maine and Georges Bank pollock stock calculated from virtual population analysis or VPA, 1973-1980.

Year	Age 2	3	4	5	6	7	8	9	10	11	12+		
	Fishing Mortality[1]											Mean F AGE 5+[2]	
1973	0.039	0.104	0.393	0.711	0.455	0.624	0.599	0.771	0.822	0.657	0.657	0.657	
1974	0.026	0.214	0.276	0.470	0.491	0.420	0.800	0.371	0.484	0.483	0.483	0.483	
1975	0.012	0.192	0.409	0.292	0.407	0.392	0.188	0.223	0.420	0.335	0.335	0.335	
1976	0.013	0.123	0.324	0.395	0.315	0.440	0.319	0.053	0.196	0.371	0.371	0.371	
1977	0.004	0.079	0.242	0.381	0.493	0.515	0.558	0.370	0.220	0.449	0.449	0.449	
1978	0.006	0.080	0.206	0.368	0.551	0.789	0.677	0.791	0.646	0.509	0.509	0.509	
1979	0.014	0.147	0.240	0.267	0.421	0.436	0.385	0.421	0.356	0.326	0.326	0.326	
1980[3]	0.016	0.135	0.306	0.403	0.403	0.403	0.403	0.403	0.403	0.403	0.403	0.403	
	Stock Size (000's)											Nos.	Wt.[4]
1973	52878	17866	19165	9304	3143	1871	880	927	818	179	70	107,101	169,235
1974	26373	41628	13189	10590	3742	1633	821	396	351	294	160	99,177	162,132
1975	34661	21037	27529	8192	5420	1874	879	302	224	177	146	100,441	181,073
1976	45177	28061	14211	14971	5008	2953	1037	596	198	120	248	112,580	201,404
1977	52927	36544	20314	8416	8261	2992	1557	617	463	133	786	133,010	210,407
1978	35968	43246	27642	13058	4708	4132	1464	729	349	304	663	132,263	210,273
1979	18293	29276	32684	18413	7400	2222	1536	609	271	150	443	111,297	227,639
1980	25573[5]	14767[6]	20700[6]	21048[6]	11548[6]	3975[6]	1176[6]	856[6]	327[6]	155[6]	244[6]	100,369	233,106
1981	42403[5]	20605[6]	10563[6]	12480[6]	11517[6]	6319[6]	2175[6]	643[6]	468[6]	179[6]	85[6]	107,439	219,607

[1] Age 12+ values assumed equal to the mean for ages 5-11.

[2] Weighted by stock size (nos.).

[3] Values for age 2-4 determined from partial recruitment vector for 1973-1977.

[4] Calculated from mean weight-at-age data in Table 10, adjusted by observed/calculated ratios.

[5] The observed 1973-1977 mean at age 2.

[6] Calculated as $N_{i+1} = N_i e^{-Z_i}$.

