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AN ASSESSMENT OF THE SCUP *Stenotomus chrysops* (L.), POPULATION IN THE SOUTHERN NEW ENGLAND AND MIDDLE ATLANTIC REGIONS

by

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SUMMARY

Nominal catches of scup, (*Stenotomus chrysops*), by the USA increased from approximately 5,000 metric tons annually in the early 1930's over 20,000 tons per year in the early 1960's. Nominal commercial catch and estimated recreational catch increased to over 31,000 tons in 1963 before declining to less than 7,000 tons per year in the early 1970's. Since 1974, catches have fluctuated between 9,700 and 11,400 tons annually. Distant water fleet catches fluctuated between 2,000 and 5,000 tons in the 1960's, but have been negligible since 1976.

Nominal commercial catches by the USA from the North Atlantic region (Maine to New York) declined from an annual average of 10,000 tons in the early 1960's to 2,000 tons in the early 1970's before increasing to 5,000 tons per year in 1980 and 1981. Recreational catches from this region also declined from an estimated 6,100 tons in 1960 to 1,000 tons in 1970 and then increased to an estimated 2,300 tons in 1979. USA commercial catches from the Middle Atlantic region (New Jersey to Virginia) declined from an average of 12,000 tons in the early 1960's to 2,000 tons in the early 1970's and have increased to an average of 3,000 tons per year between 1974 and 1980 and 4,000 tons in 1981. Estimated recreational catches from this region declined from 2,000 tons in 1965 to less than 100 tons in 1979.

Abundance indices (tons per day fished) for Southern New England trawlers declined from 5.6 tons in 1964 to 2.2 tons in 1971. Values subsequently rose to 6.2 tons in 1977 and have since fluctuated between 5 and 6 tons. Commercial sample data for Southern New England reveal an increase in mean length, mean weight and mean age of scup landed between 1974 and 1980, reflecting a more balanced age structure in the late 1970's. Northeast Fisheries Center (NEFC) research vessel survey indices for the Southern New England area declined during the 1960's and increased during the 1970's and early 1980's. Survey length frequency distributions shifted from a poly-modal structure in the early 1960's to a bi-modal distribution in the early 1970's. Following recruitment of the 1973, 1975, 1977, and 1979 year classes, several modes have again been evident during the late 1970's and early 1980's. Survey indices for the Middle Atlantic suggest a decline in abundance during the 1970's, and autumn survey length frequency distributions were composed primarily of smaller fish. No consistent trends in abundance or biomass are evident from combined survey indices for both areas. However, it is hypothesized that differences in trends between areas primarily reflect distributional shifts in response to changing environmental conditions.

Instantaneous total mortality coefficients (Z) derived from commercial catch at age data increase up to age 4, when recruitment to the commercial gear is complete. Mortality estimates for ages 4 and older ranged from 0.51 to 0.54 for the

1974-1980 period. Assuming instantaneous natural mortality (M) equal to 0.2 implies that instantaneous fishing mortality (F) was approximately 0.3. Relative exploitation rates calculated during the 1960's and 1970's indicate reduced levels of mortality during 1973-81 compared to 1963-72. Yield per recruit calculations provide estimates of 0.35 for F_{max} and 0.20 for $F_{0.1}$, indicating that F in the Southern New England fishery approximated F_{max} during 1974-80.

INTRODUCTION

The fisheries for scup, Stenotomus chrysops (L.), are among the oldest on the Atlantic coast of the United States (Steindachner and Agassiz 1872). This species is now fished commercially from Cape Cod to Cape Hatteras. During summer, floating traps, pound nets, and otter trawls are employed in inshore areas; in winter, an otter trawl fishery is conducted in the deeper offshore waters. In the USA commercial fishery, nominal catches (live weight equivalent of landings excluding discards, herein referred to as landings) averaged less than 10,000 tons annually from the 1930's until the late 1940's, increased to over 20,000 tons per year during the early 1960's, then declined to less than 5,000 tons annually in the early 1970's. Commercial landings have since increased to about 8,000 to 9,000 tons per year from 1978 through 1981. Similarly, nominal recreational catches declined from an estimated 7,500 tons in 1960 to only 2,000 tons in 1970, then increased to 2,800 and 2,300 tons in 1974 and 1979 respectively. Nominal catches by distant water fleets have declined from a high of 5,900 tons in 1963 to less than 100 tons per year since 1976.

Few comprehensive analyses of the scup fisheries have been conducted despite their importance. Neville and Talbot (1964) presented an historical overview of the fisheries, but their data are from the 1930's. More recently, Smith and Norcross (1968) reviewed the offshore winter trawl fishery and Briggs (1968) evaluated the recreational fishery off Long Island. Sissenwine

and Saila (1974) reviewed the Rhode Island floating trap fishery in which scup is the principal component, and Holmsen (1973) described the operation of this fishery. Olsen and Stevenson (1975) and McHugh (1977) briefly summarized the status of scup fisheries in Rhode Island and the New York Bight. Recently, Morse (1978) described the fisheries and reviewed the status of management.

The present paper provides a comprehensive review of scup fisheries in the Southern New England and Middle Atlantic region and assesses their current status. Trends in abundance, recruitment and mortality are evaluated based on analyses of commercial and research vessel survey data. A yield per recruit analysis is presented and used to evaluate options for age at recruitment to the commercial fishery.

BIOLOGY AND DISTRIBUTION

Scup inhabit the area from the Gulf of Maine to Cape Hatteras, North Carolina (Bigelow and Schroeder 1953); they are most abundant in inshore areas between Cape Cod and New Jersey in summer and in offshore waters (40-180 m) between New Jersey and Virginia in winter. During spring, scup migrate from the offshore wintering grounds into coastal waters extending from New England to New Jersey where spawning occurs from May through August (Morse 1978). By September, scup begin to move southward and offshore. Neville and Talbot (1964) noted that winter distribution and movements of scup are related to the location of

the 7.2°C minimum isotherm and Edwards (1965) reported scup in the vicinity of 8°-10°C water during their inshore spawning migration.

Tagging studies conducted during the 1930's (Neville and Talbot 1964) indicated a summer segregation into two contingents; one was located in New Jersey bays and inlets and the other inhabited Long Island Sound and inshore areas off Southern New England. Subsequent tagging during the late 1950's (Cogswell 1960, 1961; Hamer 1970, 1979) reaffirmed the existence of these units and further indicated a separation on the offshore wintering grounds. The Southern New England contingent was reported to overwinter in the area between Baltimore and Hudson/Block Canyons, while the New Jersey group overwintered further south in the offshore areas between Cape Hatteras and Wilmington Canyon. However, the lack of adequate tag returns in these studies precluded any delineation of stock boundaries. Pierce (MS 1981) also studied these data and found no conclusive evidence for separate stocks, although Hamer (1979) observed meristic differences between samples collected off Cape Cod during summer and those collected on the wintering grounds off Virginia. Recent data from NEFC bottom trawl surveys on distribution and size composition of scup presented in this paper suggest that scup inhabiting the Southern New England and Middle Atlantic regions comprise a single population unit.

Scup are relatively slow-growing fish, attaining maximum ages of 13-15 years and maximum lengths of 39-41 cm (Hamer 1970; Finklestein 1969a; Campbell et al. MS 1982). Age at maturity was

reported by Finklestein (1969b) as two years for both males and females. A comprehensive review of the distribution and the biological and fisheries data pertaining to scup is given by Morse (1978) and Hamer (1979).

FISHERY TRENDS

Commercial landings data for the USA are as reported in annual editions of "Fishery Statistics of the United States" for the years 1929-76 (U.S. Department of Commerce 1955-80); more recent data were taken from files of the Northeast Fisheries Center (NEFC), Woods Hole, MA. Recreational catch estimates were obtained from marine angler surveys conducted in 1960, 1965, 1970, 1974, and 1979 (Clark 1962, Deuel and Clark 1968, Deuel 1973, Ridgely and Deuel 1975, and U.S. Department of Commerce 1980). Catches for other years were estimated for the North Atlantic (Maine to New York) and Middle Atlantic (New Jersey to Virginia) regions separately by calculating the ratio of recreational catches to commercial landings for the two closest survey years (see Table 2) and applying a weighted average of these ratios to commercial landings in each of the intervening years. Nominal catches by distant water fleets are as reported to the International Commission for the Northwest Atlantic Fisheries (ICNAF), now the Northwest Atlantic Fisheries Organization (NAFO) (ICNAF 1965-1980; NAFO 1981, 1982).

Landings from all sources (including recreational and distant water fleet catches) peaked at 31,800 tons in 1963 and

then declined precipitously to an average of only 6,700 tons in 1970-71 (Table 1, Figure 1). Total landings have since risen to an average of 11,300 tons in 1977-78 and 10,600 tons in 1980-81 (Table 1).

Commercial Fishery

Between 1930 and 1947, USA commercial scup landings averaged less than 10,000 tons annually. Subsequent landings increased to over 22,200 tons in 1960 (Table 1), declined to less than 4,000 tons in 1971, then increased to 8,900 tons in 1978. Landings in 1980 and 1981 equalled 7,900 and 9,100 tons, respectively (Table 1). During the peak years of the fishery, 45% of the USA commercial scup landings were taken in the North Atlantic region, but since 1977 this percentage has increased to 62% (Table 2).

The USA commercial fishery is prosecuted by a variety of gear types depending on area and season. The Southern New England otter trawl fishery is conducted primarily from April to October in waters from Massachusetts to New York including Long Island Sound. Scup are taken as far east as Nantucket Shoals in late summer; small amounts are also taken during winter in the offshore area between Hudson and Baltimore Canyons. Annual landings in this fishery declined from an average of 8,200 tons during 1958-60 to 1,000 tons in 1970-72, but have since increased to an average of 3,100 tons since 1977 (Table 3). Scup are also caught incidentally in the Southern New England industrial fishery (Edwards 1958; Edwards and Lawday 1960), but have generally accounted for less than 1% of the annual total. Annual

industrial catches have declined from an average of 200 tons in 1957-58 to less than 100 tons since 1977.

In the Southern New England fixed gear fishery, pound nets are used in coastal New York and Massachusetts state waters from April to August, while floating traps are fished off Rhode Island from April to July as prescribed by state regulations. Trends in landings have been similar to those observed for the trawl fishery, declining from an average of 3,600 tons per year during 1963-65 to 1,000 tons in 1970-72 and then increasing to an average of 1,800 tons per year since 1977 (Table 3).

Scup fisheries in the Middle Atlantic region are conducted primarily by New Jersey and Virginia vessels. Three types of gear have been employed off New Jersey. The pound net fishery is the oldest (dating from the 1800's) and, at present, the least significant, with landings of less than 10 tons annually since the late 1960's. The purse seine fishery dates back to 1920; landings increased from an annual average of 1,300 tons during the 1920's to over 2,000 tons during the early 1960's but subsequently declined to zero in 1967 (Table 3). The New Jersey otter trawl fishery operates throughout the year in response to the migratory behavior of scup. The major portion of the catch is taken in autumn and winter from offshore areas between Hudson and Wilmington Canyons. By late winter and early spring, effort shifts to the area between Baltimore and Norfolk Canyons at depths between 70 and 180 m and, by late spring, the fleet is fishing at depths of about 60 m, south of Hudson Canyon. During the summer months, the vessels move into the Long Island Sound-

Southern New England area. In effect, this fishery overlaps the Virginia trawl fishery in winter and the Southern New England trawl fishery in summer. Annual landings averaged 4,000 tons between 1960 and 1962, declined to 1,300 tons during 1970-72, and have since risen to an average of 2,600 tons since 1977 (Table 3).

The Virginia trawl fishery is conducted during winter and early spring in the deeper offshore waters between Baltimore Canyon and Cape Hatteras. The fishery began in 1929 when New England and New Jersey trawlers located concentrations of scup, summer flounder, black sea bass, and croakers in relatively warm, deep water southeast of Virginia (Pearson 1932). Annual landings at Virginia ports averaged 5,500 tons between 1959 and 1961, but subsequently declined to less than 200 tons in 1974-76. Since 1977, however, annual landings have increased to over 1,000 tons. The 1981 total of 1,100 tons is the largest amount taken since 1969 (Table 3). Combined landings from Maryland and Delaware have also declined from 100 tons per year in 1964-66 to less than 50 tons since 1976.

During the peak years of the early 1960's, domestic landings from NAFO Subarea 6 averaged approximately 13,000 tons annually, while the Subarea 5 yield averaged less than 5,000 tons (Table 4). While landings from both areas declined throughout the 1960's, only Subarea 5 exhibited a recovery in the 1970's. Scup landings from the more southerly Subarea 6 are now only about one-third of their former level. Thus, data on commercial landings by area caught reveal the same trends as those by region

of landing, that is, a northward shift in the center of activity.

The reported nominal catch of scup by distant water fleets (principally USSR) declined from 5,900 tons in 1963 (the first year for which statistics are available) to an annual average of 1,100 tons during 1964-75 (Table 4). Since the implementation of FCMA regulations in 1977 catches have averaged less than 100 tons annually. The reported 1980 and 1981 catches were 16 and 1 tons, respectively. Most catches were reported from the area off Southern New England (Subdivisions 5Ze and 5Zw and Division 6A).

Recreational Fishery

The recreational scup fishery commences in May and continues through September in coastal waters off Southern New England, New York, and New Jersey (Briggs 1968). In the North Atlantic region, the recreational landings equalled 61% of the commercial landings in 1960, but subsequently declined to only 42% of the commercial total in 1979 (Table 2). In the Middle Atlantic region the proportion increased from 12% in 1960 to 41% in 1970 and then declined to only 1% in 1979 (Table 2). Because of the lengthy recall period (1 year) involved in the design of the 1960, 1965, and 1970 surveys, these earlier results may be overestimates and are comparable to recent estimates only in a general way (U.S. Department of Commerce 1980). Estimated recreational scup landings declined from 7,500 tons in 1960 to 2,000 tons in 1970, then increased to 2,300 tons in 1979 (Table 1).

