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Assessment of Redfish

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AN ASSESSMENT OF THE REDFISH, *Sebastes fasciatus*, STOCK IN THE GULF OF MAINE - GEORGES BANK REGION

by

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SUMMARY

USA redfish landings from the Gulf of Maine - Georges Bank region declined in 1982 for the third consecutive year. The 1982 total of 6,700 tons was less than one-half of the 1977-79 average, and represented the lowest amount landed since the directed fishery commenced in the mid-1930's. Since the late 1960's, commercial catch per unit effort indices have steadily declined from 6.1 tons per standard day fished in 1968 to 1.5 tons in 1982. Estimated total effort increased during the 1970's from 1,100 days fished in 1968 to 7,800 days in 1979, but has since declined to 4,500 days in 1982. Autumn NEFC bottom trawl survey abundance indices have also declined from 143.4 fish per tow (40.4 kg) in 1968 to 9.0 fish per tow (3.4 kg) in 1982.

The size and age composition of the landings has changed considerably since the 1960's when numerous year classes supported the Gulf of Maine - Georges Bank fishery. Except for the strong 1971 year class, recruitment to this fishery has been extremely poor since the mid-1960's, and consequently the current age structure of the stock is dominated by this year class. The proportion of total landings represented by the 1971 year class steadily increased from 11% by weight in 1976 and 48% in 1980; this year class will continue to dominate the landings in the near future due to poor recruitment of subsequent year classes.

VPA estimates of total (age 1+) stock size declined by 63% from 517 million fish in 1969 to 191 million in 1980. Exploitable (age 5+) and recruited (age 9+) stock size estimates similarly declined by 70% and 51%, respectively. The mean fishing mortality of fully recruited ages for the 1969-80 period was slightly greater than F_{max} and about twice the $F_{0.1}$ level. However, the combination of declining overall stock size, and increased fishing effort on the 1971 year class in the late 1970's produced fishing mortality rates that were 50% greater than F_{max} and three times higher than $F_{0.1}$.

The population is now in a severe state of disequilibrium and, with the present age structure and exploitation pattern, the fishery has become extremely sensitive to recruitment. However, except for the moderate 1978 and 1979 year classes, recruitment prospects are poor. Abundance estimates based on NEFC bottom trawl survey results indicate that these year classes are approximately one-tenth the size of the strong 1971 year class. The extremely low $F_{0.1}$ level (0.07) implies that the number of fish which can be harvested, allowing for stock recovery, cannot be much greater than the number dying through natural causes, assuming that the natural mortality rate equals 0.05. Given the lack of substantial recruitment following the 1971 year class, stock abundance and commercial CPUE indices will continue to decline even if catches remain at or below their current level. Consequently any increases in stock size will ultimately depend on the extent that future year classes appear in the population. The 1978 and 1979 year classes will recruit to the fishery in 1983 and 1984, but it does not appear that these year classes are large enough to significantly alter the expected decline in stock size.

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INTRODUCTION

The USA fishery for redfish, Sebastes fasciatus, has been in a severe state of decline since the early 1970's. The 1982 nominal catch[1] was the lowest since the initiation of the USA fishery in the mid-1930's. Since restrictions were imposed in 1978 prohibiting USA vessels from fishing within Canadian-claimed waters, the domestic redfish fishery has been essentially confined to the Gulf of Maine - Georges Bank region (Northwest Atlantic Fisheries Organization (NAFO) Subarea 5). However, limited amounts are still taken from the western edge of the Scotian Shelf in NAFO Division 4X.

USA redfish landings from Subarea 5 declined from an average of 13,900 metric tons (tons) during 1977-79 to 7,900 tons in 1981 and 6,700 tons in 1982. The 1981-82 average of 7,300 tons is comparable to average Subarea 5 landings during 1964-66. Previous assessments of the Subarea 5 redfish fishery (Mayo 1975, 1976, 1980; Mayo et al. 1979) have indicated steady declines in commercial catch rates and stock abundance and poor recruitment prospects throughout the 1970's and early 1980's. Recent information on growth, distribution, and speciation of redfish has been summarized by Mayo (1980) and Ni (1982).

The present report provides an assessment of the Subarea 5 redfish stock based on analyses of commercial landings and effort data and research vessel survey data. As in previous assessments, resource trends were monitored by commercial catch per unit effort (CPUE) and research vessel abundance indices. In addition, age composition estimates of the commercial landings from 1969 through 1980 have been utilized in a virtual population analysis (VPA) to

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[1]Live weight equivalent of landings exclusive of discards, hereafter referred to as landings.

document changes in stock biomass and fishing mortality throughout the 1970's. Estimates of catchability (q) and total instantaneous mortality (Z) were also computed from these data.

MANAGEMENT

Management of the Subarea 5 redfish fishery began in 1973 when a total allowable catch (TAC) of 30,000 tons was adopted under the auspices of the International Commission for the Northwest Atlantic Fisheries (ICNAF). The TAC was maintained at 30,000 tons in 1974 but was lowered to 25,000 tons in 1975. After an initial assessment (Mayo 1975) indicated a substantially lower surplus yield, the TAC was further reduced to 17,000 tons in 1976. Subsequent analyses (Mayo 1976) indicated that a greater reduction in catch would be required to allow for stock recovery, and the TAC for 1977 was reduced further to 9,000 tons. Although the 1977 TAC was adopted by ICNAF at its 1976 Annual Meeting (ICNAF 1976), it was never entered into force due to USA withdrawal from ICNAF in December of 1976. Since then, the USA redfish fishery in Subarea 5 has not been regulated. Between 1973 and 1976, redfish landings remained below the TAC levels set by ICNAF, but landings during 1977-80 exceeded the 9,000 ton level considered necessary by ICNAF for stock recovery.

COMMERCIAL FISHERY

Commercial landings data for the USA were obtained from annual and historical statistical summaries published by NAFO and its predecessor, ICNAF (ICNAF 1952-1980; NAFO 1981, 1982). Detailed analyses of USA fishery trends from

1964 through 1982 were based on commercial landings and effort data files maintained at the Northeast Fisheries Center (NEFC), Woods Hole, Massachusetts. Nominal catches by distant water fleets are as reported to ICNAF and NAFO. Recreational catches of redfish are considered negligible in the Gulf of Maine - Georges Bank area since marine angler surveys conducted since 1960 do not list any rockfishes (Sebastes) in the North Atlantic region.