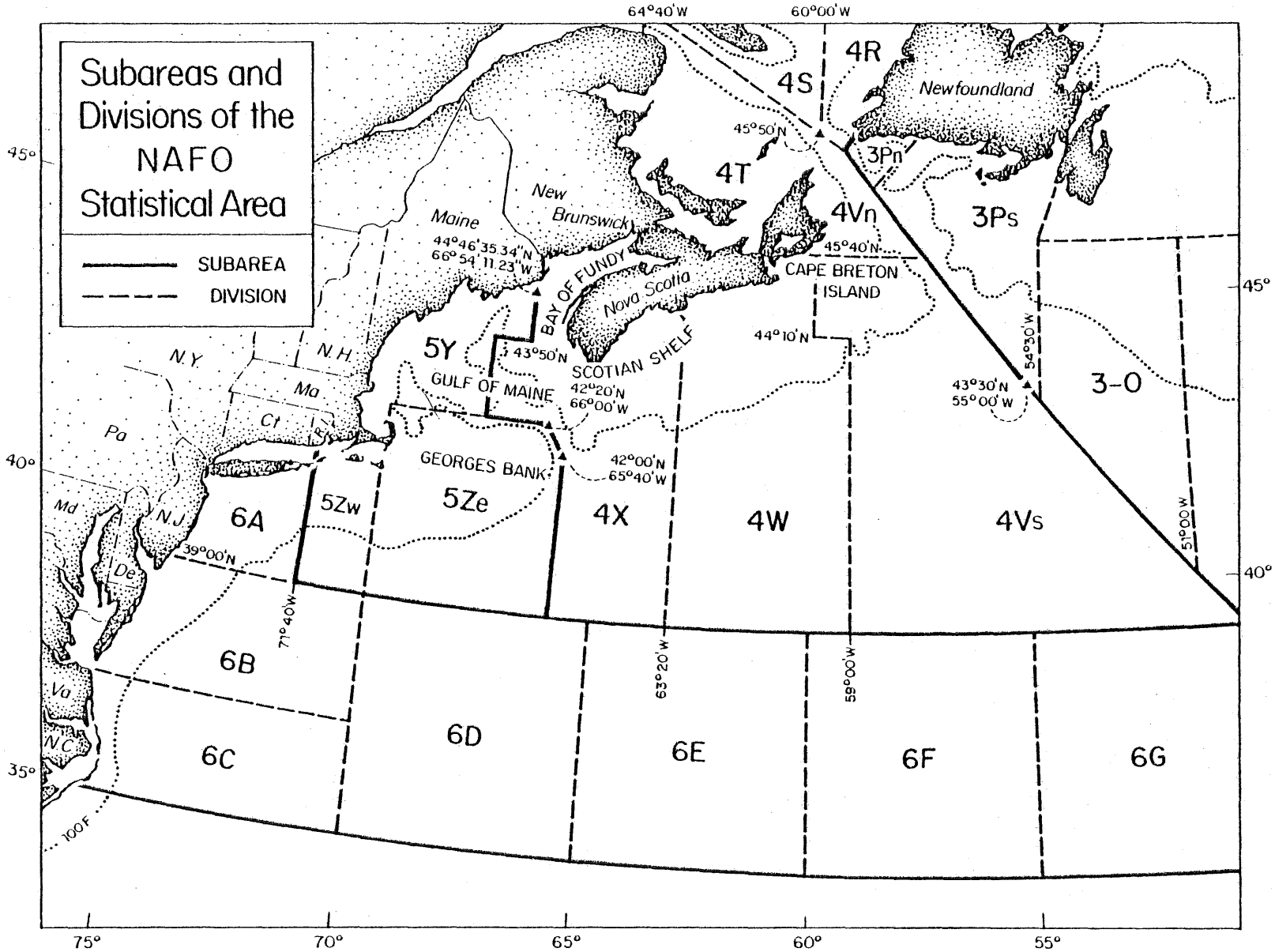

Figure 1. Northwest Atlantic, showing the southern portion of the NAFO area.

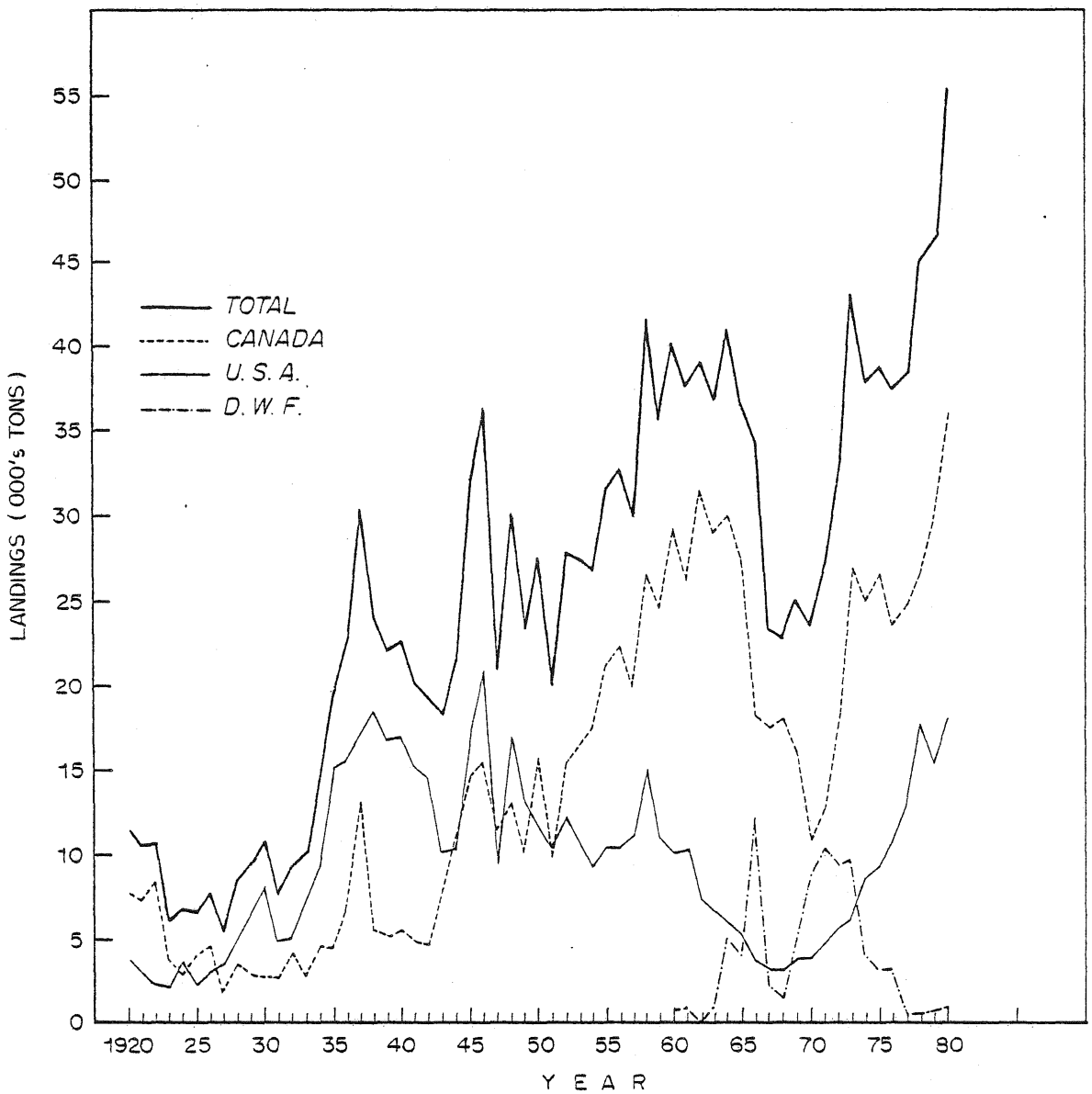

Figure 2. Commercial landings from the Scotian Shelf, Gulf of Maine, and Georges Bank pollock stock, 1920-1980.