Length and Age Composition of Commercial Landings

Commercial length and age samples have been taken since 1974 by NMFS port samplers primarily from otter trawl landings in Southern New England and New York ports (Table 5). Consequently, analyses of commercial length and age composition were limited to the Southern New England-New York area (NAFO Subdivision 5Zw and Division 6A). Samples of landings from other gears were pooled with trawl samples because of the limited number involved. Age/length keys constructed from commercial samples obtained in 1974-78 and from research vessel samples collected in 1979-80 were applied to the corresponding annual length frequency distributions of the commercial landings. Percentage age compositions and mean lengths and mean weights at age are presented in Table 6.

The size of scup landed in the Southern New England commercial fisheries since 1974 has ranged from 16 to 41 cm, with most fish between 20 and 30 cm (Figure 2). Recruiting year classes first appeared in substantial numbers at about 19-23 cm (age 2) in the 1974, 1975, 1977 and 1979 landings, reflecting the abundance of the relatively strong 1972, 1973, 1975 and 1977 year classes. Between 1974 and 1978, the mean length of scup in the landings increased from 20.9 cm to 25.9 cm while mean weight increased from 0.22 kg to 0.45 kg (Table 6). At the same time mean age also increased from 2.4 years in 1974 to 4.1 years in 1978. No trends are evident in either mean lengths at age or mean weights at age over this time span. These results suggest a trend towards a more balanced age structure associated with

improved recruitment and/or reduced mortality during the latter half of the 1970's.

Landings in 1974 were dominated by ages 1-3 but, by 1978, ages 3-7 predominated (Table 6). Landings in 1980 consisted primarily of 1975 and 1977 year class fish. Landings of age 1 scup have increased in years immediately following production of stronger year classes, and the discard of small scup may have been relatively high as well.

The increase in the mean size of scup landed may have been influenced by a shift towards larger mesh in the latter years. However, NMFS interview data indicate a decrease in the proportion of scup landed by vessels using mesh sizes in excess of 76 mm (3 inches) from 40% in 1974 to 22% in 1979.

Traditionally, average weights of scup taken in the recreational fishery have been approximately 0.4 to 0.5 kg. The mean weight of scup reported in the 1979 survey for the North Atlantic region was 0.38 kg, about the same as the 1979 commercial average of 0.37 kg. Thus, it is assumed that the average sizes of scup taken in the recreational and commercial fisheries in recent years have been similar.

TRENDS IN ABUNDANCE

Commercial Catch Per Unit Effort

Catch per unit effort (CPUE) indices for the Southern New England trawl fishery from 1964 to 1980 were calculated from individual trip records in which scup comprised at least 50% of

the total landings. A unit of effort was defined as a day fished and is considered to represent 24 hours of fishing time. Effort data from the Rhode Island floating trap fishery (number of traps) and the Virginia winter trawl fishery (number of vessels) were extracted from "Fishery Statistics of the United States" for the years 1952 to 1976 (U.S. Department of Commerce 1955-1980) and from unpublished data on file at NEFC, Woods Hole, MA for 1977 to 1980. Since the Rhode Island floating trap fishery is largely directed at scup, CPUE data from this component should also provide a reasonable measure of scup abundance. Also, since the fishing season is limited by Rhode Island state regulations (Holmsen 1973), the number of days fished per trap should not vary substantially from year to year. In the Virginia winter trawl fishery, use of number of vessels as an effort index implies upward upward bias for recent years since much of the recent increase in activity of Virginia based trawlers is not directed towards scup (DuPaul and Baker 1979). Thus, the extremely low catch per vessel indices evident since the mid-1970's do not appear representative.

The CPUE index of Southern New England trawlers declined from 5.6 tons per day in 1964 to 2.2 tons in 1971 (Table 7). Jensen (1974) reported a similar decline in scup catch per trip for New York trawlers between 1962 and 1971. Since 1971, however, the Southern New England otter trawl CPUE has steadily increased to 6.2 tons per day in 1979, although the 1980 index declined to 5.0 tons. The number of traps in the Rhode Island floating trap fishery remained relatively stable at about 18 per

year between 1952 and 1964 while the mean annual scup catch per trap rose from 58 to 179 tons (Table 7). Between 1965 and 1969, the number of traps increased by 33% over the former period, and catch per trap declined. Since 1970, however, the number of traps has stabilized at the pre-1965 level and both catch and catch per trap have increased. Throughout the entire period from 1952 to 1980, scup have generally accounted for 50-70% of the total trap catch. During 1961-67, however, when the scup catch per trap indices were highest, the scup proportion consistently exceeded 70% (Table 7).

The data presented by Neville and Talbot (1964) indicate that, between 1922 and 1934, the mean annual catch per trap in Rhode Island increased from 11 tons to 50 tons. Sissenwine and Saila (1974) presented evidence showing an average catch of 45 tons per trap between 1947 and 1951. Thus, the relatively high catch per trap values (>100 tons) evident during the 1960's were considerably higher than any previously documented level. Recent values of about 60 to 90 tons per trap, however, indicate that abundance has increased to that of the pre-1960 level.

The number of vessels in the Virginia winter trawl fishery increased from an average of 57 vessels between 1952 and 1958 to 89 vessels between 1959 and 1962, and then declined to an average of 62 vessels between 1963 and 1974 (Table 7). Despite the decline in the number of vessels during the 1960's, actual effort probably increased since the average vessel size has been increasing throughout the time period. The recent sharp increase in the number of Virginia vessels since 1975 is not a true

indicator of effort in the winter trawl fishery since many of these vessels are currently directing most of their effort towards other species (DuPaul and Baker 1979). However, the continuous decline in scup landings, particularly since 1967, coupled with an apparent increase in effort has resulted in a precipitous decline in scup catch per vessel from 97.2 tons in 1954 to less than 20 tons during the 1970's.

All of the above indices reveal a decline in scup CPUE in the late 1960's and early 1970's. Since then, however, landings and CPUE in the Southern New England area have increased, suggesting increased abundance in this region, while CPUE data for the Middle Atlantic region are inconclusive. The tagging studies conducted during the 1930's and 1950's indicated a possible separation of the scup population into northern and southern components (Neville and Talbot 1964; Hamer 1970, 1979). Of the fisheries described above, the ones which exploit the northern group of scup (Southern New England trawl and fixed gear and New Jersey trawl) appear to be recovering from the declines which occurred during the 1960's. Recent increases in both catch and CPUE in the Southern New England trawl and fixed gear fisheries suggest a rebuilding of this segment of the population. Those fisheries which are dependent upon the southern component of the scup population have, since the early 1960's, become non-existent (New Jersey pound net and purse seine) or remain at historically low levels (Virginia winter trawl fishery).

Research Vessel Survey Indices

The Northeast Fisheries Center (NEFC) has conducted a stratified random bottom trawl survey each autumn since 1963 in offshore (>27 m) waters extending from Hudson Canyon to the Scotian Shelf; coverage in the Mid-Atlantic area from Cape Hatteras northwards commenced in 1967 (Figure 3). A spring survey covering the same area was initiated in 1968, and a summer survey has also been conducted intermittently. Similar surveys have also been conducted in inshore (<27 m) waters since 1972 (Figure 4). The research vessels ALBATROSS IV and DELAWARE II have been used in these surveys; a "36 Yankee" trawl equipped with 41 cm rollers has been used in all summer and autumn surveys and in spring surveys between 1968 and 1972, while a "41 Yankee" trawl equipped with 30-46 cm rollers was used in the spring between 1973 and 1981. Both trawls are equipped with 13 mm mesh codend liners. In all surveys, a 30-minute tow is performed at a vessel speed of 6.5 km/hour (3.5 knots) at each station. The total weight and number and the size composition of each species is recorded for each tow. Additional information concerning NEFC surveys is provided by Grosslein (1969, 1974), Azarovitz (1981) and Clark (1981). Data from these surveys have been used to develop indices of abundance and biomass (stratified mean catch per tow in number and weight (kg)). The Commonwealth of Massachusetts has also conducted bottom trawl surveys in spring and autumn within state coastal waters since 1978 (Howe et al. 1979, 1980, 1981).

Separate autumn survey catch per tow indices were calculated for Southern New England and Middle Atlantic offshore strata, and a combined index was also developed from these strata sets (Table 8). Separate autumn indices were also calculated for inshore Southern New England and Middle Atlantic strata sets to further delineate recruitment patterns (Table 9). Since scup are distributed in deeper offshore water in the more southern part of their range in spring, a combined spring survey index was also developed based primarily on Middle Atlantic strata (Table 10). Because of the high degree of variability associated with catches of young of the year (YOY) scup, YOY (<14 cm) and age 1+ (> 14 cm) indices were computed for all autumn surveys (Tables 8 and 9, Figures 8a and 8b).

Catch per tow indices for combined Southern New England - Middle Atlantic strata are highly variable and no consistent trends in (total) abundance or biomass are evident (Tables 8 and 10). However, examination of age 1+ indices for the combined autumn Southern New England - Middle Atlantic series reveals an increase in age 1+ abundance during the 1970's but very little change in age 1+ biomass (Table 8). The increase in numbers can be attributed to recruitment of several relatively strong year classes during the mid-to-late 1970's. Recruitment patterns are more evident when the autumn survey indices for Southern New England and Middle Atlantic strata are examined separately. In the Southern New England area, several relatively strong year classes appeared in alternate years beginning in 1973 (Table 8), whereas during the 1960's only the 1964 and 1969 year classes

appear to have been strong ones. This has resulted in increased abundance and biomass for age 1+ fish since the early 1970's in the Southern New England area (Table 8). For the Middle Atlantic region, however, few relatively strong year classes were evident during the 1970's, and abundance and biomass for age 1+ fish have declined (Table 8).

NEFC autumn inshore survey results (Table 9) reveal recruitment patterns similar to those seen in offshore autumn surveys. Since 1973, several relatively strong year classes have appeared in the Southern New England area. Except for 1978, when the index was inflated by one unusually large catch of YOY scup, the occurrence of strong year classes coincided with offshore survey results (Table 8). In the Middle Atlantic area, recruitment appears to have been less consistent than for Southern New England. No clear trends are evident in age 1+ abundance in either inshore area.

In summary, it appears that recruitment and subsequent survival of YOY scup has differed considerably between the two areas over the last decade and that the apparent increase in abundance in Southern New England was coupled with a simultaneous decline in the Middle Atlantic area. This shift in relative abundance between the two areas, and the lack of consistent trends in the combined Southern New England - Middle Atlantic indices since 1967, suggests that overall abundance has not changed appreciably; rather distributional changes are indicated. The implications of changing availability are considered further in a subsequent section.

Scup have been one of the most abundant species taken off Cape Cod in Commonwealth of Massachusetts inshore surveys. Young-of-year fish have generally accounted for more than 90% of autumn survey catches of scup by number while spring catches have consisted largely of adult (age 2+) individuals. Age 1 scup (1979 year class) appeared in 1980 surveys in substantially greater numbers than in previous years (Howe et al. 1981). Future surveys should provide valuable information on the relative strengths of recruiting year classes.

Length and Age Composition

Length frequency distributions (stratified mean number per tow at length) were computed from NEFC offshore survey data for the Southern New England (Figure 5) and Middle Atlantic regions (Figure 6) in autumn and for both areas combined in spring (Figure 7). Because of their extreme range, the stratified means were converted to $\log_{10}$ values prior to plotting. Age compositions were also calculated from autumn surveys in the Southern New England region from 1977 to 1980 (Table 11).

Length frequencies in the Southern New England area shifted from poly-modal in the early 1960's to bi-modal in the late 1960's and early 1970's. These data indicate a population composed almost entirely of YOY (<14 cm) and 1 year old (14-19 cm) fish between 1968 and 1972 (Figure 5). During this period there were generally no fish larger than 28 cm and few fish larger than 25 cm present. Beginning in 1974, older fish again began to appear and, by 1978, a number of modes were evident

including fish as large as 40 cm. Age composition data suggest that even in recent years the population has been dominated by age 0 and 1 fish (Table 11).

Autumn survey catches of scup from the Middle Atlantic area have been dominated by smaller fish throughout the entire time series (Figure 6). Few scup larger than 22 cm were taken in any of the years between 1967 and 1977, and subsequent data were inadequate for plotting. In NEFC spring surveys, larger scup have generally been better represented, with the exception of the early 1970's (Figure 7). In recent years larger scup were consistently taken during spring, but were not evident the following autumn. Very few scup larger than 28 cm were taken in inshore NEFC surveys in either spring or autumn between 1972 and 1980. The absence of larger scup in the offshore Middle Atlantic strata during autumn might result from inshore movements, although larger scup tend to be readily available off Southern New England. Accordingly, it is more logical to assume that larger scup which are found off the Middle Atlantic area during spring subsequently migrate to Southern New England. This would support the hypothesis of a single stock throughout the Southern New England-Middle Atlantic region.

Abundance vs. Availability in Relation to Water Temperature

Winter fisheries for scup have historically experienced acute annual fluctuations in yield due to changes in availability and abundance (Neville and Talbot 1964). During the past two decades, declines in catch have been most pronounced in the

Middle Atlantic region, particularly in the Virginia winter trawl fishery (Table 3). Nesbit and Neville (1935) noted that catches of scup in the winter trawl fishery during the early 1930's were taken from a band of deep (>100 m), relatively warm bottom water greater than 7.2°C (45°F). The largest catches occurred during years of extreme cold when scup were concentrated in these relatively confined warm zones. During warmer years, when the area covered by the warmer water was more extensive, scup were scattered over the continental shelf, and catches were considerably less. Similar seasonal trends of increased catches associated with colder water temperatures between 1958 and 1962 were noted by Smith and Norcross (1968).The success of the winter fishery is dependent upon the formation of relatively high concentrations of scup within these restricted zones of warm water in offshore areas. A warming trend would, therefore, reduce the concentrations of scup in the deeper water and possibly cause a northward shift in their winter distribution.

Scup which remain in the vicinity of Hudson Canyon during the winter are thought to migrate towards the New Jersey coast before moving north and east, since a thermal barrier of cold 4°-5°C bottom water exists on the continental shelf off Southern New England during spring (Colton and Stoddard 1973). During autumn, the temperature regime off Southern New England and New York would allow scup to migrate directly offshore. The widely scattered distribution of scup off Southern New England during autumn suggests that scup may proceed directly to the northern part of the wintering grounds without undertaking coastal migrations.