Fishery Trends in the Northwest Atlantic

A directed fishery for redfish commenced off the New England coast (NAFO Subarea 5) in the 1930's and rapidly expanded to the Scotian Shelf and the Gulf of St. Lawrence (NAFO Subarea 4) in the 1940's and the Grand Banks of Newfoundland (NAFO Subarea 3) in the 1950's. During this initial expansion phase, the fishery exhibited a classic pattern of rapidly increasing landings based on accumulated stock followed by a steady decline and a subsequent shift in effort to unexploited areas (Mayo 1975). Subarea 5 landings peaked at 60,000 tons in 1941 while Subarea 4 landings continued to increase to a maximum of 83,000 tons in 1951. Although total USA redfish landings peaked in 1951 at 127,000 tons, expansion continued in Subarea 3 until 1954 when 31,000 tons were landed from this region (Figure 1). Since the mid-1950's, USA redfish landings have steadily declined in all Subareas, although minor increases have occurred occasionally.

Since 1964, the USA redfish fishery has been concentrated primarily in the Scotian Shelf and the Gulf of Maine - Georges Bank region. Following the exclusion of USA vessels from Canadian waters in 1978, landings have come primarily from waters under USA jurisdiction (NAFO Subarea 5).

Gulf of Maine - Georges Bank Trends

Following an initial peak of 60,000 tons in 1941, USA landings declined in the early 1950's and fluctuated between 11,000 and 18,000 tons annually between 1953 and 1962. By 1962, other nations (primarily the USSR, see Mayo et al. 1979) had begun to report redfish landings of over 1,000 tons annually from Subarea 5. The combined landings for all nations subsequently rose to 20,000 tons in 1971 before declining to an average of 10,600 tons annually during 1974-76 (Table 1). The Distant Water Fleet landings declined from a maximum of 6,000 tons in 1972 to less than 100 tons per year since 1978.

During the 1970's USA landings from Subarea 5 increased from an annual average of 9,300 tons in 1974-76 to 13,900 tons in 1977-79 before declining to 10,100 tons in 1980, 7,900 tons in 1981 and 6,700 tons in 1982. Although the 1981-82 average (7,300 tons) is comparable to that observed during 1964-66, USA vessels also landed an average of 31,000 tons annually from other areas during those earlier years. In 1981 and 1982, however, USA vessels only took an average of 1,200 additional tons annually from a portion of Subarea 4 off southwest Nova Scotia not claimed by either USA or Canada under extended jurisdiction.

Bottom trawls have been the most widely used gear in the redfish fishery (Kelly et al. 1972, TRIGOM 1978). Between 1964 and 1982, over 99% of all redfish landed were taken by this gear. Attempts to capture redfish with midwater trawls in 1973 and 1974 proved unsuccessful (TRIGOM 1978), and the gear was abandoned in the Gulf of Maine area until 1982. Incidental landings of redfish by gillnetters have been reported since 1971, but are of minor importance. The major ports of landing for redfish are Rockland and Portland, Maine and Gloucester, Massachusetts. (Lynch et al. 1961). Boston, Massachusetts

has also accounted for a substantial share of recent redfish landings (Mayo 1980). In 1982, as in previous years, these ports accounted for over 95% of all USA redfish landings.

The size distribution of vessels engaged in the redfish fishery in the Gulf of Maine - Georges Bank region has shifted from a predominance of small tonnage class (TC) 2 (5-50 gross register tonnage (GRT)) and medium TC 3 (50-150 GRT) vessels in 1964 to primarily medium and large TC 4 (150-500 GRT) vessels in the late 1970's (Figure 2). Since 1967, over 50% of all redfish landings were taken by TC 4 vessels. When landings from directed redfish trips (Mayo 1980) are considered, TC 4 vessels accounted for an even greater share, e.g., 62% of the 1982 total was taken by this tonnage class (Figure 2).

Domestic fishing patterns were further examined for each of four geographic areas within the Gulf of Maine - Georges Bank region as follows (Figure 3):

Area 51 - Northern Georges Bank and Great South Channel (Georges-Channel)

Area 52 - Central Gulf of Maine (Central Gulf)

Area 53 - Coastal Massachusetts and Southwestern Maine (Western Gulf)

Area 54 - Coastal Northeastern Maine (Northern Gulf)

These four areas combined produce over 99% of all redfish landings from the region. Areas 51 and 52 comprise the offshore fishing grounds and areas 53 and 54 comprise the inshore grounds.

The central Gulf (Area 52) has been the most productive area, generally accounting for approximately 50% of all redfish landings since 1964 (Figure 4). The Georges-Channel area (Area 51) has produced between 20 and 40% of the annual totals since 1964, the highest proportions occurring between 1972 and 1974 when landings were equivalent to those from the Central Gulf area. The

western Gulf (Area 53) produced between 10 and 15% of the total between 1964 and 1975, but has accounted for about 20% since 1976. The proportion taken from the northern Gulf (Area 54) has remained relatively constant throughout the 1964-82 period at less than 10% of the regional total. The major grounds, according to Kelly et al. (1972), include the areas around Cashes and Fippennies Ledges in the central Gulf of Maine, off Monhegan and Mt. Desert Islands in the northern Gulf, around Jeffries Ledge in the western Gulf, and off the Highlands of Cape Cod in the South Channel area. Regardless of geographic area, the redfish fishery is conducted primarily in depths between 111 and 274 m (Mayo 1975).