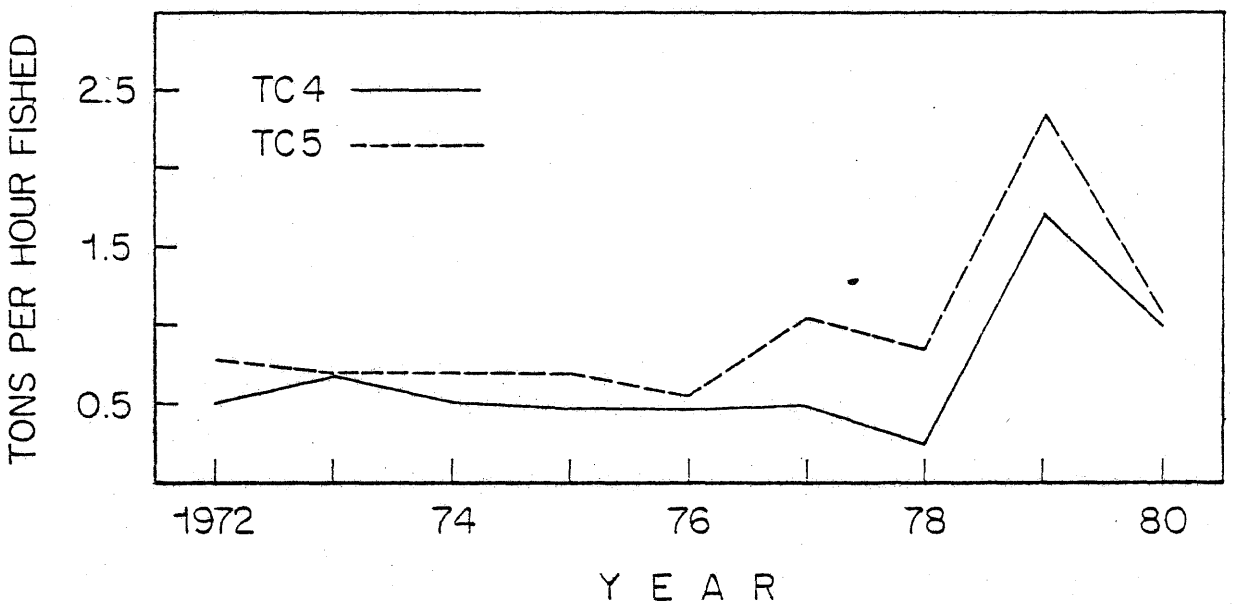

Figure 3. Commercial abundance indices for Scotian Shelf, Gulf of Maine, and Georges Bank pollock for Canadian tonnage class 4 and 5 otter trawlers, 1972-1980. Calculations based on trip data for June, July, and August for which 50% or more of the total catch consisted of pollock.