Davis (1979) reported a warming trend in the Middle Atlantic Bight during 1968-76. The mean spring bottom water temperature measured 6.7°C in 1968 and 9.0°C in 1976. The minimum temperature (4.6°C) occurred in 1970 and the maximum (10.1°C) in 1974. Further, annual means before 1972 were less than 7°C, while those since 1972 were greater than 8°C. A similar trend occurred in the Southern New England area between Cape Cod and Hudson Canyon. Recent temperature data presented by Nickerson and Wright (1980), however, suggest that a cooling trend commenced during the late 1970's.

Stratified mean spring bottom temperatures for the Southern New England and Middle Atlantic strata sets between 1968 and 1981 (Table 10, Figure 8c) also indicate a warming trend peaking in 1974, followed by a modest cooling trend. To determine the extent of dispersion in the winter distribution of scup, the coefficient of variation (CV) of the stratified mean number per tow of age 2+ scup (≥14 cm)[1] caught during each of the 1968-79 spring surveys (Table 12) was plotted against the corresponding mean bottom temperature (Figure 8d). Between 1968 and 1974, as water temperatures rose, the corresponding CV's declined, indicating a more uniform dispersal of scup throughout the survey area. Variation in catches remained relatively low until 1977, the first year in which water temperature remained below 8°C. Since then, water temperature has generally remained low and the corresponding CV's relatively high (Table 12).

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[1]By convention, ages are incremented by one year on January 1, and then 1+ scup in autumn becomes 2+ fish in spring.

The plots for age 2+ scup reveal two clusters of points (Figure 8d). In the first cluster, where temperatures are less than 8°C, the CV's are high, ranging from 77 to 98. The second cluster of points represents temperatures in excess of 8°C and relatively low CV's, between 43 and 67. This second cluster corresponds to the period between 1972 and 1976, the peak of the warming cycle.

It appears from these observations that the within-year variability of survey catches and, presumably, the degree of dispersion of scup are related to bottom water temperature. These results corroborate the hypothesis proposed by Nesbit and Neville (1935) to explain the variation in winter catches off the Virginia Capes between 1931 and 1935. Further, elevated spring temperatures throughout the mid-1970's in the northern area between Cape Cod and Hudson Canyon would have afforded scup a wider area of suitable winter grounds, decreasing the probability of a southward migration, and resulting in a general northward progression of the center of abundance.

The simultaneous declines in commercial scup catches in the northern and southern regions of the Middle Atlantic Bight during the 1960's may have resulted from a decline in scup abundance following above average levels of catch and effort in the late 1950's and early 1960's. The subsequent recovery of scup fisheries in the Southern New England and New Jersey area and the continued depressed level of the catches from the Virginia winter trawl fishery appear to be related to a dispersal of scup in the

south and a northward shift in the center of abundance. It should also be noted that Virginia landings of scup, while still low, have been steadily increasing since 1976 concurrent with the recent decline in water temperature.

POPULATION PARAMETERS

Growth

Growth rates of scup have been reported by several authors, based primarily on site-specific collections in the Southern New England-New Jersey regions (Finklestein 1969a; Hamer 1970; Sisson MS 1974; Crecco et al. MS 1981; Pierce MS 1981) (Table 13). Campbell et al. (MS 1982) present growth parameter estimates derived from a comprehensive collection of scale samples taken from Cape Cod to Cape Hatteras during 1977 and 1978 NEFC bottom trawl surveys and from Southern New England commercial landings. This study provided the highest estimate of L_∞ (42.48 cm) and the lowest estimate of K (0.174) (Figure 9), a likely event since the other studies were based exclusively on inshore samples dominated by younger, faster growing fish. As an indication of scup growth throughout their range, the estimates of Campbell et al. (MS 1982) appear most appropriate.

Mortality

Estimates of instantaneous total mortality (Z) were calculated from catch at age data from the Southern New England fishery (Table 14). Annual CPUE at age was determined by

dividing annual catch in numbers at age by fishing effort (expressed as days fished). Fishing effort was estimated by dividing the total commercial landings from NAFO Subdivision 5Zw and Division 6A by the corresponding CPUE of Southern New England otter trawlers (Tables 7 and 14). Mortality estimates were derived by catch curve analysis of the 1969 through 1975 year classes and by pooling over fully recruited ages (Gulland 1969; Ricker 1975). Estimates were obtained by both methods for ages 2+ through 5+ (Table 15a).

The average Z over all year classes ranged from 0.36 for age 2+ to 0.53 for age 4+. Pooled estimates also varied from 0.34 for age 2+ to 0.54 for age 4+. Estimates for age 5+ were similar using either technique (Table 15a). The apparent increase in mortality between ages 2+ and 4+ results from partial recruitment of 2 and 3 year old scup in the commercial fishery. Since these data represent landings, the effect of discarding of smaller fish has not been taken into account. Thus, estimates for ages 4+ and 5+, ranging from 0.51 to 0.54, most accurately reflect total mortality during the 1974-80 period. Assuming instantaneous natural mortality (M) equal to 0.20 (Crecco et al. MS 1981), the level of instantaneous fishing mortality (F) during this period was in the order of 0.3.

Relative Exploitation Rates

Although the results presented here are insufficient to determine if mortality has changed over time, changes in F may have occurred over the last two decades. As an approximation of

F, a relative exploitation rate (E) (Clark 1981) was calculated for four periods between 1963 and 1981 by dividing the average annual commercial catch in weight by the average autumn survey age 1+ weight per tow index for the Southern New England and Middle Atlantic areas (Table 15b). This technique has recently been employed to approximate fishing mortality for mackerel (Anderson 1979) and cod (Serchuk et al. 1982).

Relative exploitation rates for the Southern New England area were highest during 1963-67, declined through 1968-72, and then stabilized during 1973-81. Values for the 1978-81 period are approximately the same as those for the 1973-77 period and are well below those from the 1960's. The results from these calculations indicate a relatively high fishing mortality rate during the 1960's and early 1970's compared to more recent years. In the Middle Atlantic area, relative exploitation rates were stable between 1968 and 1977, but have since increased sharply (Table 15b).

YIELD PER RECRUIT

Yield per recruit calculations were performed using the Beverton and Holt (1957) model as modified by Paulik and Gales (1964). Growth parameters used are those determined by Campbell et al. (MS 1982) and length-weight parameters are from NEFC research vessel data as reported by Morse (1978). All parameters utilized in the calculations are given in Table 16.

Yield estimates for scup are particularly sensitive to the value of M used in the analysis because of the relatively low level of F at which maximum yield per recruit is achieved (F_{max}). Pierce (MS 1981) obtained a doubling of the yield when M decreased from 0.36 to 0.11. Trial runs performed in the present study with levels of M varying from 0.1 to 0.3 and mean age at recruitment varying from 2 to 4 years resulted in an increase in F_{max} and a decrease in corresponding yield as M increased (Figure 10). The maximum yield per recruit at M equal to 0.3 was approximately 37% of that obtained at M equal to 0.1 (Table 17). The intermediate value of M equal to 0.2 was used by Crecco et al. MS 1981) in their analysis of Long Island scup and was considered appropriate given the growth rate and lifespan of scup.

Mortality estimates presented earlier in this paper suggest that scup are fully recruited to the commercial fisheries by age 4. Therefore, a mean age at recruitment of 3 years should be appropriate, although local variations can be expected among gears (Crecco et al. MS 1981).

The relationship between age at entry and mesh size was examined by determining the minimum selection length for each mesh size utilized in the scup fishery. The length of the diagonal of the mesh opening was calculated from the expression:

$$M_o = \sqrt{2*(1/2M_s)^2} = {}^1/_2 M_s \sqrt{2} = 0.707\ M_s$$

where:

M_o = mesh opening (mm), and M_s = stretch mesh measurement

(mm), and fish length was determined from the regression of scup fork length on body depth as given by Smith and Norcross (1968). Minimum age at entry was calculated from the estimated selection lengths using the von Bertalanffy growth equation (Table 18). The retention lengths given in this table represent minimum theorectical values rather than mean selection lengths. These estimates, however, appear reasonable considering the value of the calculated selection factors determined from the estimated lengths. A mean recruiting age of 2 years corresponds to a mesh of 76 mm. Scup are captured primarily by trawls with cod end mesh sizes of between 76 and 114 mm; thus, a mean age at recruitment of 3 years appears reasonable for these mesh sizes (Table 18).

The yield curve with t_p' equal to 3 years and M equal to 0.20 indicates a conditional maximum yield per recruit of 178.1 gms at an F_{max} value of 0.35 (Table 17; Figure 10). The $F_{0.1}$ value, defined as the level of F at which the change in yield per recruit with respect to the change in F is 10% of that which would occur if the fishery began on a virgin stock (Gulland and Boerema 1973), is estimated to be 0.20 with a corresponding yield of 166.9 gms. Thus, F for the Southern New England fishery appears to have been at or about the F_{max} level in recent years. The relative exploitation rates presented above suggest that F was considerably higher in the 1960's and early 1970's.

CONCLUSIONS

Scup landings declined from over 20,000 tons annually during the early 1960's to less than 7,000 tons in the early 1970's. Although landings of scup have increased throughout the entire Atlantic Coast during the 1970's and early 1980's, the recovery has primarily occurred in the Southern New England area. Commercial and survey abundance indices for the Southern New England area suggest a gradual increase in the scup population during the middle and late 1970's, reversing a declining trend which was evident throughout the 1960's. During the 1970's, stock abundance and biomass was augmented by recruitment of several strong year classes appearing in alternate years. As a consequence, the age structure of the population broadened, and landings by every major gear type have more than doubled since 1972. Despite this increase in landings, the pattern of relative exploitation rates implies a decrease in fishing mortality during the 1970's compared to earlier years. The current level of F appears to be at or near F_{max}.

Abundance indices for the Middle Atlantic region are less conclusive, but available data do not suggest any substantial recovery of the scup population. Although landings have followed the same pattern of decline and subsequent recovery, much of the recent increase was due to New Jersey trawlers which fish during summer in the Southern New England area. The Virginia winter trawl fishery has remained at historically low levels throughout the 1970's, and has only begun to exhibit a resurgence in 1980

and 1981. Recruiting year classes have appeared in this area at less frequent intervals than in the Southern New England area in the 1970's. Research vessel survey indices suggest a decline in abundance, and relative exploitation rates have increased sharply in recent years.

The above trends appear to have been influenced to a great degree by changes in distribution, as combined indices for both areas do not reveal consistent trends. The dispersal of scup on the southern wintering grounds and the consequent northward shift in the center of abundance, in response to elevated water temperatures during the early 1970's, appear to have persisted through the late 1970's. Recent increases in Virginia winter trawl landings in 1980 and 1981 may signal a return of scup to their former distribution pattern.

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Table 1. Scup landings (metric tons, live) from the Northwest Atlantic (Maine to Virginia), 1930-1981.

Year	USA Commercial	USA Recreational	Other Countries	Total
1930	5441			
1931	5556			
1932	6220			
1933	5508			
1934	N/A			
1935	7214			
1936	N/A			
1937	8514			
1938	9477			
1939	8494			
1940	9344			
1941	N/A			
1942	7099			
1943	6726			
1944	8789			
1945	9915			
1946	6375			
1947	8474			
1948	13997			
1949	13130			
1950	16069			
1951	16530			
1952	15221			
1953	19511			
1954	20947			
1955	20094			
1956	16394			
1957	15632			
1958	17734			
1959	21357			
1960	22236	7529		
1961	20994	7432		
1962	20831	7333		
1963	18884	7059	5863	31806
1964	17204	6682	459	24345
1965	15785	6530	2089	24404
1966	11960	4948	823	17731
1967	8748	3757	896	13401
1968	6630	2945	2251	11826
1969	5149	2214	485	7848
1970	4493	2005	288	6786
1971	3974	1706	889	6569
1972	4203	1592	1647	7442
1973	5024	2235	1783	9042
1974	7106	2776	958	10840
1975	7623	2806	685	11114
1976	7302	2366	87	9755
1977	8330	2796	28	11154
1978	8936	2511	3	11450
1979	7960	2300	0	10260
1980	7858	2143	16	10017
1981	9061	2168	1	11230

1981 Landings provisional
N/A Not Available

Table 2. USA commercial and recreational landings of scup (metric tons, live) by region, 1960-1981.

	North Atlantic ME to NY				Mid-Atlantic NJ to VA				Total ME to VA		
Year	Recr.-Comm Ratio	Comm Land.	Est. Recr. Land.	Tot. Land.	Recr. Comm. Ratio	Comm Land.	Est. Recr. Land.	Tot. Land.	Comm. Land.	Recr. Land.	Tot. Land.
1960[1]	.614	9908	6087	15995	.117	12328	1442	13770	22236	7529	29765
1961[2]	.598	9635	5762	15397	.147	11359	1670	13029	20994	7432	28426
1962	.582	8973	5222	14195	.178	11858	2111	13969	20831	7333	28164
1963	.566	8747	4951	13698	.208	10137	2108	12245	18884	7059	25943
1964	.550	8263	4545	12808	.239	8941	2137	11078	17204	6682	23886
1965[1]	.534	8620	4603	13223	.269	7165	1927	9092	15785	6530	22315
1966[3]	.525	6121	3214	9335	.297	5839	1734	7573	11960	4948	16908
1967	.515	4810	2477	7287	.325	3938	1280	5218	8748	3757	12505
1968	.506	3953	2000	5953	.353	2677	945	3622	6630	2945	9575
1969	.496	2189	1086	3275	.381	2960	1128	4088	5149	2214	7363
1970[1]	.487	2136	1041	3177	.409	2357	964	3321	4493	2005	6498
1971[4]	.533	2156	1148	3304	.307	1818	558	2376	3974	1706	5680
1972	.578	1960	1133	3093	.205	2243	459	2702	4203	1592	5795
1973	.624	3303	2059	5362	.102	1721	176	1897	5024	2235	7259
1974[1]	.669	4149	2776	6925	.000	2957	0	2957	7106	2776	9882
1975[5]	.620	4516	2799	7315	.002	3107	7	3114	7623	2806	10429
1976	.571	4119	2350	6469	.005	3183	16	3199	7302	2366	9668
1977	.521	5322	2775	8097	.007	3008	21	3029	8330	2796	11126
1978	.472	5240	2474	7714	.010	3696	37	3733	8936	2511	11447
1979[1]	.423	5370	2269	7639	.012	2590	31	2621	7960	2300	10260
1980[6]	.423	4985	2109	7094	.012	2873	34	2907	7858	2143	10001
1981	.423	5009	2119	7128	.012	4052	49	4101	9061	2168	11229

1981 Landings provisional

[1]1960,1965,1970,1974 and 1979 recreational scup landings taken from recreational angler surveys for the North Atlantic and Mid-Atlantic regions.