Figure 5 depicts the pattern of fishing activity of TC 2, 3, and 4 vessels by area since 1964. Small (TC 2) vessels have typically fished in the western Gulf because of their small size and limited range, although some increases in landings from the Georges-Channel area have been noted since 1979. Medium (TC 3) vessels have fished primarily in the Georges-Channel area since 1968, but, since 1976, activity has become more evenly distributed between Areas 52 and 53. Of the three classes, the pattern exhibited by TC 4 vessels is most typical of overall vessel activity in the fishery. These vessels have fished primarily in the central Gulf with remaining activity concentrated primarily in the Georges-Channel area; landings from the inshore areas (53 and 54) have generally represented less than 15% of the TC 4 total. Landings from Georges-Channel area were comparatively high during the mid-1960's, but declined from the late 1960's through the mid-1970's. In 1980, however, landings from the central Gulf declined and, by 1982, landings from the Georges-Channel and central Gulf areas were approximately equal. During 1976-80, TC 4 vessels also fished more heavily in the inshore areas (primarily

area 53) but, by 1981, landings from these areas were of minor importance.

Size and Age Composition

Commercial length frequency samples were applied to the landings data on a monthly basis to estimate numbers of fish landed by length from 1962 through 1982. Length frequency distributions of the landings from 1964 through 1978 were presented by Mayo (1980). In addition, ages of redfish sampled from the commercial fishery between 1969 and 1980 were determined to estimate the age composition and mean weight at age of redfish landed. Numbers landed and mean weights at age were computed from the commercial sample data by applying annual age/length keys and length-weight equations to estimated numbers landed at 1 cm length intervals by sex. Weighted means of the male and female average weights at age were calculated for sexes combined for each year. Although these results represent an average weight of a fish over the entire fishing year, we feel they are representative of weights for the beginning of each year because of the extremely slow annual growth rate of redfish, particularly for ages 6 and older (Table 2). Average weights of pre-recruit age fish were also computed using the combined-sex growth curve presented by Mayo (1980). As a check on the accuracy of the average weights, the estimated weights landed at each age were summed over all age groups and the sum of products compared to the reported landed weight for each corresponding year. Differences between estimated and reported weights were less than 1% in 10 out of 12 years; deviations in the other two years were less than 3%.

The mean size of redfish landed from the Gulf of Maine - Georges Bank region, after increasing throughout the 1960's and early 1970's, began to decline in 1976. Mayo (1980) interpreted the sharp decline in mean length to

indicate a period of improved recruitment. The average size of both males and females continued to decline through 1978, but began to increase again in 1979. The increasing trend in average size has continued through 1982 (Figure 6), reflecting individual growth of recruiting fish.

Examination of the mean length data by area (Figure 7) reveals pronounced differences in trends over time. The most extreme fluctuations in mean size occurred in the inshore western and northern Gulf areas while oscillations in the offshore central Gulf and Georges-Channel areas were much less pronounced. The relative stability in mean size of redfish from offshore areas compared to inshore areas suggests a time lag in recruitment of young fish to more offshore areas during which individuals increase in length and weight. Such a time lag could account for the increased size of redfish taken in deeper water as noted by several authors (Hennemuth and Brown 1964; Gulland 1965; McKone 1979).

The Georges-Channel area exhibits the greatest stability in mean size of fish landed, suggesting a longer lag time for recruitment, while inshore areas appear to be most immediately affected by incoming year classes. Mayo (1975, 1980) has suggested that the inshore Gulf of Maine contains the major nursery grounds for redfish in the region. The spatial and temporal size distribution of redfish in the commercial landings supports this hypothesis. However, the northern Gulf, which is the least heavily fished, has consistently produced fish which are larger in overall mean size than any other area within the region.

Commercial length frequencies during 1975-82 (Figure 8) reveal an increasing dominance of smaller fish which have been identified as belonging to the 1971 year class (Mayo 1980, Mayo et al. 1981). Landings of 1971 year

class fish first became substantial in 1976 with a concomitant shift from a uni-modal (by sex) to a bi-modal distribution. The bi-modal distribution pattern became more pronounced through 1978 when the 1971 year class became dominant. Subsequently, the relative impact of the 1971 year class became less evident and, by 1982, the 1971 mode had become virtually indistinguishable from the rest of the stock (Figure 8).

During the early 1970's, the catch-at-age distribution was well balanced with several year classes from the 1950's and early 1960's predominating (Table 3, Figure 9). A period of extremely poor recruitment between the mid-1960's and mid-1970's resulted in a pronounced shift in the catch-at-age matrix which continued throughout the 1970's. In 1974, redfish from the 1971 year class began to recruit and, in 1976, this year class contributed 30% of the total number landed (Table 3) although the contribution by weight represented only 11% of the total due to the small size of these fish. By 1980, however, the 1971 year class accounted for 63% by number and 47% by weight of the total landed.

It appears that between 1976 and 1980, fishing activity was directed at the relatively strong 1971 year class. This is reflected in the increased proportion of landings from inshore areas and the sharp decline in mean size of redfish in commercial landings from these areas. The recruitment of this year class to the fishery accounts for the bi-modal length frequency distributions evident during the late 1970's and early 1980's (Figure 8). Subsequent recruitment to the fishery, however, has been negligible. Until newly recruited year classes appear, the 1971 year class will continue to dominate landings in the Gulf of Maine - Georges Bank fishery. Since this year class is fully recruited, any increase in landings which may occur

in the near future can do so only through growth of individual fish or substantial increases in fishing effort.

INDICES OF ABUNDANCE

Commercial CPUE Indices

Commercial CPUE indices (tons per standard day fished) presented in Table 1 were re-calculated according to the method described by Mayo (1980). When the original fishing power coefficients were calculated, Mayo (1980) noted that the catch rates of the large (TC 4) vessels were lower in relation to the standard medium (TC 3) vessels in the later years, resulting in a negative trend in the regression residuals. Therefore, in the present analysis, two sets of fishing power coefficients were calculated, one set for 1964-72 and a second set for 1973-82. The re-calculated fishing power coefficients were then applied to summarized effort of each vessel tonnage group and the corresponding landings and standardized effort were accumulated over all vessel categories. Unstandardized CPUE indices are also given in Table 1 for comparative purposes. Only otter trawl trips in which redfish comprised 50% or more of the total landings were used in the CPUE calculations. Between 1964 and 1979, these "directed" redfish trips consistently accounted for 25-35% of all trips in which redfish were landed (Table 4) and the amount of redfish landed on these trips represented 80-90% of the Gulf of Maine - Georges Bank total. In 1980, however, the directed trip percentage declined to 12% and the landings percentage to 58% and, in 1982, corresponding values were only 6 and 32% respectively. This indicates a major reduction in directed redfish effort in the fishery during the past three years.