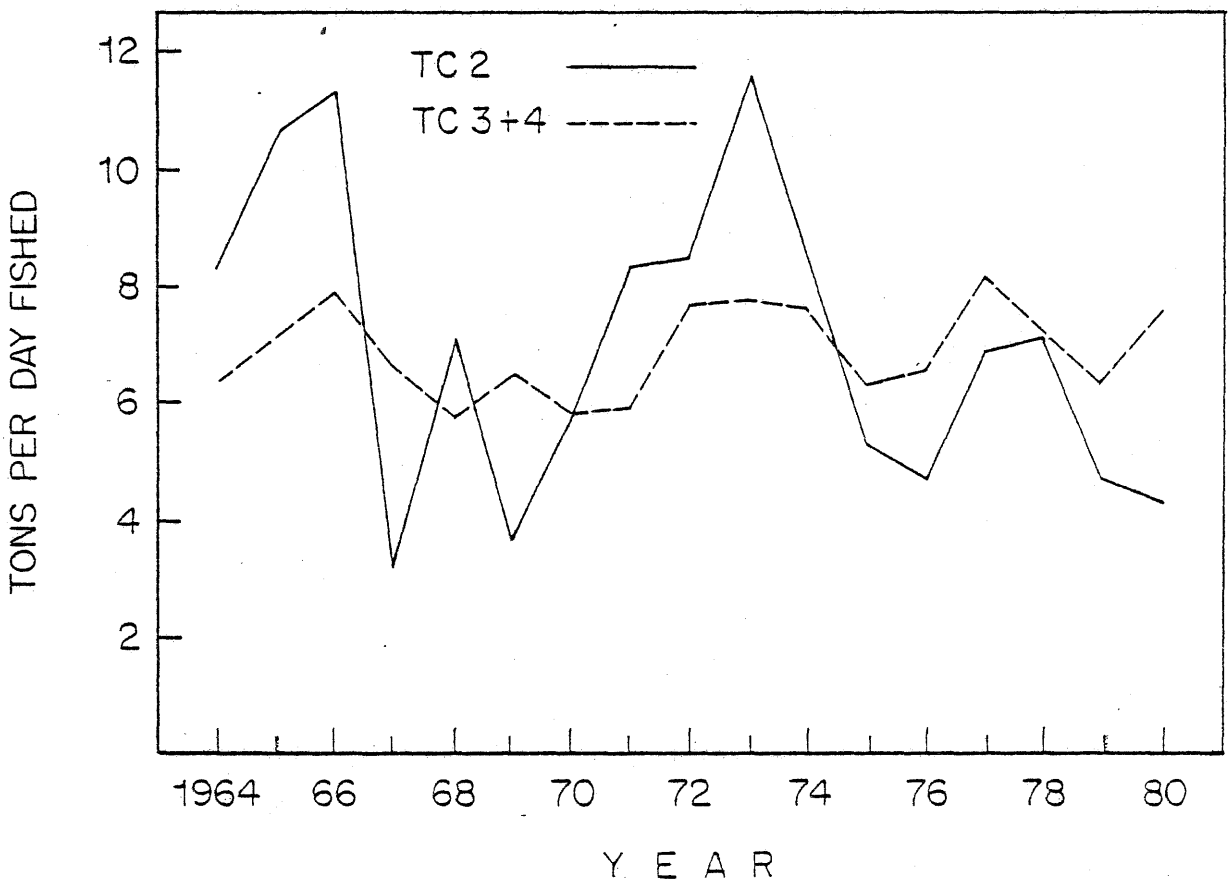

Figure 4. Commercial abundance indices for Scotian Shelf, Gulf of Maine and Georges Bank pollock for USA tonnage class 2, 3, and 4 otter trawlers, 1964-1980. Calculations based on trip data for entire year for which 50% or more of the catch consisted of pollock.

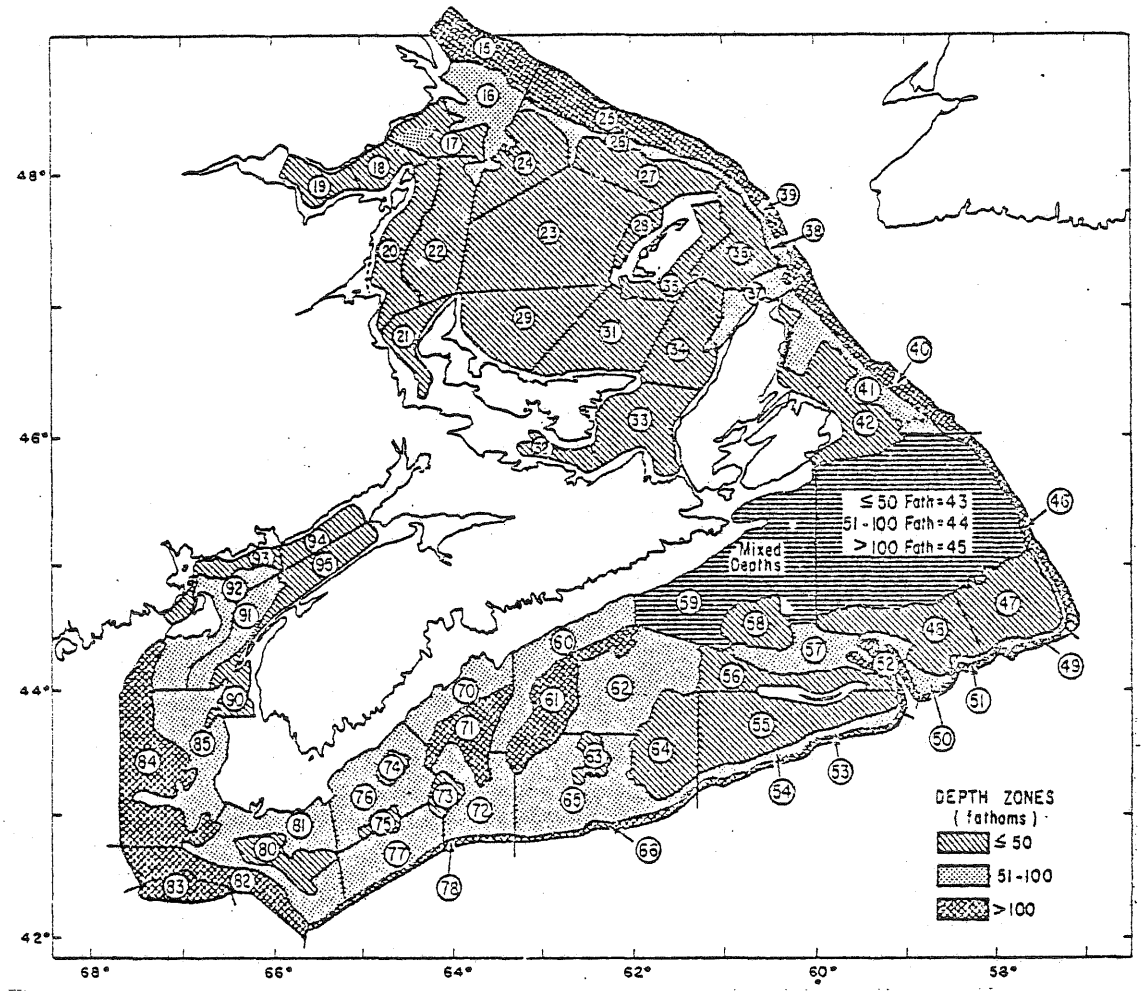

Figure 5. Strata used in Canadian summer bottom trawl surveys, 1970-1981.