[2]1961-1964 recreational scup landings estimated for the North Atlantic and Mid-Atlantic regions separately by interpolating 1960 and 1965 ratios of recreational/commercial landings and applying the resulting values to 1961-1964 commercial landings.

[3]1966-1969 recreational scup landings estimated for the North Atlantic and Mid-Atlantic regions separately by interpolating 1965 and 1970 ratios of recreational/commercial landings and applying the resulting values to 1966-1969 commercial landings.

[4]1971-1973 recreational scup landings estimated for the North Atlantic and Mid-Atlantic regions separately by interpolating 1970 and 1974 ratios of recreational/commercial landings and applying the resulting values to 1971-1973 commercial landings.

[5]1975-1978 recreational scup landings estimated for the North Atlantic and Mid-Atlantic regions separately by interpolating 1974 and 1979 ratios of recreational/commercial landings and applying the resulting values to 1975-1978 commercial landings.

[6]1980-1981 recreational scup landings estimated from the 1979 ratio of recreational/commercial landings.

Table 3. USA commercial scup landings (metric tons, live) by state and major gear type, 1952-1981.

	North Atlantic Region								Middle Atlantic Region					
	Massachusetts		Rhode Island		Connecticut		New York		New Jersey			Virginia	Delaware	Maryland
Year	Otter Trawl	Pound Net	Otter Trawl	Floating Trap	Otter Trawl	Pound Net	Otter Trawl	Pound Net	Otter Trawl	Pound Net	Purse Seine	Otter Trawl	All Gear	All Gear
1952	348.0	25.8	998.6	994.0	720.8	0	3954.0	31.4	2321.9	958.6	1100.3	3450.2	29.9	102.6
1953	316.6	17.1	963.1	1484.0	1046.6	0.1	4525.2	52.5	4578.1	926.6	1586.3	3798.7	8.2	38.6
1954	132.1	23.6	907.2	1686.6	932.1	0.1	5531.4	53.0	4502.8	542.2	1129.1	5246.0	10.5	29.1
1955	441.2	18.4	909.2	1773.4	1539.2	0.1	5760.4	91.8	2761.7	188.5	499.1	5962.1	5.4	56.2
1956	509.6	9.0	1092.0	1156.8	720.8	0.1	4804.5	55.3	1994.5	247.4	507.2	5115.9	16.3	58.1
1957	649.2	3.7	970.6	1477.9	485.1	0	5034.4	158.6	2930.8	435.5	199.4	2867.6	3.6	81.2
1958	530.3	38.6	1354.1	1238.3	594.2	0	6282.2	60.5	2728.0	471.5	855.8	3088.6	0.5	48.5
1959	560.2	87.2	1092.3	1793.1	610.4	0	5833.0	118.7	3595.9	447.8	1694.1	5224.4	0	126.1
1960	523.6	31.3	1166.0	1789.8	513.1	0	5690.0	31.8	4293.6	215.5	1690.3	6077.0	0	47.2
1961	488.0	6.0	1019.6	2179.1	449.7	0	5033.9	233.5	3852.9	46.9	2307.7	5105.5	0	44.9
1962	607.1	22.5	995.3	2051.6	445.5	0	4707.1	50.1	4236.9	240.6	2269.4	5058.7	0.5	46.3
1963	331.9	6.8	916.7	2924.8	344.1	0	3882.8	150.5	3097.0	113.5	2554.3	4331.5	0	30.8
1964	209.4	12.9	537.9	3396.1	327.2	0	3291.3	265.1	3491.0	8.7	375.9	4955.7	0.5	98.9
1965	126.0	65.6	895.8	3679.3	434.7	0	2845.5	362.6	4030.6	22.2	71.0	2843.4	0	191.4
1966	101.8	91.2	1018.8	2856.2	235.3	0	1593.5	81.9	1869.6	56.7	38.4	3718.5	0	108.9
1967	82.1	221.1	562.4	2347.8	104.5	0	1218.0	102.2	1782.4	7.2	31.7	2008.1	0	91.6
1968	110.9	199.9	869.3	1272.6	229.8	0	1007.9	103.9	1546.6	3.8	0.1	1092.3	0	22.7
1969	68.0	50.3	381.0	563.0	61.1	0	653.4	40.1	1639.5	1.1	0	1272.9	0	22.2
1970	168.1	11.2	335.5	996.7	45.3	0	438.2	37.8	1412.2	0.8	0	941.1	0	2.3
1971	166.2	80.5	397.3	843.7	49.0	0	485.1	56.7	935.6	0.9	0	866.8	0	12.2
1972	122.6	115.9	326.9	733.5	25.6	0	474.4	65.9	1653.8	0.2	0	588.5	0	0.2
1973	204.8	84.7	706.3	798.5	86.4	0	612.2	352.0	1346.0	0.5	0	372.4	0	0.5
1974	249.8	154.4	812.7	1006.4	27.1	0	1020.6	258.3	2734.8	1.1		214.0	0	1.4
1975	162.7	104.9	1035.4	1387.7	33.5	0	1054.8	311.8	2835.5	6.4	0	184.9	0	77.6
1976	513.6	264.0	941.1	1012.3	180.7	0	836.8	148.5	3043.9	0.4	0	121.7	0	15.8
1977	449.7	206.3	1490.7	1487.2	96.6	0	1024.8	253.8	2617.6	0.4	0	361.7	0	17.8
1978	468.6	115.2	1052.1	1729.7	172.2	0	1232.1	205.2	3149.6	0.2	0	489.1	0	2.1
1979	457.4	229.0	1906.0	1187.0	79.2	0	1045.6	167.6	2170.6	0.3	0	385.3	0	21.2
1980	375.5	144.3	1365.6	1554.8	79.0	0	944.1	56.1	2307.6	1.4	0	528.1	0	31.5
1981	176.0	155.5	1647.1	1291.4	22.2	0	1205.8	92.1	2989.5	0.4	0	1053.4	0	8.5

Table 4. Commercial landings of scup (metric tons, live) by Northwest Atlantic Fisheries Organization (NAFO) area.

Year	Domestic Landings											Distant Water Fleet Landings											
	NAFO Division										Grand	NAFO Division											Grand
	5Y	5Ze	5Zw	5Nk	5Total	6A	6B	6C	6Nk	6Total	Total	5Y	5Ze	5Zw	5Z	5Nk	5Total	6A	6B	6C	6Nk	6Total	Total
1961	4	46	3903		3953												-						
1962	61	46	3892		3999												-						
1963	19	50	4278		4347				14543	14543	18890	1441			3191		4632				1231	1231	5863
1964	11	14	4576		4601				13039	13039	17640						-				459	459	459
1965	0	59	5079		5138				11078	11078	16216				1371		1371				718	718	2089
1966	0	16	4265		4281				8154	8154	12279				257		257				566	566	823
1967	5	12	3368		3385				5589	5589	8974				347		347				549	549	896
1968	0	0	2759		2759				4047	4047	6806		1244	538			1782				469	469	2251
1969	1	2	1081		1084				3645	3645	4729		30	170		7	207	86	86	88	18	278	485
1970	2	1	1528		1531				3009	3009	4540		51	42		90	183	54	40	11		105	288
1971	8	6	1471		1485				2516	2516	4001		74	148		54	276	282	300	31		613	889
1972	4	7	1195		1206				2967	2967	4173		205	551			756	317	438	136		891	1647
1973	0	3	1378		1381				3551	3551	4932		200	507			707	216	756	104		1076	1783
1974	1	58	2161		2220	2650	2157	81	2	4890	7110		51	138			189	466	293	10		769	958
1975	7	15	2359		2381	3256	1863	111		5230	7611		292	62			354	308	10		13	331	685
1976	4	21	2614		2639	2044	2444	101		4589	7228			14			14	47	24	2		73	87
1977	1	38	3538	91	3668	2617	1944	239		4800	8468						-	2	10	8	8	28	28
1978	2	17	3358	77	3454	3156	1932	786		5874	9328			1			1	1	1			2	3
1979	2	73	3800	113	3988	2291	1776	692		4759	8747						-					-	0
1980	3	59	3598	61	3721	181	2335	630		4776	8497						-	2	13	1		16	16
1981	2	74	3119	60	3255	2426	3338	725	-	6489	9744			1			1					-	1

Table 5. Number of commercial scup length frequency samples by area and gear, 1973-1980.

Year	NAFO Division	Gear: Otter Trawl	Gear: Floating Trap	Gear: Pound Net	Gear: Others[1]	Total
1973	5Zw				1	1
	6C	3				3
1974	5Zw	5	4			9
	6A	1		1	5	7
1975	5Zw	12				12
	6A	8	1	1	4	14
1976	5Zw	3	1			4
	6A	4		2		6
1977	5Zw	4	3			7
	6A	9				9
1978	5Zw	4	8			12
	6A	2		1	1	4
1979	5Ze	1				1
	5Zw	5				5
	6A	4				4
1980	5Zw	6				6
	6A	7				7
	6B	13				13

[1]Other gear include: line trawl, hand line, common seine.

Table 6. Age composition of scup landed in the Southern New England-New York trawl and fixed gear commercial fisheries, 1974-1980.

	Percent at Age										
Year	1	2	3	4	5	6	7	8	9	10+	Mean Age
1974	10.5	42.1	42.5	4.1	0.5	0.1	-	-	-	-	2.4
1975	2.7	47.6	21.0	24.5	2.8	1.0	0.1	-	0.1	0.2	2.8
1976	7.3	17.1	37.0	17.7	18.5	1.5	0.7	-	-	0.2	3.3
1977	3.5	34.8	18.1	26.1	7.5	8.8	1.1	-	-	-	3.3
1978	3.1	6.3	39.9	9.7	21.0	6.9	11.2	1.4	0.3	0.2	4.1
1979	2.1	26.4	12.6	39.5	10.2	4.5	2.9	1.4	0.4	-	3.6
1980	2.1	19.1	27.9	10.1	21.2	8.0	5.4	3.1	2.4	0.8	4.1

	Mean Length(cm) at Age										
Year	1	2	3	4	5	6	7	8	9	10+	Mean Length
1974	17.5	19.6	22.3	25.3	28.6	33.0	-	-	-	-	20.9
1975	17.4	20.5	23.3	25.1	27.7	29.1	-	-	35.0	37.5	22.5
1976	17.9	21.4	23.4	25.6	27.1	31.2	33.6	-	-	40.0	23.9
1977	18.5	20.5	22.9	25.1	27.7	28.9	32.1	-	-	-	23.5
1978	17.6	21.2	23.8	25.8	27.8	29.9	30.9	32.7	35.6	38.0	25.9
1979	19.0	21.6	23.4	25.3	26.3	28.9	28.8	31.8	29.8	-	24.5
1980	17.8	20.8	23.0	25.9	27.1	28.5	29.3	32.2	31.9	33.5	25.0

	Mean Weight (kg) at Age										
Year	1	2	3	4	5	6	7	8	9	10+	Mean Weight
1974	.122	.179	.268	.398	.584	.910	-	-	-	-	.222
1975	.122	.205	.306	.388	.525	.619	-	-	1.096	1.367	.286
1976	.137	.235	.308	.409	.494	.768	.977	-	-	1.674	.349
1977	.147	.207	.292	.388	.524	.604	.834	-	-	-	.336
1978	.125	.235	.328	.420	.538	.671	.753	.889	1.165	1.423	.454
1979	.161	.242	.313	.401	.455	.609	.611	.820	.677	-	.372
1980	.124	.214	.291	.427	.492	.527	.670	.850	.832	.993	.408

Table 7. Total landings, effort, and catch per unit effort (CPUE) for selected scup fisheries.

	Southern New England Trawl Fishery (MA, RI, CT, NY)		Rhode Island Floating Trap Fishery					Virginia Winter Trawl Fishery					
Year	Scup Catch (MT)	Catch per day Fished (MT) MA & RI 50% Trips	Total Catch (MT)	Scup Catch (MT)	Per-cent Scup	Number of Traps	Scup catch per Trap (MT)	Total Catch (MT)	Scup Catch (MT)	Per-cent Scup	No. of Vessels	Ave. Vessel Tonnage (GRT)	Scup Catch per Vessel (MT)
1952	6021	Data not available	2207	994	45.0	17	58.5	8145	3450	42.4	60	32	57.5
1953	6852	"	2944	1484	50.4	16	92.8	9209	3799	41.2	56	34	67.8
1954	7503	"	3185	1687	53.0	18	93.7	10156	5246	51.7	54	38	97.2
1955	8650	"	3407	1773	52.1	18	98.5	8682	5962	68.7	64	31	93.2
1956	7127	"	3110	1157	37.2	18	64.3	10372	5116	49.3	60	35	85.3
1957	7139	"	3062	1478	48.3	18	82.1	6843	2868	41.9	49	37	58.5
1958	8761	"	2972	1238	41.7	19	65.2	7811	3089	39.5	54	35	57.2
1959	8096	"	2988	1793	60.0	16	112.1	10221	5224	51.1	94	33	55.6
1960	7893	"	2729	1790	65.6	16	111.9	10828	6077	56.1	99	56	61.4
1961	6991	"	2874	2179	75.8	14	155.6	8786	5106	58.1	85	54	60.1
1962	6755	"	2883	2052	71.2	17	120.7	8862	5059	57.1	78	56	64.9
1963	5476	"	3528	2925	82.9	18	162.5	7548	4332	57.4	64	56	67.7
1964	4366	5.6	4019	3396	84.5	19	178.7	7812	4956	63.4	63	64	78.7
1965	4302	5.6	4459	3679	82.5	24	153.3	7294	2843	39.0	65	61	43.7
1966	2949	5.0	3695	2856	77.3	26	109.8	7046	3718	52.8	66	63	56.3
1967	1967	3.7	3246	2348	72.3	21	111.8	4255	2008	47.2	66	67	30.4
1968	2218	4.5	2324	1273	54.8	25	50.9	3460	1092	31.6	73	69	15.0
1969	1164	3.1	1282	563	43.9	23	24.5	3997	1273	31.8	74	72	17.2
1970	987	2.9	1563	997	63.8	17	58.6	3674	941	25.6	57	75	16.5
1971	1098	2.2	1478	844	57.1	12	70.3	2552	867	34.0	52	77	16.7
1972	950	2.5	1695	734	43.3	16	45.8	2097	588	28.1	49	85	12.0
1973	1610	3.6	1960	798	40.7	19	42.0	2771	372	13.4	55	80	6.8
1974	2110	3.3	1862	1006	54.0	19	53.0	2435	214	8.8	66	71	3.2
1975	2286	4.1	2189	1388	63.4	18	77.1	3428	185	5.4	84	77	2.2
1976	2472	4.2	2000	1012	50.6	17	59.5	2646	122	4.6	112	83	1.1
1977	3062	6.2	2014	1487	73.8	18	82.6	3679	362	9.8	134	87	2.7
1978	2925	5.1	2316	1730	74.7	18	96.1	4788	489	10.2	159	74	3.1
1979	3488	6.2	1987	1187	59.7	20	59.4	6449	385	6.0	173	100	2.2
1980	2764	5.0	2111	1555	73.7	14	111.1	-	528	-	132	-	4.0

Table 8. Stratified mean catch per tow (number and weight in kg) of scup in NEFC autumn offshore bottom trawl surveys, 1963-1981.