The standardized CPUE index reveals a continuation of the decline in abundance reported by Mayo (1975, 1980). Commercial CPUE indices have

steadily declined from a recent maximum of 6.1 tons per day fished in 1968 to 1.5 tons in 1982. A temporary remission was evident between 1976 and 1978 coincident with the recruitment of the 1971 year class (Table 1). In 1979, however, the index resumed its downward progression. The recent reduction in the proportion of directed redfish trips also suggests a more serious decline in abundance since fewer vessels meet the criterion, and only the most successful are involved in the CPUE calculations. The estimated total standard effort in the redfish fishery has also recently declined from a maximum of 7,766 days fished in 1979 to 4,487 days in 1982 (Table 1).

Research Vessel Survey Indices

The Northeast Fisheries Center 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 (Figure 10). A spring survey covering the same area commenced in 1968, and a summer survey has also been conducted intermittently. The research vessels Albatross IV and Delaware II have been used in these surveys; a "36 Yankee" trawl equipped with 41 cm rollers was used during all summer and autumn surveys and in spring surveys during 1968-1972 and since 1982, 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/hr (3.5 knots) at each station. Additional information concerning NEFC surveys and the application of resulting data to assessments 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)) for redfish in the Gulf of Maine - Georges Bank region.

Two strata sets have been defined for redfish to delineate the inshore western and northern Gulf of Maine regions (strata 26, 27, 39, 40) from the offshore central Gulf - Georges Bank - Great South Channel regions (strata 24, 28-30, 36-38). Abundance and biomass indices and average lengths and weights were calculated for the above strata sets and for all areas combined from spring (1968-82) and autumn (1963-82) survey data (Tables 5 and 6); average lengths and weights are plotted in Figure 11, and autumn length frequency distributions (stratified mean number per tow at length) are given in Figure 12.

Combined autumn abundance indices (stratified mean number per tow) (Table 5) declined from an average of over 100 fish per tow between 1966 and 1970 to less than 30 fish per tow since 1979. Initially, abundance was high due to the presence of several strong year classes produced during the early 1960's and a temporary increase in abundance occurred from 1972 through 1975 with the appearance of the 1971 year class (Figure 12). Periods of peak abundance in the inshore strata preceded those in the entire region, reflecting earlier recruitment in the inshore areas. Overall numerical abundance appears to have declined by a factor of 3 or 4 since the late 1960's despite the appearance of the relatively strong 1971 year class. Autumn weight per tow indices exhibit similar trends although the overall decline in biomass is not as pronounced due to concurrent increases in the mean weight of individual fish (Table 5).

Between 1963 and 1982, the average size of redfish measured on autumn surveys has fluctuated considerably in both inshore and offshore strata (Figure 11). Despite this, the general trend suggests a gradual increase in size over time as a result of poor recruitment during the late 1960's

and 1970's. The declines in mean size which occurred in the mid-1960's and early 1970's depict the two periods of favorable recruitment within the 20-year series. Subsequent increases in mean size reflect growth of the recruited individuals. In every year, the average size of redfish in the inshore strata was smaller than the mean for the offshore strata, indicating a size-dependent offshore movement. A delay in recruitment of 2-3 years between inshore and offshore areas is also suggested by the differences in the trends in mean size over time. Trends in mean size of redfish collected on spring surveys (Table 6) are more variable than those for autumn, and differences in mean size between inshore and offshore areas are not as great. Redfish from inshore strata in spring do not exhibit the pronounced decline in mean size caused by recruitment of the 1971 year class which is evident in the autumn data. These results may indicate a greater amount of mixing of adult and pre-recruit redfish in inshore strata during the spring months.

Autumn length frequency distributions (Figure 12) illustrate the substantial changes in the size composition of the redfish stock which occurred between 1963 and 1982. Recruitment of several strong year classes was reflected in the progression of two large modal groups of fish less than 20 cm between 1963 and 1969 in the inshore strata. Subsequent movement of these recruiting year classes to the offshore strata in the late 1960's resulted in a relatively broad-based size distribtion of the stock in the deeper water. The 1970 distributions reveal a sharp decline in the inshore abundance and an almost complete integration of the recruits with the offshore adult stock.

Recruitment during the 1970's was essentially limited to the 1971 year class which can be seen in the inshore data until 1979. In the late 1970's inshore abundance of this year class declined sharply as these fish also moved

offshore into deeper water. The initial appearance of recruiting fish in the mid-1960's and early 1970's accounts for the sharp decrease in mean size (Figure 11) of fish in the inshore strata. Subsequent increases in mean size also correspond with increases in modal length resulting from growth of individual fish (Figure 12).

The length frequency data also reveal evidence of recent recruitment in the 1978 and 1979 autumn surveys. Although the relative abundance of these fish appears extremely low, initial comparisons of catch per tow values suggest that the size of the 1978 and 1979 year classes is an approximate order of magnitude less than the strong 1971 year class.

EXPLOITATION PATTERN

By comparing the proportionate representation of 1971 year class redfish in 1977 and 1978 commercial and research vessel catches, Mayo (1980) concluded that males recruited to the commercial fishery at age 6 and females at age 7. Mesh selection experiments (Clark 1963, Templeman 1963) indicate that selection of redfish by small mesh commercial gear (stretched mesh size < 102 mm) is essentially complete between 24 and 27 cm at corresponding ages of 6 and 9 years (Mayo 1980). The shifting exploitation pattern of commercial vessels described above also suggests increased availability of 1971 year class fish during the late 1970's. It is, therefore, reasonable to assume that, between 1978 and 1980, 1971 year class redfish had become both fully available to the commercial fishery and vulnerable to selection by the gear. A partial recruitment vector was derived from the above information, assuming full recruitment for ages 9 and older as follows:

Age	4	5	6	7	8	9+
Partial Recruitment	0.10	0.25	0.50	0.75	0.85	1.00

MORTALITY ESTIMATES

Total Mortality

Total instantaneous mortality coefficients (Z) were calculated from the commercial catch-at-age data available from 1969 through 1980. Annual CPUE-at-age estimates (Table 7) were computed by dividing annual numbers landed at age (Table 3) by total standardized effort (Table 1) for the corresponding year. Individual catch curves were constructed for the 1948 through 1961, 1963, and 1964 year classes, the remaining year classes being excluded because of sporadic recruitment from the mid-1960's. The 1971 year class, although a dominant feature of the age composition during the late 1970's was excluded because of the lack of fully recruited age groups in the fishery.