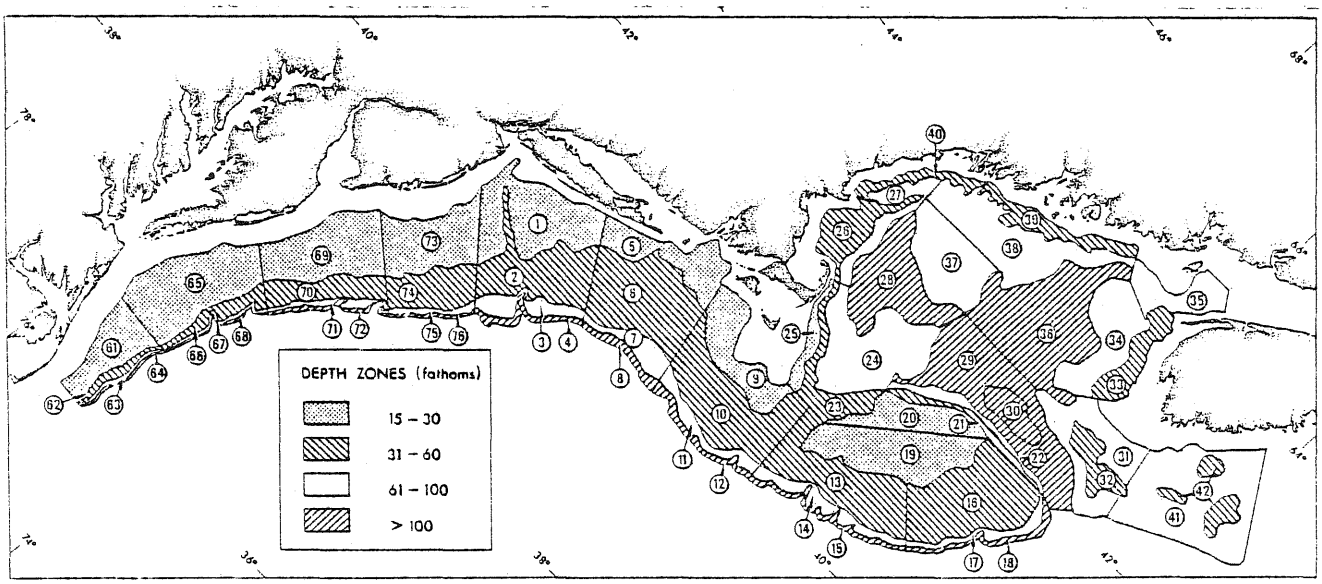

Figure 6. Strata used in USA spring and autumn bottom trawl surveys, 1963-1981.

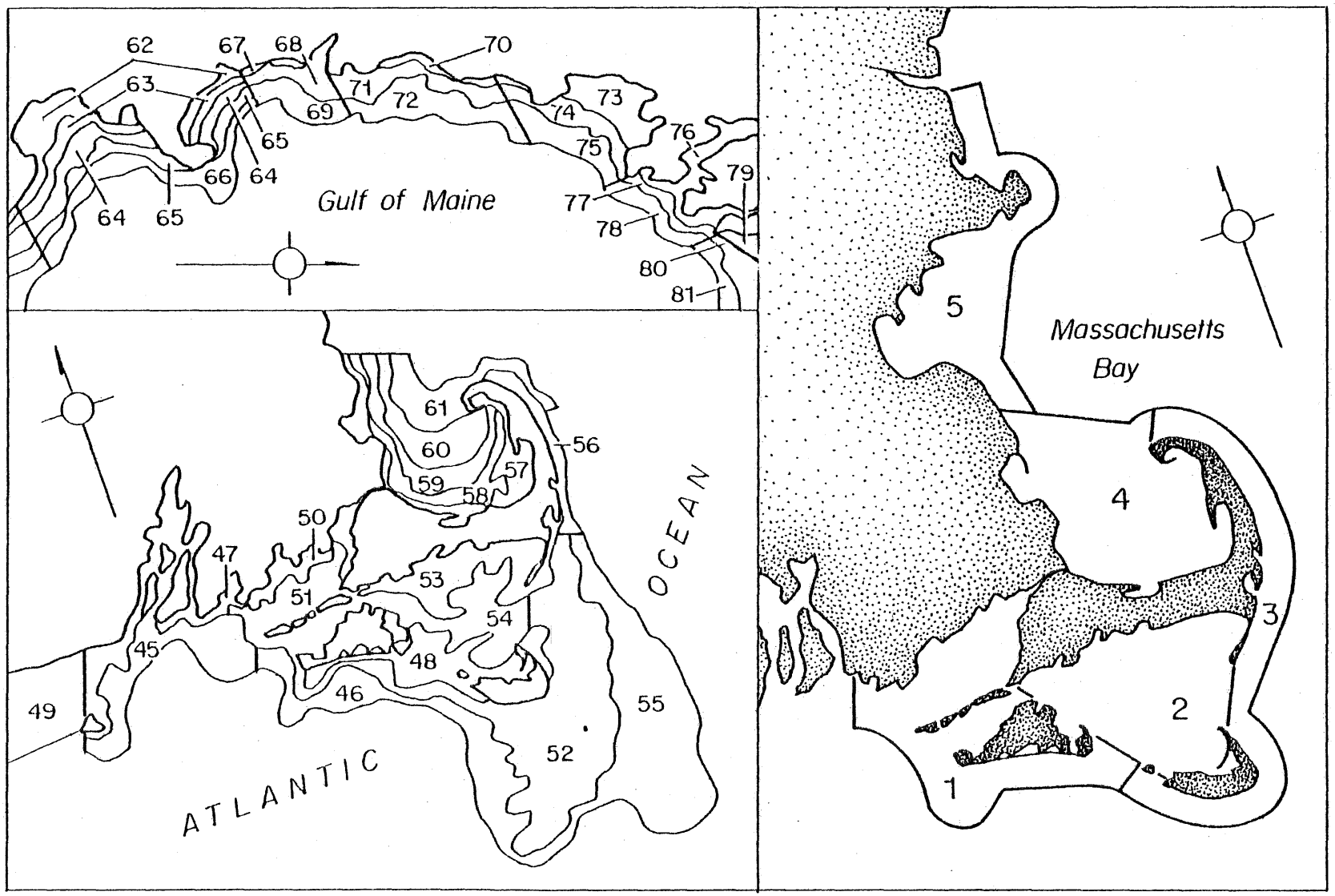

Figure 7. Strata used in NEFC inshore (<27m) spring, summer, and autumn bottom trawl surveys and strata groups used in Massachusetts spring and autumn inshore surveys.