	Number						Weight (kg)					
	Southern New England[1]			Middle Atlantic[2]			Southern New England[1]			Middle Atlantic[2]		
Year	YOY	Age 1+	All Fish	YOY	Age 1+	All Fish	YOY	Age 1+	All Fish	YOY	Age 1+	All Fish
1963	0.35	3.07	3.42				0.04	1.92	1.96			
1964	187.95	5.85	193.80				2.08	1.55	3.63			
1965	3.09	3.07	6.16				0.13	0.87	1.00			
1966	1.15	0.83	1.98				0.07	0.42	0.49			
1967	11.29	2.30	13.59	69.45	2.73	72.18	0.17	0.72	0.89	2.77	0.59	3.36
1968	22.47	0.24	22.71	16.72	2.22	18.94	0.37	0.15	0.52	0.65	0.39	1.04
1969	55.67	1.87	57.54	222.75	6.97	229.72	1.38	0.97	2.35	7.22	3.31	10.53
1970	24.67	1.37	26.04	3.65	0.19	3.84	0.34	0.17	0.51	0.12	0.01	0.13
1971	13.02	1.76	14.78	6.03	1.58	7.61	0.19	0.17	0.36	0.22	0.15	0.37
1972	11.70	25.42	37.12	71.79	4.33	76.12	0.21	2.15	2.36	2.96	1.05	4.01
1973	51.01	10.10	61.11	2.16	2.09	4.25	0.57	1.77	2.34	0.07	0.24	0.31
1974	0.60	8.20	8.80	17.64	2.39	20.03	0.04	1.91	1.95	0.72	0.19	0.91
1975	78.44	26.20	104.64	35.93	9.68	45.61	1.15	6.65	7,80	0.60	1.14	1.74
1976	4.81	12.19	17.00	450.29	3.37	453.66	0.10	2.57	2.67	15.60	3.16	18.76
1977	54.43	14.63	69.06	19.08	5.49	24.57	0.72	3.19	3.91	0.49	0.54	1.03
1978	19.37	15.30	34.67	0.00	0.00	0.00	0.23	3.56	3.79	0.00	0.00	0.00
1979	35.56	8.36	43.92	0.13	0.81	0.94	0.36	1.27	1.63	0.01	0.09	0.10
1980	13.60	17.92	31.52	0.00	0.29	0.29	0.23	2.39	2.62	0.00	0.03	0.03
1981	106.27	42.90	149.17	43.43	1.68	45.11	1.33	5.66	6.99	1.42	0.30	1.72

[1]Strata Set: 1,2,5,6,9

[2]Strata Set: 61,65,69,73,74.

Southern New England and Middle Atlantic Combined[3]

	Number			Weight (kg)		
Year	YOY	Age 1+	All fish	YOY	Age 1+	All fish
1967	40.16	2.51	42.68	1.46	0.66	2.12
1968	19.62	1.22	20.84	0.51	0.27	0.78
1969	138.61	4.40	143.01	4.28	2.13	6.41
1970	14.24	0.78	15.02	0.23	0.09	0.32
1971	9.55	1.67	11.22	0.20	0.16	0.36
1972	41.53	14.95	56.48	1.58	1.60	3.18
1973	26.76	6.12	32.88	0.32	1.01	1.33
1974	9.06	5.32	14.37	0.38	1.06	1.43
1975	57.34	18.00	75.34	0.88	3.91	4.79
1976	225.96	7.81	233.77	7.79	2.86	10.66
1977	36.88	10.09	46.97	0.61	1.87	2.48
1978	9.75	7.70	17.46	0.12	1.79	1.91
1979	17.97	4.61	22.58	0.19	0.68	0.87
1980	6.85	9.17	16.02	0.12	1.22	1.33
1981	75.07	22.44	97.51	1.37	3.00	4.37

[3]Strata Set: 1,2,5,6,9,61,65,69,73,74.

Table 9. Stratified mean number per tow of scup in NEFC autumn inshore bottom trawl surveys, 1972-1979

	Southern New England[1]			Middle Atlantic[2]		
Year	YOY	Age 1+	All Fish	YOY	Age 1+	All Fish
1972	6.03	5.94	11.97	0.11	2.70	2.81
1973	233.30	285.01	518.31	2.73	22.61	25.34
1974	31.88	31.06	62.94	61.81	15.02	76.83
1975	82.02	53.71	135.73	6.18	1.48	7.66
1976	21.28	16.48	37.76	326.85	19.90	346.75
1977	503.98	27.24	531.22	251.53	13.85	265.38
1978	1030.32	27.29	1057.61	0.94	5.03	5.97
1979	30.87	5.73	36.60	0.85	2.79	3.64

[1]Strata set: 1-11, 45-55

[2]Strata set: 12-44

Table 10. Stratified mean catch per tow (number and weight in kg), coefficient of variation (C.V.) and mean bottom temperature (°C) in NEFC spring offshore bottom trawl surveys, 1968-1981.

	Southern New England and Mid-Atlantic[1]				
Year	Kg/tow	No/tow	C.V.	Mean Temp.	# Tows
1968	6.28	165.31	92	7.2	44
1969	1.11	6.29	96	6.6	42
1970	8.29	213.69	80	7.7	51
1971	6.74	197.91	88	8.2	43
1972	6.20	138.13	59	9.4	46
1973	3.33	10.11	42	8.5	53
1974	8.58	83.14	56	11.3	31
1975	9.45	42.99	54	3.7	29
1976	1.77	11.36	29	9.8	47
1977	12.44	118.38	81	7.3	46
1978	9.74	111.26	71	7.1	43
1979	5.39	62.50	74	7.9	43
1980	3.57	25.86	65	8.8	41
1981	3.21	41.02	39	7.6	40

[1]Strata set: 61,62,63,65,66,67,70,71,74,75,2,3

Table 11. Age composition of scup taken in NEFC autumn offshore bottom trawl surveys in the Southern New England region (strata set: 1,2,5,6,9).

Percent at Age

Year	0	1	2	3	4	5	6	7	8	9	Mean Age
1977	78.9	9.8	8.9	1.0	1.1	0.2	0.1	0.1	-	-	0.4
1978	55.6	25.0	6.4	8.3	1.7	2.0	0.5	0.3	0.1	-	0.8
1979	80.9	15.0	3.2	0.1	0.3	0.1	0.1	<.1	<.1	<.1	0.2
1980	43.2	45.7	10.0	0.8	0.2	0.2	-	-	-	-	1.3

Mean Length (cm) at Age

Year	0	1	2	3	4	5	6	7	8	9	Mean Length
1977	8.48	17.02	20.83	25.26	26.17	27.70	30.00	30.76	-	-	10.9
1978	7.93	16.26	21.63	23.81	25.89	27.95	31.04	28.33	32.00	-	13.2
1979	7.72	15.99	20.88	22.65	25.39	27.42	29.32	31.00	31.50	32.00	9.6
1980	9.08	16.19	20.71	24.19	26.43	28.00	-	-	-	-	13.7

Stratified Mean Number per tow at age

Year	0	1	2	3	4	5	6	7	8	9	0+	1+	2+	3+	4+
1977	54.44	6.74	6.11	0.66	0.78	0.17	0.03	0.03	-	-	68.96	14.52	7.78	1.67	1.01
1978	19.46	8.75	2.25	2.90	0.60	0.70	0.19	0.09	0.03	-	34.97	15.51	6.76	4.51	1.61
1979	35.53	6.59	1.41	0.06	0.12	0.06	0.06	0.03	0.02	0.01	43.89	8.36	1.77	0.36	0.30
1980	13.60	14.37	3.13	0.26	0.07	0.07	-	-	-	-	31.50	17.90	3.51	0.40	0.14

Table 12. Stratified mean number per tow of age 2+ (≥14 cm) scup, coefficient of variation (C.V.) and mean bottom temperature (°C) in NEFC spring offshore bottom trawl surveys, 1968-1979.

Year	Southern New England[1]				Middle Atlantic[2]			
	No/tow Age 2+	C.V.	Mean Temp	# Tows	No/tow Age 2+	C.V.	Mean Temp.	# Tows
1968	0.48	98	7.8	16	78.42	77	6.7	28
1969	0.00	00	7.1	16	8.42	97	6.3	26
1970	33.40	98	6.7	25	99.01	97	8.4	26
1971	5.90	57	8.8	16	126.80	80	7.8	27
1972	3.77	54	9.1	19	23.46	57	9.7	27
1973	0.00	--	8.7	28	15.99	43	8.4	28
1974	42.33	52	10.8	15	15.83	64	11.6	16
1975	10.59	58	8.8	17	68.14	63	8.5	12
1976	12.56	43	9.7	17	3.06	44	9.8	30
1977	0.08	81	6.5	17	166.21	96	7.9	29
1978	0.00	--	6.3	17	58.96	98	7.7	26
1979	2.71	67	8.7	16	28.63	82	7.4	27

[1] strata set: 2, 3, 74, 75

[2] strata set: 61, 62, 63, 65, 66, 67, 70, 71

Table 13. Summary of growth studies of scup conducted in the Southern New England and Middle Atlantic area.

Reference	Location	L_∞	K	t_o
Finklestein (1969a)	Long Island Sound, NY	34.25	0.2688	-0.40531
		37.41	0.2247	-0.47047
Hamer (1970)	Sandy Hook, NJ	34.10	0.2945	-0.7964
Sisson (MS 1974)	Narragansett Bay, RI	32.38	0.3365	0.312
Campbell *et al.* (MS 1982)	So. New England and Mid. Atlantic Shelf	42.48	0.174	-0.533
Pierce (MS 1981)	Vineyard Sound, MA	39.60	0.240	-0.350
Crecco *et al.* (MS 1981)	Long Island Sound, NY	36.63	0.250	-0.350

Table 14. Catch composition of scup landings from NAFO Subdivision 5Zw and Division 6A for Southern New England - New York trawl and fixed gear fisheries.

Year	Age 1	2	3	4	5	6	7	8	9	10	11	12+	Total	Metric tons	Tons per day fished	Estimated days fished
	Estimated Landings (1000's of fish)															
1974	1999	8002	8067	787	105	20	7	9	-	-	2	2	18997	4265	3.3	1292
1975	405	7262	3212	3742	425	147	22	-	22	24	-	3	15265	4381	4.1	1068
1976	847	2000	4324	2072	2160	176	80	-	-	-	25	-	11686	4091	4.2	974
1977	547	5496	2866	4129	1182	1389	177	19	-	-	-	-	15806	5279	6.2	851
1978	362	728	4605	1123	2420	794	1290	162	34	24	-	-	11542	5222	5.1	1024
1979	308	3788	1804	5664	1456	644	420	199	52	-	-	7	14342	5322	6.2	853
1980	260	2308	3378	1225	2562	972	648	377	292	46	27	-	12095	4924	5.0	985

Year	Age 1	2	3	4	5	6	7	8	9	10	11	12+	2+	3+	4+	5+	6+
	Estimated Landings (No. of fish/day fished)																
1974	1547	6193	6244	609	80	15	5	7	-	-	1	1	13155	6962	718	109	29
1975	379	6800	3007	3504	398	138	21	-	21	22	-	3	13914	7114	4107	603	205
1976	870	2053	4439	2127	2218	181	82	-	-	-	26	-	11126	9073	4634	2307	289
1977	643	6458	3368	4852	1389	1632	208	22	-	-	-	-	17929	11471	8103	3251	1862
1978	354	711	4497	1097	2363	775	1260	158	33	23	-	-	10917	10206	5709	4612	2249
1979	359	4415	2103	6601	1697	751	490	232	61	-	-	8	16358	11943	9840	3239	1542
1980	264	2343	3429	1244	2601	987	658	383	296	47	27	-	12015	9672	6243	4999	2398

Table 15a. Estimates of instantaneous total mortality rates (Z) for scup based on Southern New England commercial catch compositions in NAFO Subdivision 5Zw and Division 6A.

Catch Curve Analysis	Age			
Year class	2+	3+	4+	5+
1969	-	-	-	0.26
1970	-	-	0.41	0.41
1971	-	0.54	0.55	0.60
1972	0.46	0.44	0.45	0.43
1973	0.51	0.57	0.71	0.83
1974	0.22	0.32	-	-
1975	0.23	0.27	-	-
Average	0.36	0.43	0.53	0.51

Pooled Year Classes

	AGES												
Years	1/2	2/3	3/4	4/5	5/6	6/7	7/8	8/9	9+/10+	2+/3+	3+/4+	4+/5+	5+/6+
74/75	-1.48	0.72	0.58	0.43	-0.55	0.34		-1.10	-1.10	0.61	0.53	0.17	-
75/76	-1.69	0.43	0.35	0.46	0.79	0.52			0.17	0.43	0.43	0.49	0.74
76/77	-2.00	-0.50	-0.09	0.43	0.31	-0.14	1.32			-0.03	0.11	0.35	0.30
77/78	-0.10	0.36	1.12	0.72	0.58	0.26	0.27	-0.41		0.56	0.70	0.56	0.37
78/79	-2.52	-1.08	-0.38	-0.44	1.15	0.46	1.69	0.95		-0.09	0.04	0.57	1.10
79/80	-1.88	0.25	0.53	0.93	0.54	0.13	0.25	-0.24	0.26	0.53	0.65	0.68	0.30
									Average	0.34	0.41	0.47	0.56
									Pooled	0.34	0.38	0.54	0.52

Table 15b. Estimates of relative exploitation rates (E) for scup from the Southern New England and Middle Atlantic regions.