Estimates of Z were obtained for each year class from the regression of $\log_e$ CPUE at age on age for fully recruited (9+) age groups. A pooled estimate of Z was also computed for this period from the geometric mean CPUE at age for all year classes used in the individual calculations. Estimates of Z by year class ranged from 0.10 to 0.34 with a mean of 0.25 (Table 8); the pooled estimate was 0.21. Between-year mortality rates, computed as $\log_e$ (CPUE age 9+/CPUE age 10+), were more variable, ranging from 0.08 to 0.44; the average of these estimates was 0.26.

An estimate of q, the fraction of the population taken by a unit of fishing effort, was derived from the functional relationship between mean Z and mean fishing effort, f (Ricker 1975):

$$q = \frac{\Sigma (\bar{Z} - M)}{\bar{f}}$$

A mean fishing effort of 5361 days fished was computed for the 1969-80 period from the total effort column of Table 1. The mean Z for the same period, taken from the pooled year class regression, was 0.21. Assuming an instantaneous natural mortality rate (M) of 0.05, q is estimated as 0.00002985 for 1969-80.

Fishing Mortality

Annual estimates of instantaneous fishing mortality (F) were derived from virtual population analysis (VPA) of the 1969-80 redfish catch at age data (Table 3), with an exploitation pattern for ages 6 to 9 as described above. A trial VPA was performed with a terminal F of 0.19 (ages 9+), computed by multiplying 1980 fishing effort by the previously calculated value of q as:

$$F_{80} = q \cdot f_{80}$$

where:

q = 0.00002985 and,

f = 1980 fishing effort (6364 standard days fished).

M was set equal to 0.05 for all age groups.

A more refined estimate of the 1980 terminal F value was obtained by regressing mean fully recruited (ages 9+) annual fishing mortality estimates from the initial VPA against annual fishing effort from 1969 to 1979 using a power curve functional relationship. The VPA was re-run with a new terminal F (0.21) estimated from the fitted curve, and resulting estimates of annual F were again regressed on fishing effort. The VPA-regression procedure was repeated until the terminal F predicted by the regression for 1980 equalled the terminal F used in the preceding VPA. Convergence, was thus achieved after three trials, and a final VPA was performed with a 1980 terminal F of 0.22. The final regression of the resulting fishing mortality estimates on effort (Figure 13) yielded a correlation coefficient of 0.84.

Weighted mean fishing mortality for fully recruited ages (9+) estimated from the VPA (Table 9) ranged from 0.12 in 1969 to 0.28 in 1979. Two periods of peak fishing mortality (1971-73 and 1977-79) coincide with years of maximum estimated fishing effort (Table 1). Yield per recruit analyses performed with M equal to 0.05 (Mayo 1980) indicated that yield is maximized at F_{max} equal to 0.14 for males recruiting at age 6 and females at age 8. The corresponding $F_{0.1}$ value (Gulland and Boerema 1973) was 0.07. Thus, the VPA results suggest that fishing mortality exceeded F_{max} throughout most of the 1970's and was generally between two and three times the $F_{0.1}$ level.

STOCK SIZE ESTIMATES

Age-specific stock size estimates from VPA are given in Table 10; annual stock biomass estimates for 1969-80 (Table 11) were determined by applying mean weights at age from Table 2 to the stock size estimates. Since 1971 year class redfish began recruiting to the fishery in substantial numbers in 1976, stock size and biomass sub-totals are presented for ages 5+ as well as for ages 9+ (full recruitment).

The total redfish stock (age 1+) in the Gulf of Maine - Georges Bank region declined from 517 million fish in 1969 to 191 million in 1980, a decrease of over 63%. Stock sizes of age 5+ and 9+ fish also declined by 70% and 51%, respectively. Total (age 1+) stock biomass also declined sharply from 137 thousand tons in 1969 to 52 thousand tons in 1980, a decrease of 62%. Age 5+ and 9+ biomass also declined by 62% and 51%, respectively. The decreases in stock size and biomass between 1969 and 1980 parallel the overall decline noted for the standardized commercial CPUE index (Table 1, Figure 14).

The relationship between stock size and CPUE was examined by comparing mean stock size estimates in year i with the corresponding annual CPUE indices. Average mid-year stock sizes of age 1+, 5+, and 9+ fish were computed as the geometric mean of age j fish in year i and age j+1 fish in year i+1. Corresponding annual CPUE indices were expressed in terms of numbers (Table 12). Linear correlations of CPUE with age 1+, 5+, and 9+ stock sizes at the midpoint of year i were performed on the data from 1969 through 1979. The strongest correspondence (r^2=0.80) exists between age 5+ stock size and annual CPUE. Correlations between CPUE and age 1+ stock size (r^2=0.26) and age 9+ stock size (r^2=0.49), however, are relatively poor. These results strongly support previous observations (Mayo 1980) that recruitment of 1971 year class redfish at age 5 in 1976 contributed to a temporary halt, between 1976 and 1978, in the declining commercial catch rates. In fact, substantial increases in the commercial CPUE index, expressed as number of fish, occurred during these 3 years (Table 12). Evidence now exists to link the temporary reversal of the declining CPUE trend to recruitment of 1971 year class fish at ages 5, 6, and 7 between 1976 and 1978. The CPUE weight index increased only slightly because of the low average weight of the recruiting fish. The CPUE index, expressed as numbers or weight, has continued to decline since 1979.