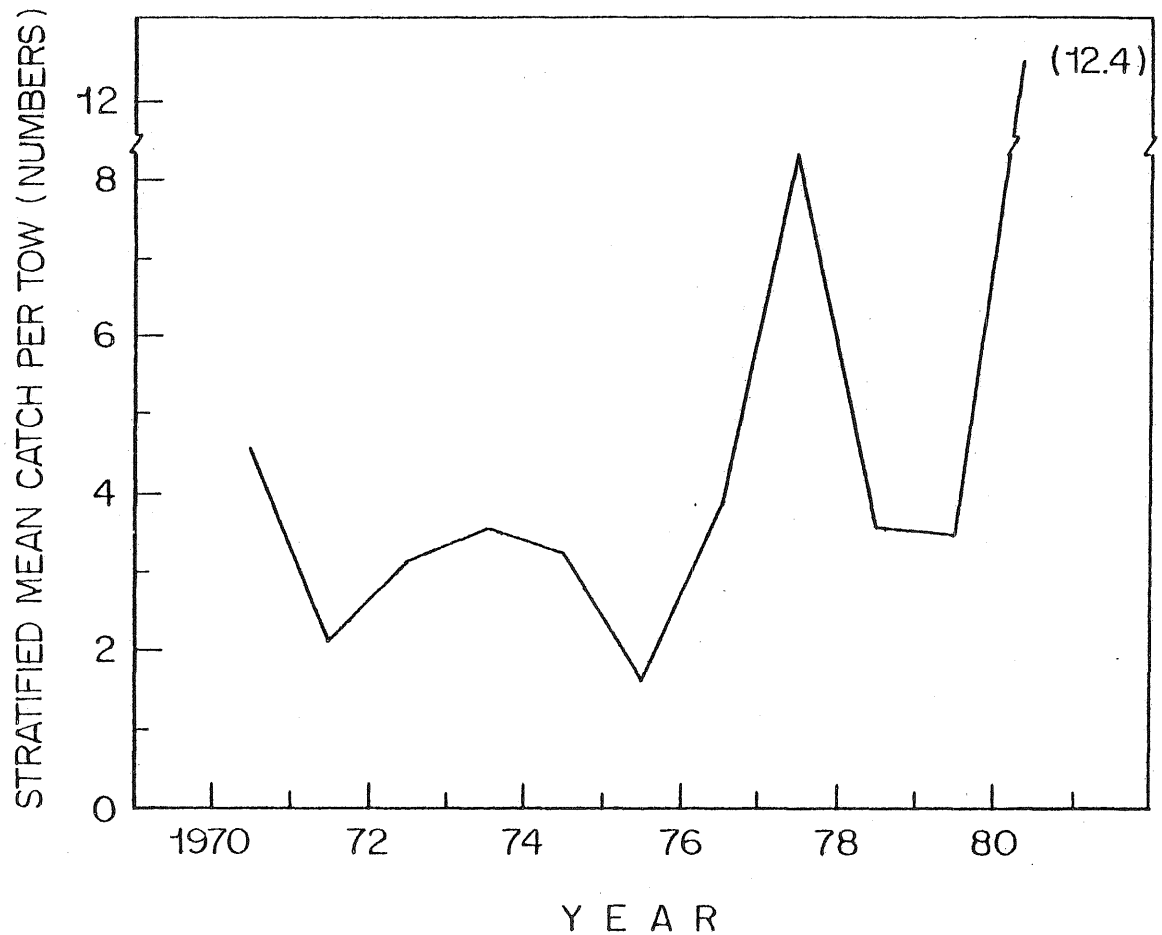

Figure 8. Stratified mean catch per tow (nos) of pollock in Canadian summer bottom trawl surveys on the Scotian Shelf (Strata 53-95), 1970-1980.