Relative Exploitation Rates (E)

	Period	Ave Commercial Landings (000's MT)	Ave wt per tow index (kg)	E
Southern New England	1963-67	11270	1.10	10.2
	1968-72	3760	0.72	5.2
	1973-77	6833	3.22	2.1
	1978-81	7394	3.22	2.3
Middle Atlantic	1968-72	2411	0.98	2.5
	1973-77	2795	1.05	2.7
	1978-81	3303	0.11	30.0

Table 16. Parameters used in yield per recruit calculations for scup.

Parameter	Values
Fishing mortality, F	0.05 - 1.40
Natural mortality, M	0.20
Maximum weight, W_∞ (g)	1988
Growth coefficient, K	0.174
Arbitrary origin of growth curve, t_o	-0.533
Length-weight exponent, b	3.169
Age at recruitment, t_p	1
Mean selection age, tp'	1-10
Maximum age, t_λ	15

Table 17. Estimates of F_{max}, $F_{0.1}$, and corresponding yields in kg per 1000 recruits for scup at various levels of natural mortality (M) and recruitment.

		Mean Age at Recruitment		
		2	3	4
M = 0.10				
	F_{max}	0.20	0.25	0.30
	yield	272.4	311.0	350.2
	$F_{0.1}$	0.13	0.15	0.18
	yield	262.6	296.2	331.6
M = 0.20				
	F_{max}	0.23	0.35	0.50
	yield	155.0	178.1	198.1
	$F_{0.1}$	0.17	0.20	0.25
	yield	148.4	166.9	184.0
M = 0.30				
	F_{max}	0.45	0.60	1.15
	yield	100.8	116.9	128.1
	$F_{0.1}$	0.21	0.27	0.33
	yield	94.2	106.3	112.3

Table 18. Estimates of minimum retention length and age of scup for various mesh sizes used in the trawl fisheries.

Stretched mesh size (in.)	(mm)	Mesh[1] opening (mm)	Minimum scup retention Length[2] (cm)	Age[3] (yr)	Selection factor
1.5	38	27	9.1	0.9	2.39
2.0	51	36	11.1	1.2	2.18
2.5	64	45	13.1	1.6	2.05
3.0	76	54	14.9	1.9	1.96
3.5	89	63	16.9	2.4	1.90
4.0	102	72	18.9	2.8	1.85
4.5	114	81	20.7	3.3	1.82
5.0	127	90	22.8	3.9	1.80
5.5	140	99	24.7	4.5	1.76

[1]Calculated diagonal

[2]From the fork length-body depth regression of Smith and Norcross (1968)

[3]From the von Bertalanffy growth equation of Campbell et al. (MS 1982)

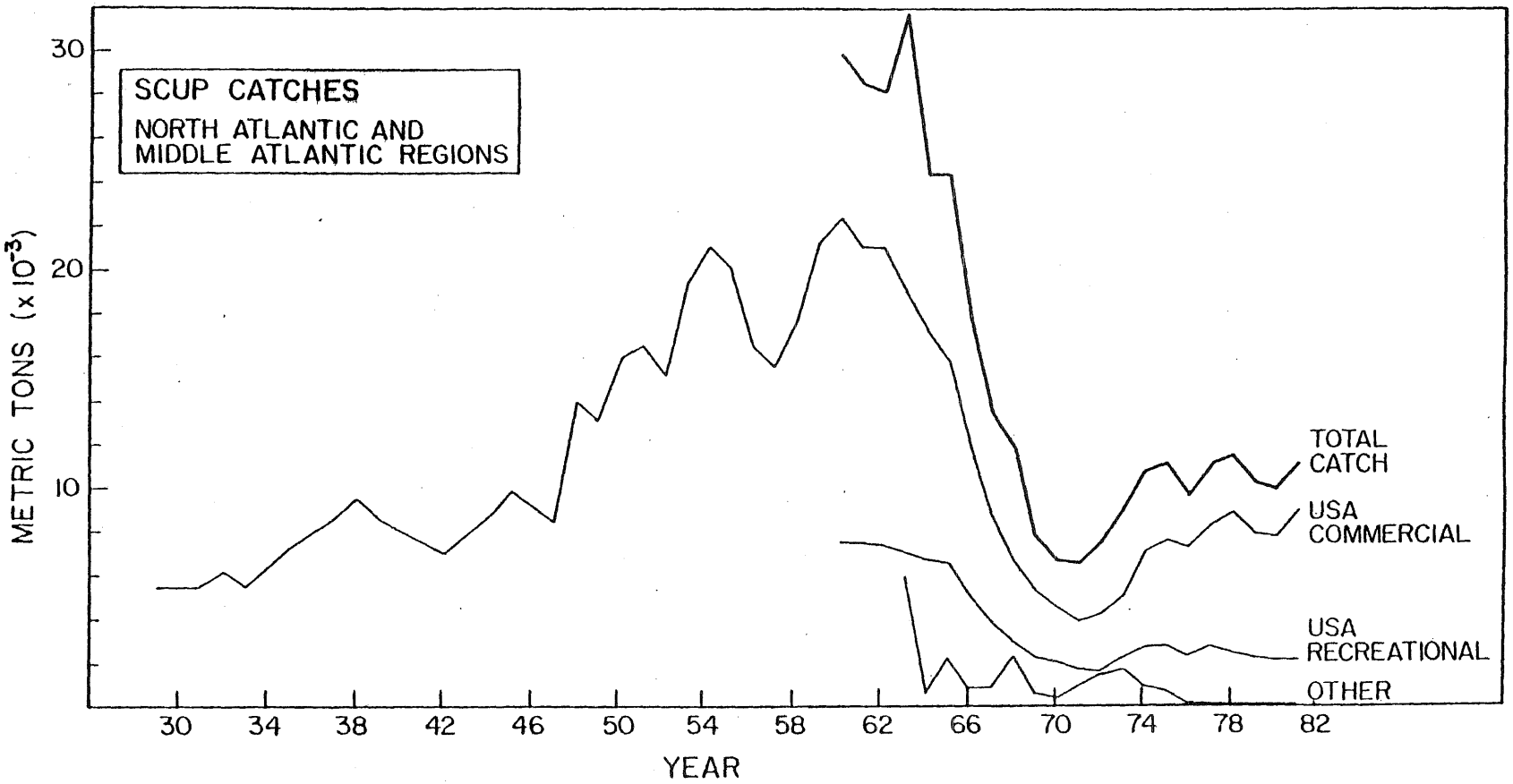


Figure 1. Landings of scup from the North and Middle Atlantic regions.

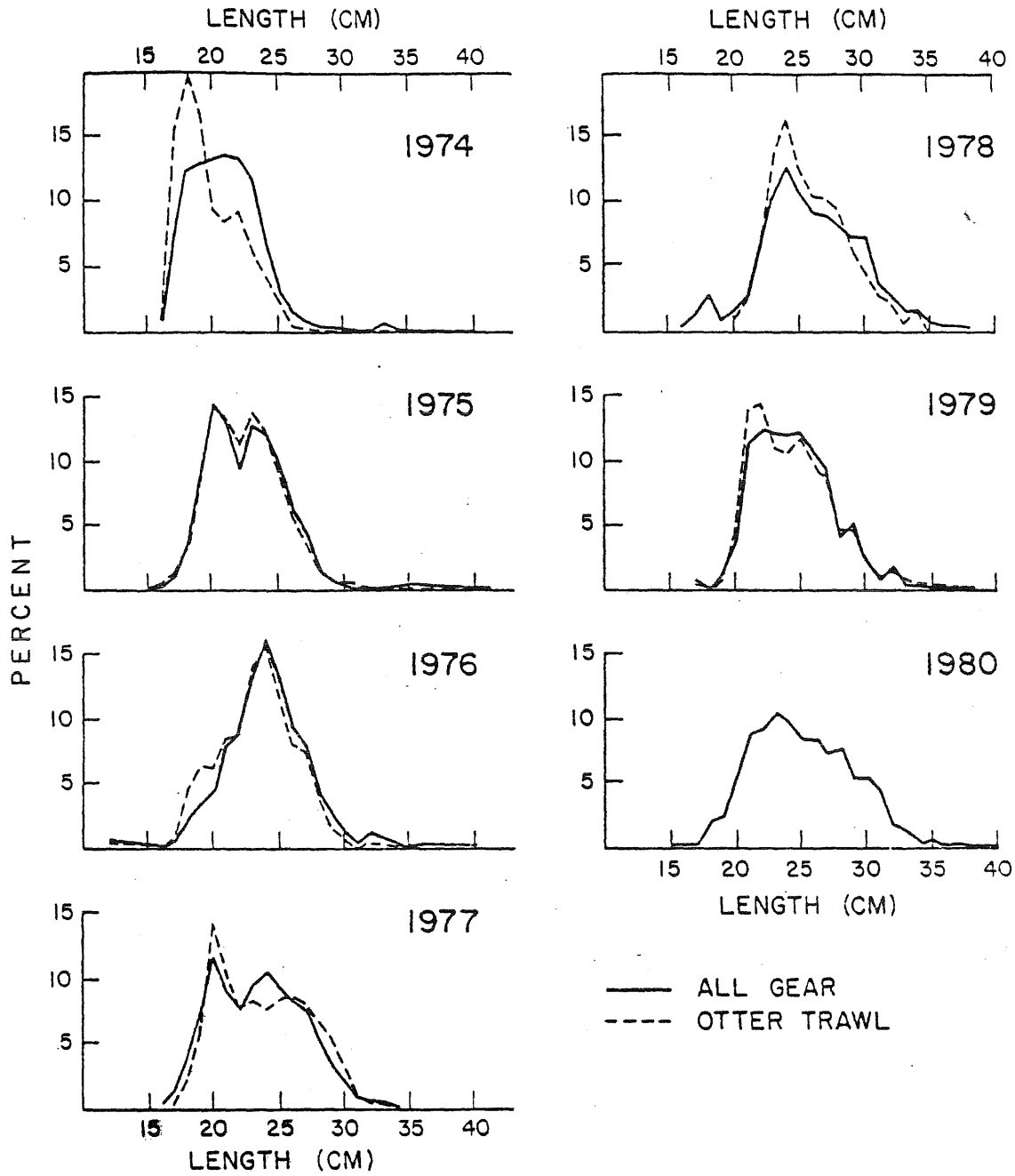


Figure 2. Percent length composition of scup in the Southern New England-New York commercial landings, 1974-1980.

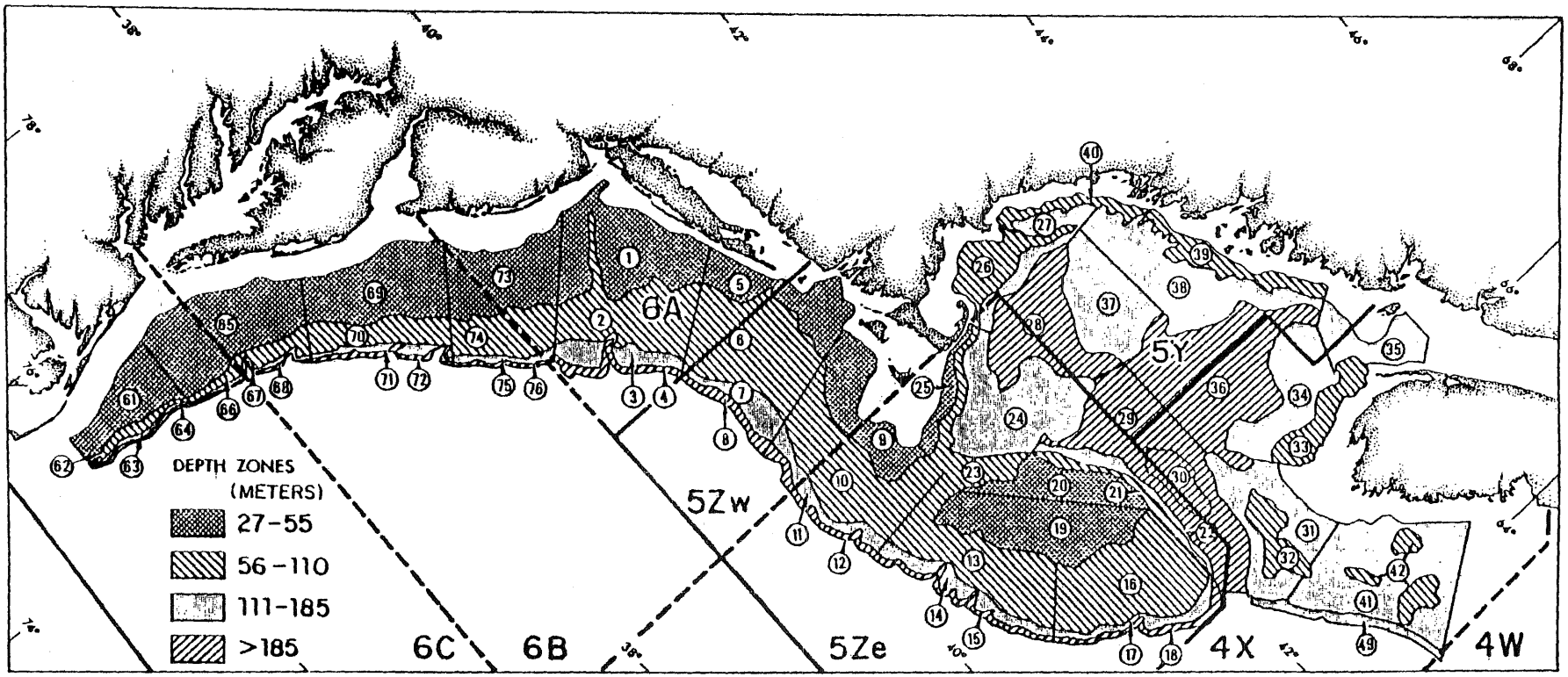
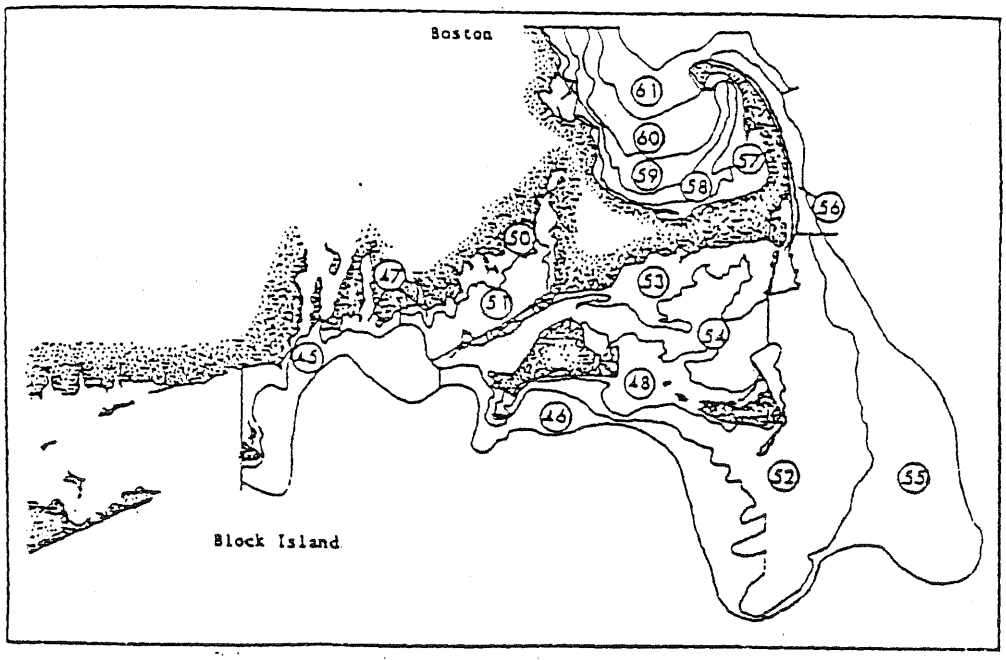