The relationship between CPUE and stock size may also be expressed as a functional regression which forces the slope through a fixed point (Ricker 1973). In this case the fixed point is the origin, since CPUE will be zero when stock size is zero; the regression is expressed as:

$$b = \frac{\Sigma \text{ CPUE}}{\Sigma \text{ Stock size.}}$$

The slope, b, may also be interpreted as the proportion of the stock taken

by a unit of fishing effort, or q (Ricker 1975). Estimates of q, obtained for age 5+ through 7+ stock sizes closely correspond to the previous value of q (0.00002985) calculated from the relationship between mean fishing mortality and effort, again indicating that the 1971 year class was contributing substantially to the fishery by age 5.

RECRUITMENT

The 1971 year class is the predominant feature of the current population dynamics of the Gulf of Maine - Georges Bank redfish stock. The importance of this year class is further emphasized by the lack of significant recruitment for several years before and since. This year class appears to be extremely large even when compared to other dominant year classes, e.g., the estimated age 9 stock size for the 1971 year class in 1980 was approximately twice that of the 1963 and 1964 year classes in 1972 and 1973. At age 6, the 1963 and 1964 year classes appeared to be only one-third the size of the 1971 year class. Comparisons of this nature must be interpreted cautiously in view of the obvious greater sensitivity of 1971 year class estimates to the 1980 terminal F value. As was noted in previous sections of this paper, fishing activity in the western Gulf of Maine increased during 1976-80 with recruitment of the 1971 year class. Therefore, proportional representation of younger fish in the landings between 1976 and 1980 was greater than in 1969 when the 1963 and 1964 year classes were 5 and 6 years old, since the overall abundance of fully recruited year classes in offshore waters was considerably higher. The combined effects of declining abundance and the lack of significant recruitment over the previous decade apparently resulted in increased exploitation of the recruiting 1971 year class in the late 1970's compared to earlier strong year classes.

Stock size estimates for the most recent years depend on estimates of pre-recruit year class size which cannot be calculated from the catch at age data. Therefore, estimates for the 1978 and 1979 year classes at age 1 were set at one-tenth the level of the strong 1971 year class, based on evidence from NEFC bottom trawl surveys. Age 1 stock sizes for the 1975 through 1977 year classes were computed as the average of the weak 1973 and 1974 year classes (Table 10). The age 2 through 5 stock sizes of the 1975-79 year classes given in Table 10 were computed from the age 1 values by applying an M of 0.05 at ages 1 through 3 and partial F's at ages 4 and 5. Given the above partial recruitment vector, it is likely that recruiting fish from the 1978 and 1979 year classes will appear in the fishery in 1983 and 1984. However, the size of these year classes, estimated at one-tenth the size of the 1971 year class, is insufficient to substantially increase the exploitable biomass.

CATCH AND STOCK SIZE PROJECTIONS

Stock size and biomass projections were developed for 1981-84 using age-specific mean weights (Table 2) and VPA stock size estimates for 1980 (Table 10) and the above exploitation pattern. Recruitment at age 1 was assumed equal to the poor 1973-74 year class average. Total stock sizes were projected by iterating with trial F values until projected 1981-82 catches agreed with reported values (Table 13). The fishing mortality which projected the 1981 catch agreed with the mortality predicted by the power curve regression of F on fishing effort (Figure 13), but the 1982 fishing mortality exceeded the F predicted from 1982 effort. Stock sizes were further projected through 1984 by approximating an expected 1983 catch of 3,400 tons based on preliminary landings estimates.

The lower 1982 fishing mortality value predicted from the regression suggests that fishing effort may have been higher in 1982 than predicted from the CPUE index, indicating an over-estimate of the 1982 CPUE index and/or an increase in q in 1982. Sissenwine (1978) cited several studies which indicate an inverse relationship between q and population size. Thus, it is unlikely that the value of q calculated for the 1969-80 period is applicable, given recent low population sizes. Also the accuracy of 1981-82 CPUE and effort estimates is questionable due to the sharp decrease in the proportion of directed redfish trips used in the CPUE calculations (Table 4).

The relatively low 1983 catch is expected to generate an F of 0.13 compared to 0.20 in 1982, although stock size will continue to decline. By the beginning of 1984, stock biomass will be at approximately 50% of the 1980 level and only 20% of the 1969 level. If fishing continues in 1984 at the 1983 level (F=0.13), stock biomass will still continue to decline. Even if no fishing occurs in 1984, stock size will decline because of poor recruitment, although stock biomass will increase slightly due to growth in weight of individual fish.

DISCUSSION

The VPA results illustrate the severe decline in redfish stock size and biomass which occurred between the late 1960's, when commercial CPUE was relatively high, and the late 1970's, when CPUE indices reached historically low levels. A period of sustained poor recruitment beginning in the mid-1960's resulted in a population age structure devoid of significant numbers of recruiting fish throughout the 1970's except those in the 1971 year class. Even with the contribution of this year class to the exploitable biomass

in the late 1970's, the CPUE index increased only temporarily before continuing to decline through 1982.

Commercial landings declined in 1982 for the third consecutive year. The 1982 Subarea 5 total of 6,700 tons was less than one-half of the 1977-79 average, and represented the lowest amount landed since the directed fishery commenced in 1935. The decline has been exacerbated since 1978 by the exclusion of USA vessels from Canadian waters where substantial quantities of redfish have traditionally been caught. This exclusion has resulted in increased effort in the Gulf of Maine - Georges Bank region despite a 75% reduction in commercial CPUE indices from 6.1 tons per day fished in 1968 to 1.5 tons in 1982.