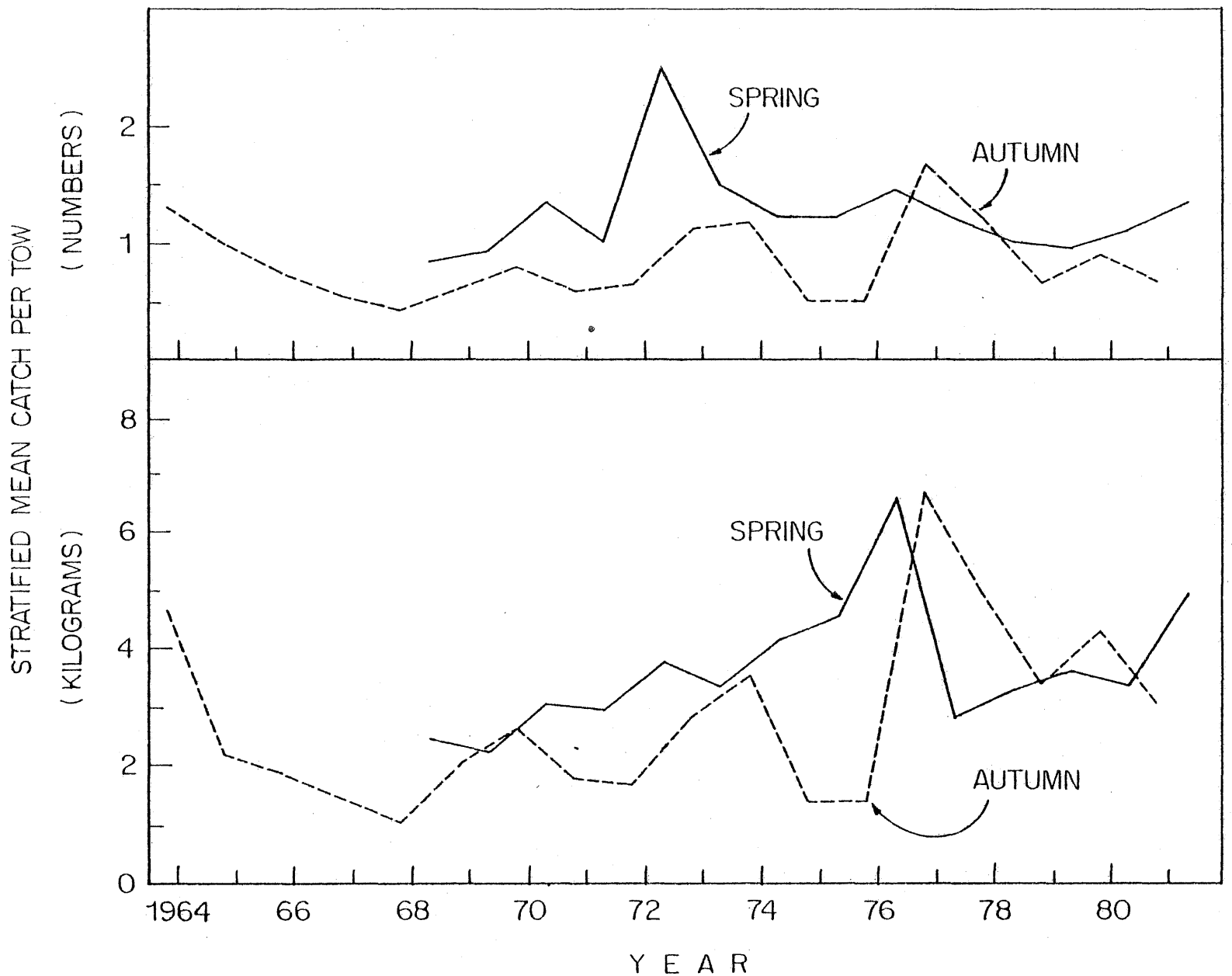

Figure 9. Stratified mean catch per tow in numbers and weight (kg, retransformed from logarithms) of pollock in USA spring and autumn bottom trawl surveys for Georges Bank, the Gulf of Maine, and the Scotian Shelf (Strata 13-40), 1963-1981.