Figure 3. Sampling strata used in NEFC offshore bottom trawl surveys.

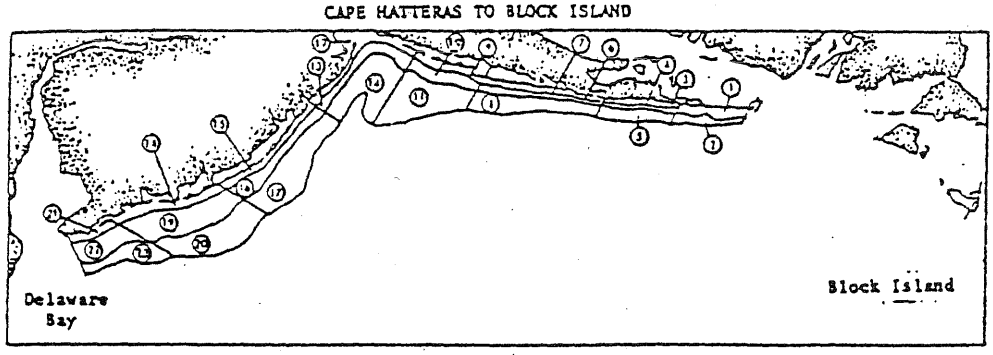
COASTAL STRATA

BLOCK ISLAND TO BOSTON



COASTAL STRATA

CAPE HATTERAS TO BLOCK ISLAND



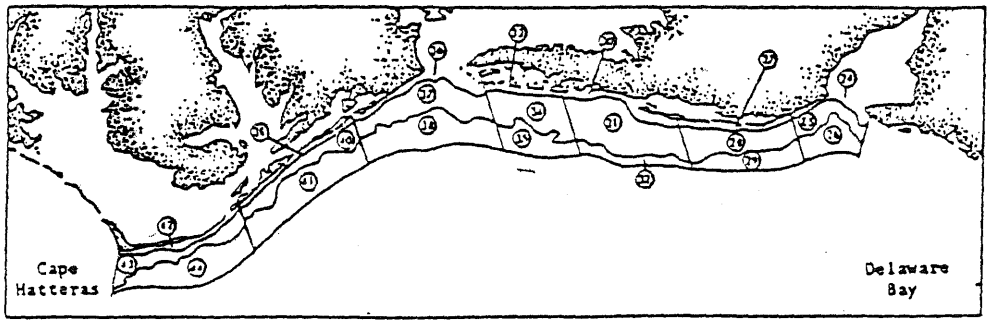


Figure 4. Sampling strata used in NEFC inshore bottom trawl surveys.

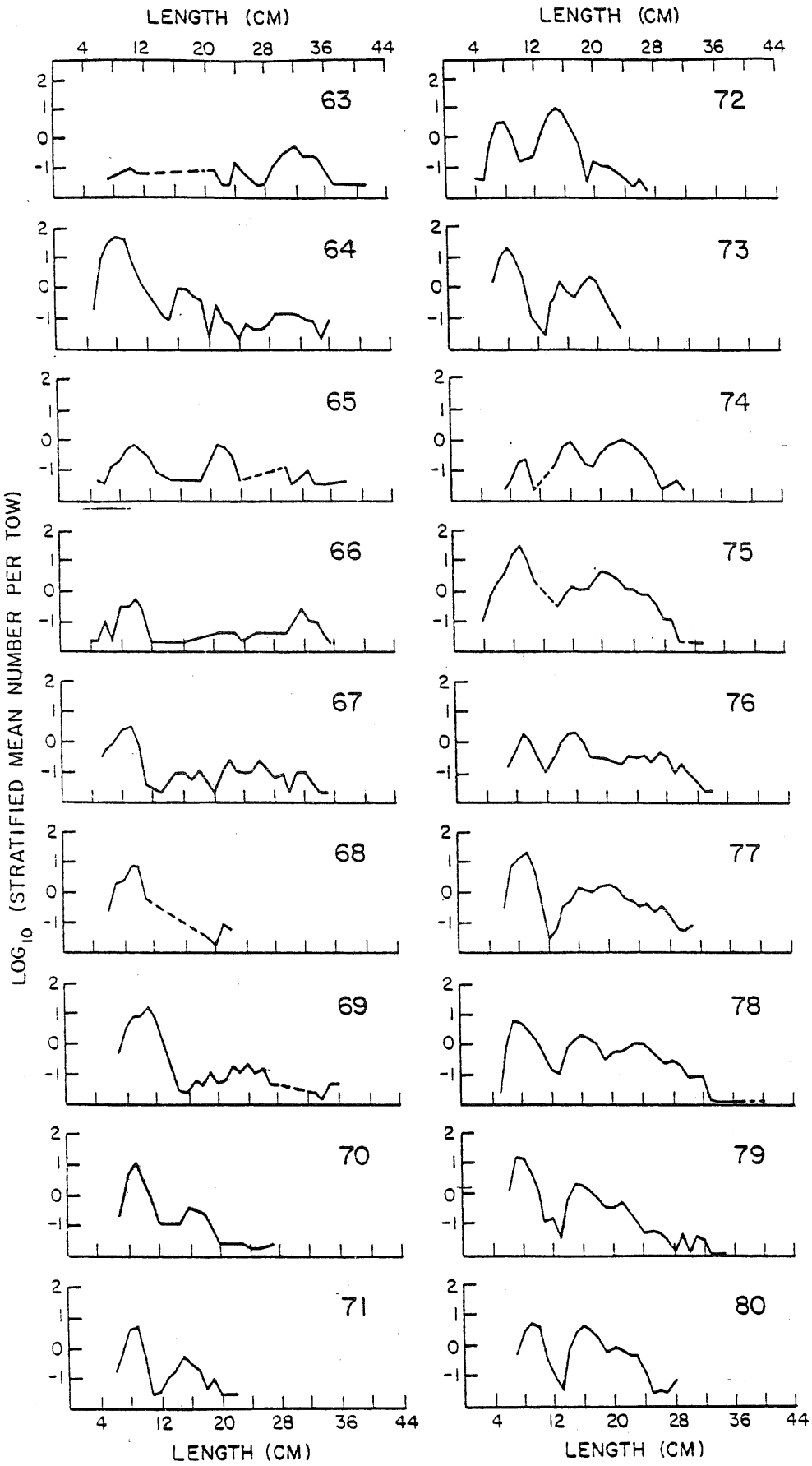


Figure 5. Length frequency distributions of scup in NEFC autumn bottom trawl surveys in the Southern New England area (strata set: 1, 2, 5, 6, 9).

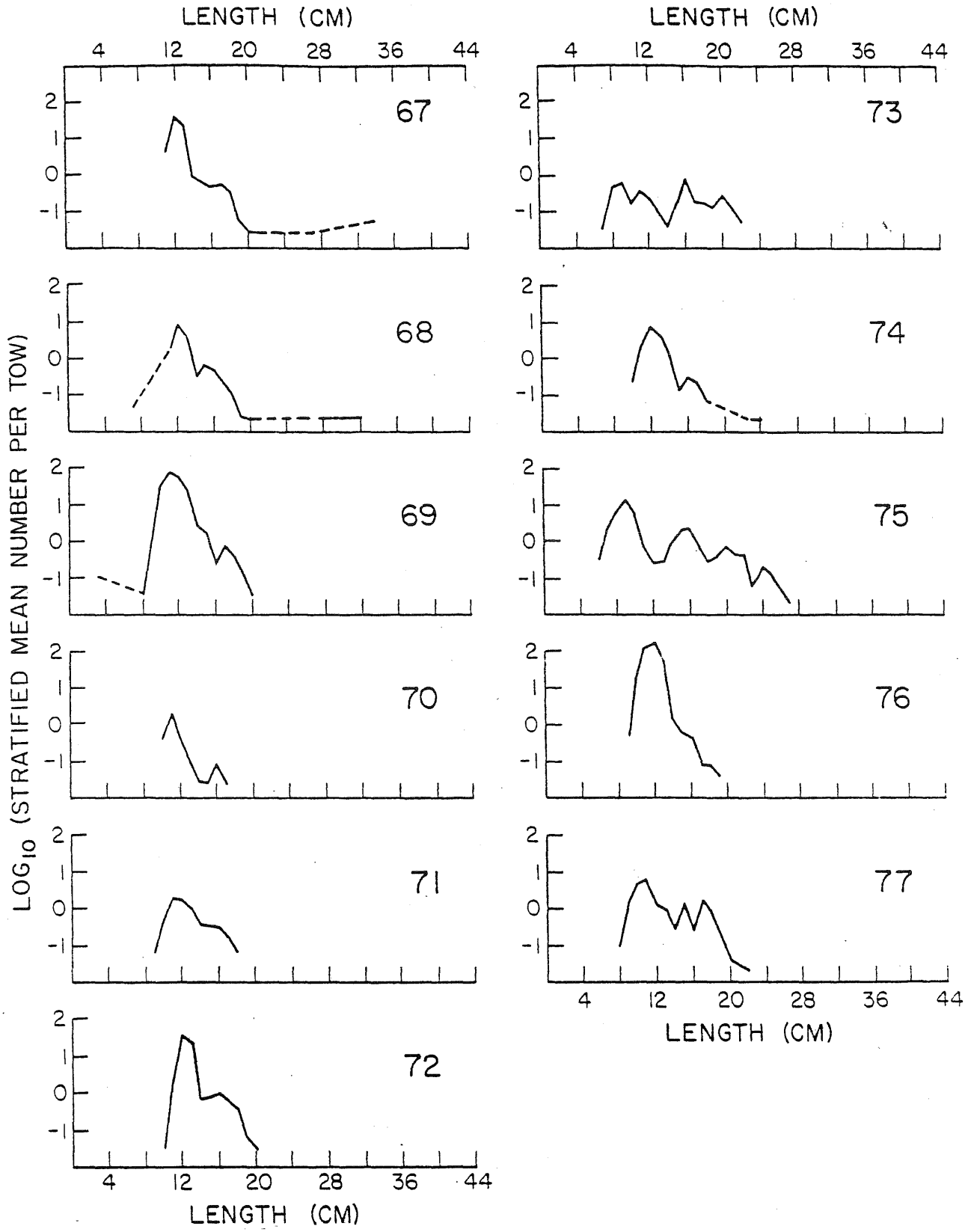


Figure 6. Length frequency distributions of scup in NEFC autumn bottom trawl surveys in the Middle Atlantic area (strata set: 61, 65, 69, 73, 74).