Between 1976 and 1979, commercial landings and fishing effort increased by 40% and 60%, respectively, as the 1971 year class recruited to the fishery. The proportion of total landings represented by the 1971 year class increased from 30% by number and 11% by weight in 1976 to 63% and 48%, respectively in 1980. Mean fishing mortality for the 1969-80 period was slightly greater than F_{max} and about twice the $F_{0.1}$ level. Further, the combination of declining stock size throughout the 1970's and increased fishing effort in the late 1970's resulted in F's that were 50% above F_{max} and three times greater than $F_{0.1}$. Given the fundamental equilibrium assumptions underlying yield per recruit analyses (Cushing 1968), it is likely that sustained fishing even at F_{max} during a period of declining stock size and poor recruitment would have continued to deplete the stock (Gulland and Boerema 1973). In fact, with the series of poor year classes produced in the middle to late 1960's following a period of favorable recruitment, the stock would have declined even if fishing mortality had remained extremely low. The catch level of 14,000 tons in 1978 and 1979, which approximated the 14,000 ton MSY estimated for equilibrium conditions (Mayo 1980), was achieved during a temporary increase

in exploitable biomass resulting from recruitment of the 1971 year class. However, the amount of effort expended (5,900 and 7,800 days fished) and the level of fishing mortality imposed on the stock (0.24 and 0.28) were approximately twice the estimated f_{msy} (3,500 days) and F_{max} (0.14) levels. Although the 1983 level of F is considerably lower than levels exerted during 1977-82, the stock will continue to decline because of poor recruitment prospects. Consequently, landings from the Gulf of Maine in 1983 and 1984 are not expected to exceed 3,500 tons.

CONCLUSIONS

All of the evidence for the Gulf of Maine - Georges Bank redfish stock suggests that excessive levels of effort and fishing mortality were exerted throughout the last decade, particularly between 1977 and 1979. Despite sharp reductions in landings and effort in the last three years, abundance indices have continued to decline. The 1971 year class has been fully exploited for the past several years and presently constitutes the major resource base for the Gulf of Maine - Georges Bank redfish fishery. However, the biomass of this year class has been steadily declining since 1979, and will continue to do so because growth in weight cannot compensate for the current level of fishing mortality. The extremely low $F_{0.1}$ level (0.07) implies that the number of fish which can be harvested at this level cannot be much greater than the number dying through natural causes, assuming that the natural mortality rates (M) equals 0.05. Projections for 1983 and 1984 indicate a further decline in landings and continued reductions in the exploitable biomass.

With the present age structure of the stock and exploitation pattern, the fishery has become extremely sensitive to recruitment. Given the lack of substantial recruitment following the 1971 year class, stock abundance and commercial CPUE will continue to decline in the near future even if catches remain at or below their current level. Consequently, any long-term increases in stock size will initially depend on the strength of the 1978-1979 year classes and ultimately on the strength of future year classes. However, it does not appear, at present, that the 1978 and 1979 year classes are large enough to balance the continued depletion of the 1971 year class.

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Table 1. Nominal redfish catches (metric tons), actual and standardized catch per unit effort, and calculated standardized USA and total effort for the Gulf of Maine - Georges Bank redfish fishery.

Year	Nominal Catch (Metric tons)			USA Catch per Unit Effort (tons/day)		Calculated Standard Effort (days fished)	
	USA	Others	Total	Actual	Standard	USA	Total
1934	519		519				
1935	7549		7549				
1936	23162		23162				
1937	14823		14823				
1938	20640		20640				
1939	25406		25406				
1940	26762		26762				
1941	59796		59796				
1942	55892		55892	6.9	6.9	8100	8100
1943	48348		48348	6.7	6.7	7216	7216
1944	50439		50439	5.4	5.4	9341	9341
1945	37912		37912	4.5	4.5	8425	8425
1946	42423		42423	4.7	4.7	9026	9026
1947	40160		40160	4.9	4.9	8196	8196
1948	43631		43631	5.4	5.4	8080	8080
1949	30743		30743	3.3	3.3	9316	9316
1950	34307		34307	4.1	4.1	8368	8368
1951	30077		30077	4.1	4.1	7336	7336
1952	21377		21377	3.5	3.4	6287	6287
1953	16791		16791	3.8	3.6	4664	4664
1954	12988		12988	3.4	3.1	4190	4190
1955	13914		13914	4.5	4.0	3478	3478
1956	14388		14388	4.4	3.8	3786	3786
1957	18490		18490	4.3	3.6	5136	5136
1958	16043	4	16047	4.4	3.6	4456	4458
1959	15521	-	15521	4.3	3.5	4435	4435
1960	11373	2	11375	3.8	3.0	3791	3792
1961	14040	61	14101	4.6	3.5	4011	4029
1962	12541	1593	14134	5.4	4.0	3135	3533
1963	8871	1175	10046	4.1	3.0	2957	3349
1964	7812	501	8313	4.3	2.9	2604	2867
1965	6986	1071	8057	7.0	4.4	1588	1831
1966	7204	1365	8569	11.7	6.4	1126	1339
1967	10442	422	10864	12.4	5.6	1865	1940
1968	6578	199	6777	14.7	6.1	1078	1111
1969	12041	414	12455	11.4	4.9	2457	2542
1970	15534	1207	16741	9.0	4.0	3884	4185
1971	16267	3767	20034	7.0	3.2	5083	6261
1972	13157	5938	19095	5.7	2.9	4537	6584
1973	11954	5406	17360	5.3	2.9	4122	5986
1974	8677	1794	10471	5.0	2.6	3337	4027
1975	9075	1497	10572	4.0	2.2	4125	4805
1976	10131	565	10696	4.6	2.3	4405	4650
1977	13012	211	13223	4.9	2.5	5205	5289
1978	13991	92	14083	4.8	2.4	5830	5868
1979	14722	33	14755	3.6	1.9	7748	7766
1980	10085	98	10183	3.2	1.6	6303	6364
1981	7898	19	7917	2.7	1.4	5641	5655
1982	6731	-	6731	2.7	1.5	4487	4487

Table 2. Average weights (kg) at age of redfish from the Gulf of Maine - Georges Bank commercial fishery, 1969-1980.