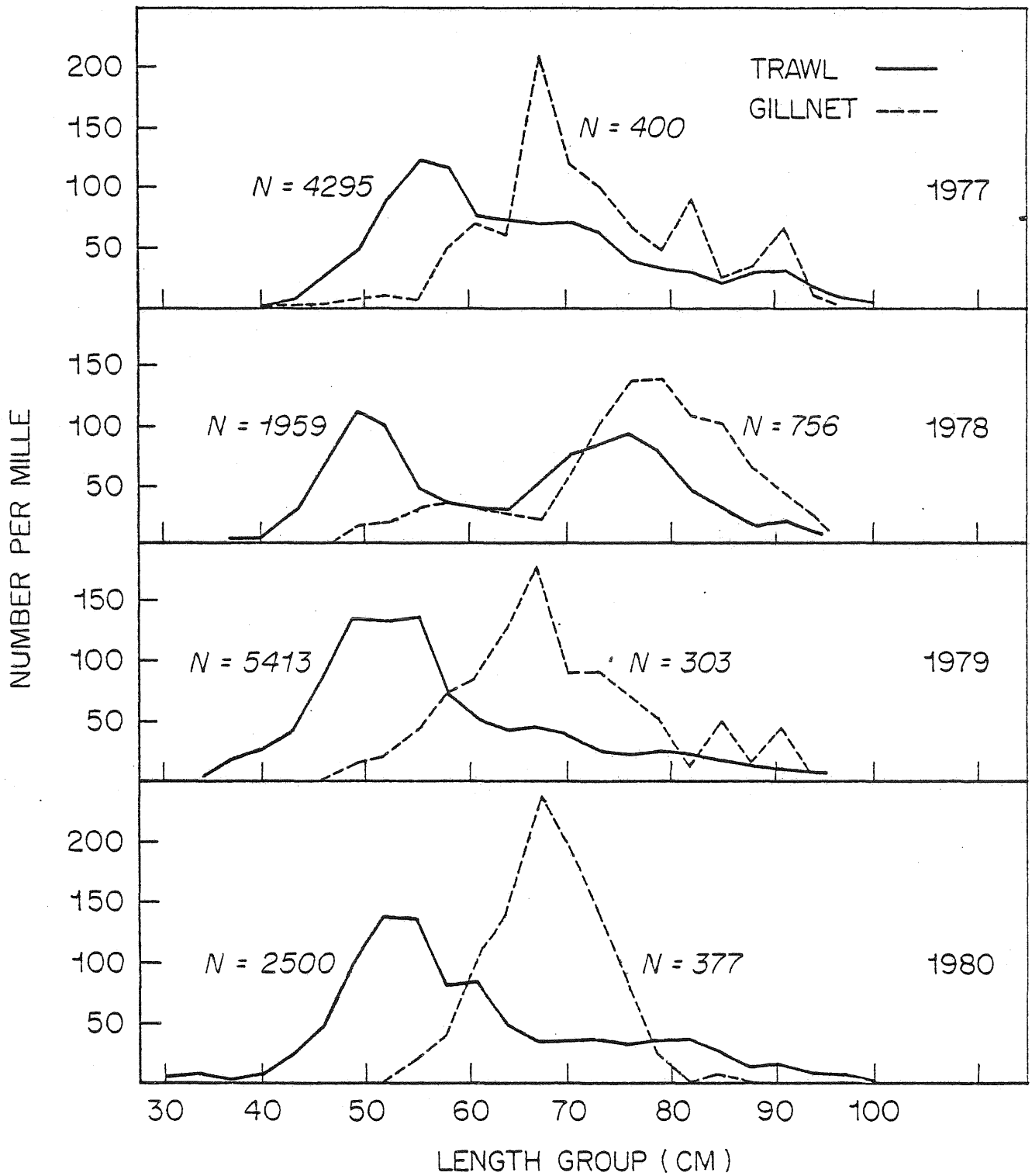

Figure 10. Length frequency distributions of pollock sampled in USA otter trawl and gillnet landings, 1977-1979, and in USA otter trawl and Canadian gillnet landings in 1980.

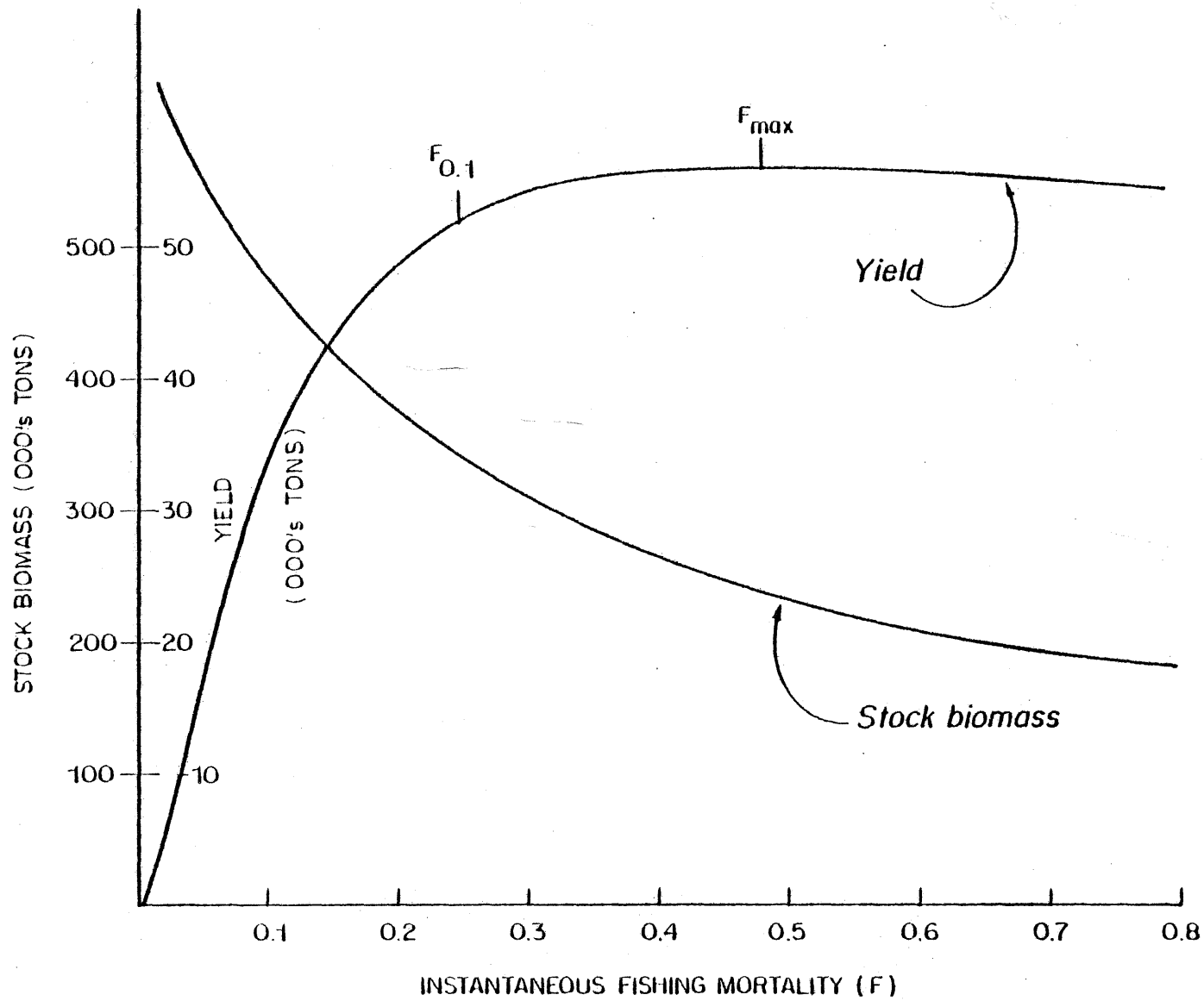

Figure 11. Catch and stock size at equilibrium for Scotian Shelf, Gulf of Maine and Georges Bank pollock assuming recruitment of 42.4 million fish at age 2, partial selection (recruitment) factors equal to the 1973-77 average and mean weights at age equal to the 1979-1980 average.