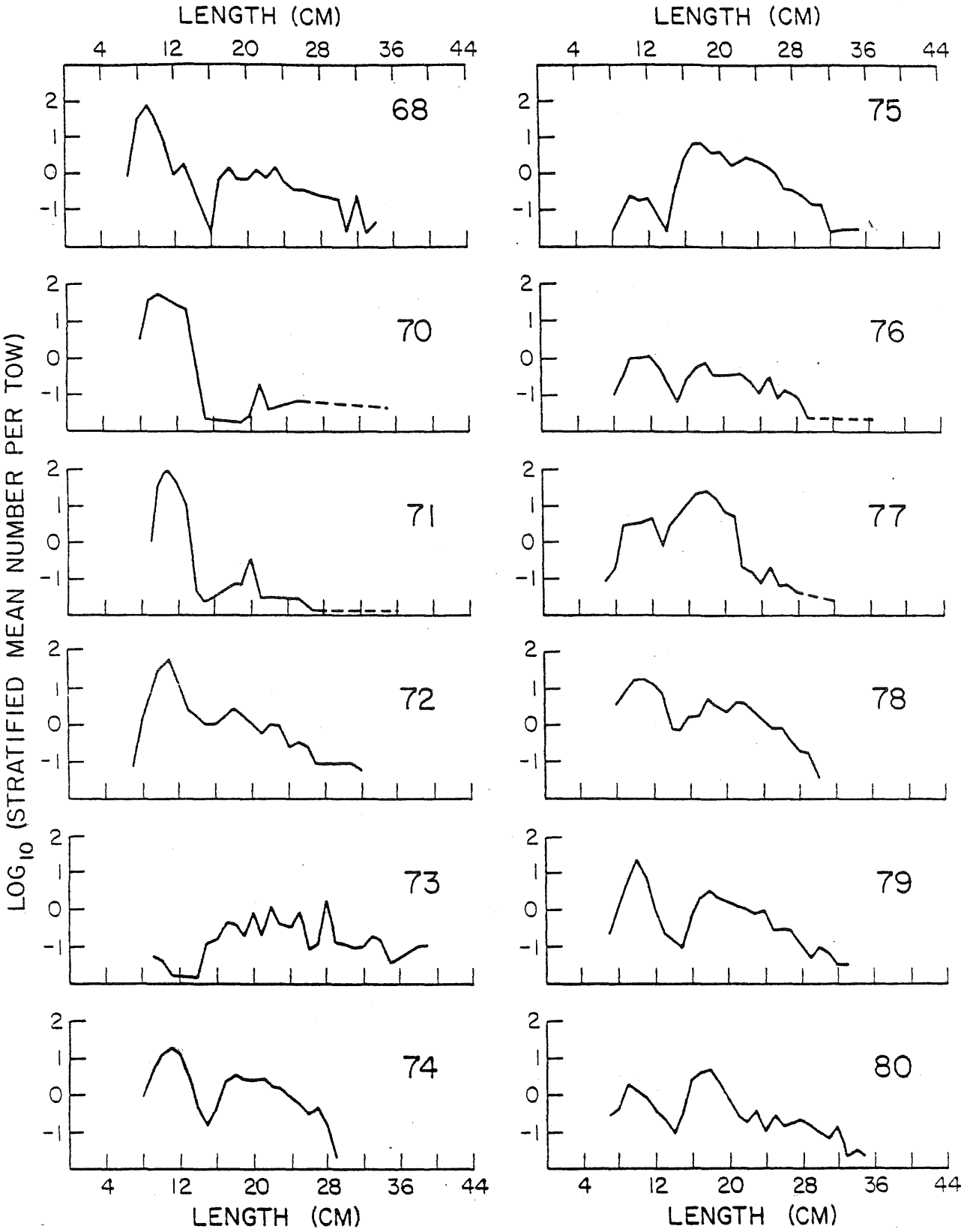


Figure 7. Length frequency distributions of scup in NEFC spring bottom trawl surveys in the Southern New England-Middle Atlantic area (strata set: 61, 62, 63, 65, 66, 67, 70, 71, 74, 75, 2, 3).

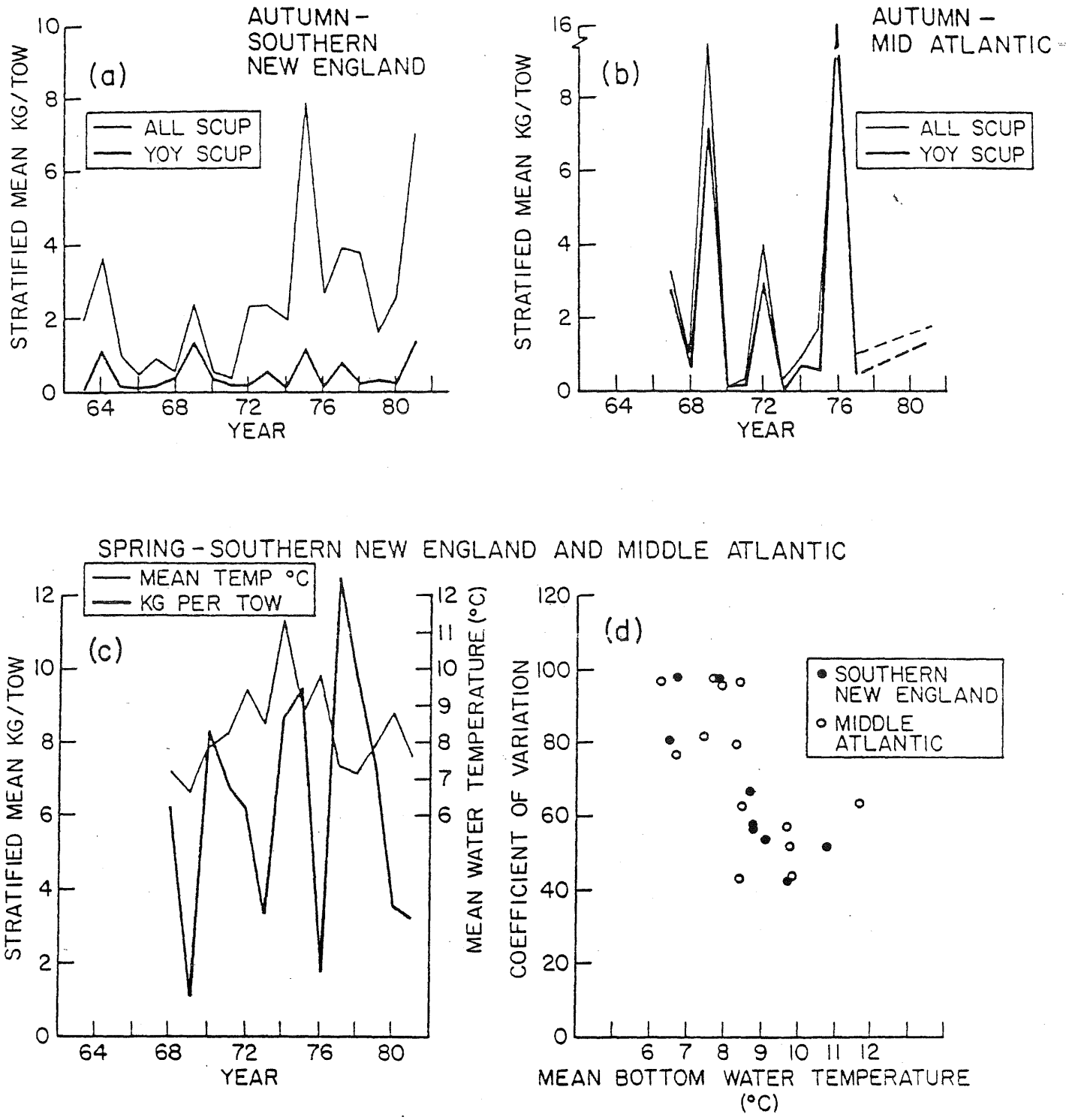


Figure 8. Trends in scup biomass indices from NEFC bottom trawl surveys.

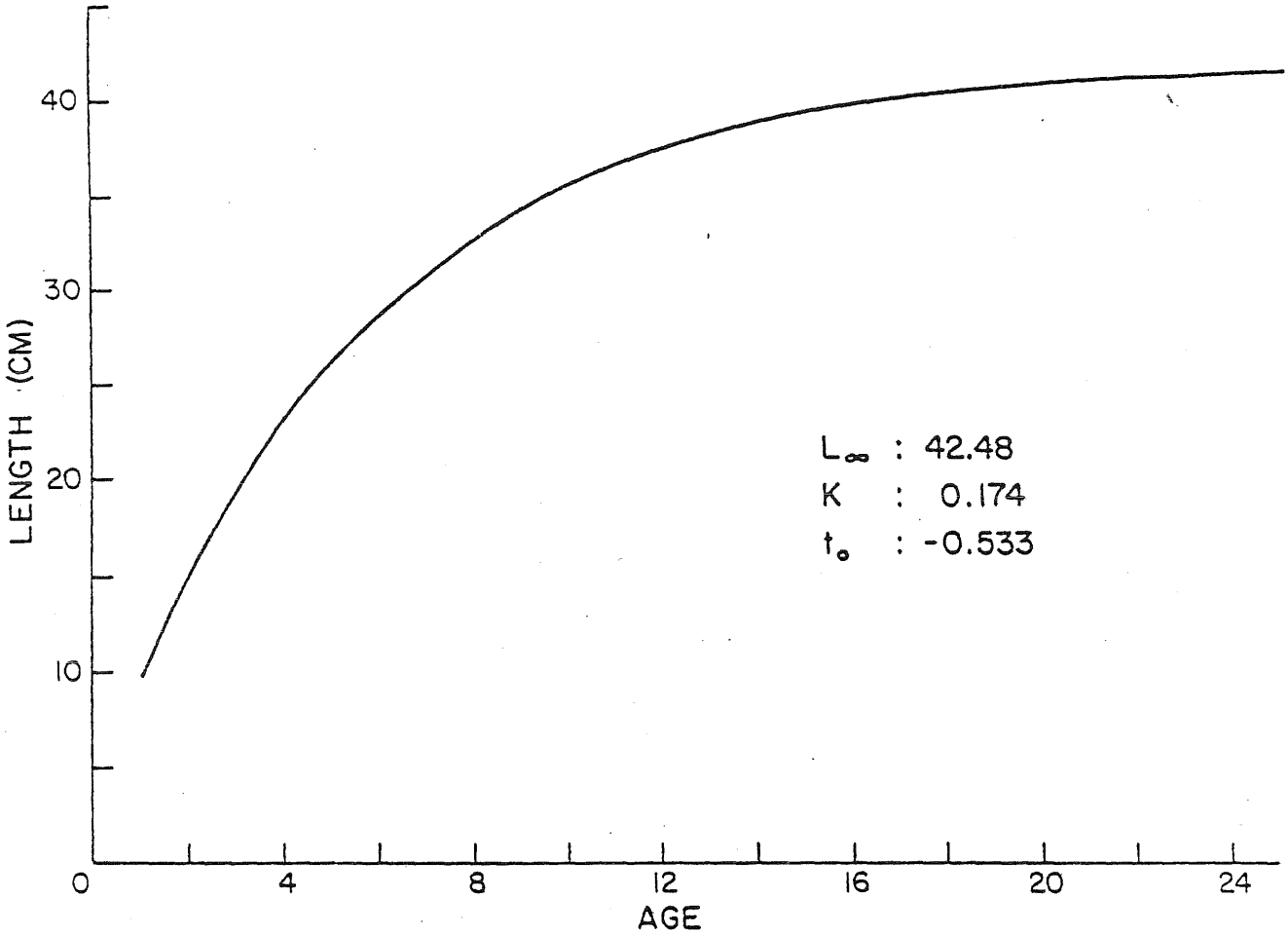


Figure 9. Fitted von Bertalanffy growth curve for scup (from Campbell et al. MS 1982).

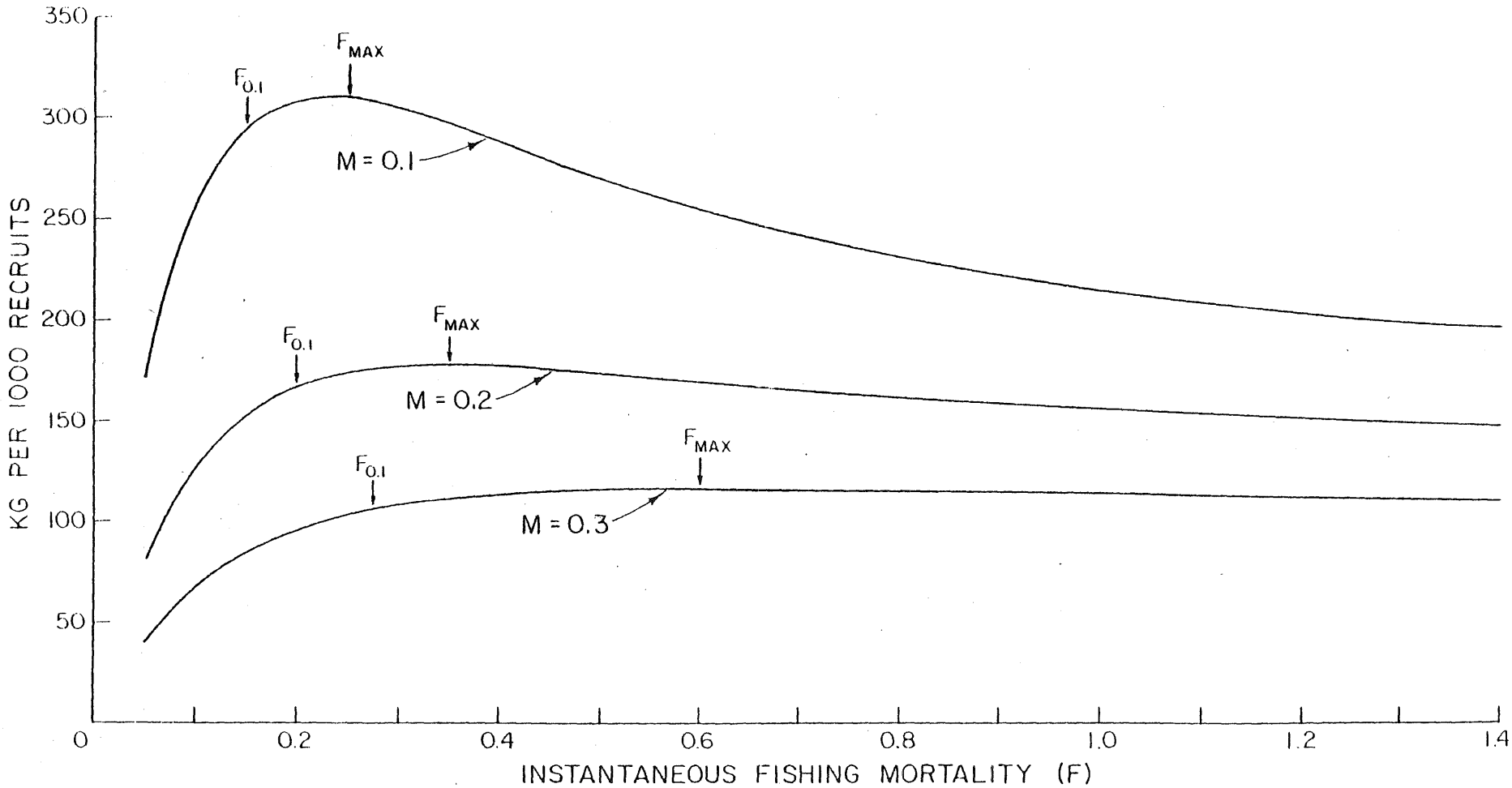


Figure 10. Yield per recruit curves for scup calculated for several levels of M with a mean age at recruitment of 3 years.