	YEAR												
AGE	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	Mean
3	-	-	-	-	-	.064	.039	-	-	-	-	-	.052
4	.113	-	-	-	-	.080	.098	.076	-	-	.092	-	.092
5	.115	.172	-	-	-	-	.161	.135	.090	-	-	-	.135
6	.142	.168	.172	-	-	.195	.221	.199	.173	.135	.200	.108	.171
7	.169	.170	.242	.197	.162	.150	-	-	.288	.209	.191	.175	.195
8	.195	.189	.244	.240	.213	.233	.383	-	-	.300	.251	.188	.245
9	.219	.221	.265	.257	.251	.270	.349	.345	-	-	.304	.283	.277
10	.260	.236	.304	.289	.281	.326	.317	.278	-	.311	.295	.371	.297
11	.320	.290	.333	.334	.343	.331	.342	.296	.350	.383	.248	.421	.333
12	.339	.339	.369	.367	.341	.378	.394	.347	.413	.468	.402	.362	.377
13	.366	.356	.399	.399	.384	.399	.399	.395	.412	.402	.508	.424	.404
14	.404	.367	.437	.427	.402	.427	.420	.389	.408	.433	.472	.454	.420
15	.425	.340	.445	.451	.482	.449	.460	.405	.433	.423	.474	.506	.441
16	.473	.418	.468	.472	.454	.442	.469	.427	.454	.458	.564	.478	.465
17	.495	.427	.435	.490	.500	.503	.533	.511	.426	.551	.526	.499	.494
18	.457	.438	.449	.515	.492	.527	.527	.469	.534	.504	.543	.518	.498
19	.589	.523	.541	.509	.523	.540	.522	.542	.537	.526	.551	.554	.538
20	.497	.579	.553	.562	.525	.565	.550	.517	.610	.547	.617	.595	.560
21	.515	.505	.514	.581	.529	.525	.600	.518	.466	.523	.664	.647	.549
22	.594	.450	.544	.565	.641	.578	.547	.552	.595	.537	.597	.664	.572
23	.589	.464	.581	.604	.633	.585	.595	.645	.611	.633	.567	.629	.595
24	.705	.476	.481	.489	.568	.641	.607	.577	.544	.551	.605	.599	.570
25	.708	.345	.473	.560	.653	.633	.663	.628	.552	.606	.567	.681	.589
26+	.591	.541	.540	.668	.620	.642	.662	.630	.605	.641	.647	.695	.624

Table 3. Catch at age matrix (Thousands of fish) for redfish in the Gulf of Maine - Georges Bank region, 1969 - 1980.

AGE	YEAR 1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
	CATCH MATRIX (NUMBERS, 1000'S)											
1	1.0	1.0	1.0	50.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2	1.0	1.0	1.0	1.0	100.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0	1.0	308.0	4.0	1.0	1.0	1.0	1.0	1.0
4	22.0	1.0	1.0	1.0	1.0	105.0	695.0	196.0	1.0	1.0	1.0	1.0
5	421.0	146.0	1.0	1.0	1.0	1.0	72.0	8961.0	234.0	1.0	25.0	1.0
6	439.0	4055.0	72.0	1.0	1.0	17.0	11.0	439.0	16747.0	271.0	205.0	132.0
7	1008.0	4048.0	1941.0	933.0	235.0	8.0	1.0	1.0	311.0	24569.0	849.0	175.0
8	6065.0	1060.0	4430.0	3296.0	2463.0	174.0	30.0	1.0	1.0	215.0	23729.0	1110.0
9	2513.0	9692.0	1536.0	7401.0	7938.0	1886.0	124.0	21.0	1.0	1.0	152.0	16900.0
10	6717.0	3221.0	7907.0	1712.0	8391.0	4724.0	1944.0	48.0	1.0	34.0	117.0	208.0
11	2660.0	8351.0	2767.0	7580.0	2201.0	2945.0	4360.0	467.0	81.0	33.0	48.0	44.0
12	3975.0	2734.0	6504.0	2782.0	7337.0	2435.0	2154.0	2706.0	2127.0	182.0	168.0	46.0
13	3287.0	4702.0	3088.0	2884.0	2078.0	1709.0	1932.0	3375.0	1262.0	1689.0	541.0	217.0
14	2221.0	2672.0	4267.0	1994.0	3100.0	1115.0	1442.0	1702.0	4012.0	1484.0	1228.0	491.0
15	2820.0	2302.0	3680.0	3531.0	2376.0	1302.0	1009.0	1725.0	1823.0	2948.0	1972.0	830.0
16	1348.0	3489.0	2895.0	2449.0	2024.0	935.0	1344.0	1388.0	2747.0	1748.0	1299.0	1221.0
17	751.0	1778.0	2206.0	1205.0	1799.0	1454.0	1360.0	1233.0	1466.0	1310.0	1580.0	860.0
18	526.0	1640.0	2765.0	1276.0	1380.0	910.0	1235.0	1166.0	1190.0	866.0	983.0	664.0
19	606.0	393.0	1347.0	2245.0	864.0	640.0	945.0	1424.0	1064.0	899.0	845.0	564.0
20	426.0	662.0	1163.0	734.0	933.0	661.0	1116.0	608.0	461.0	1283.0	1008.0	452.0
21	451.0	368.0	560.0	1011.0	411.0	589.0	608.0	769.0	706.0	895.0	798.0	473.0
22	345.0	529.0	1048.0	1172.0	590.0	730.0	887.0	681.0	541.0	734.0	594.0	370.0
23	469.0	572.0	559.0	718.0	426.0	271.0	492.0	323.0	117.0	500.0	532.0	349.0
24	38.0	488.0	282.0	538.0	295.0	285.0	294.0	672.0	571.0	192.0	538.0	294.0
25	100.0	64.0	138.0	1280.0	289.0	250.0	298.0	94.0	1013.0	530.0	427.0	265.0
26+	847.0	1743.0	2439.0	2874.0	1977.0	1755.0	1282.0	2011.0	2157.0	2220.0	2506.0	1308.0
TOTAL	38058.0	54713.0	51599.0	47670.0	47212.0	25211.0	23641.0	30014.0	38637.0	42608.0	40148.0	26978.0

Table 4. Domestic landings of redfish (metric tons, live) and number of fishing trips on which redfish were caught for total and directed (50% redfish) fishing activity.

	Landings (metric tons)			Number of Trips		
Year	Total Landings	50% Trip Landings	Percent of Total	Total Trips	50% Trips	Percent of Total
1964	7843.1	6893.7	87.9	1693	603	35.6
1965	6977.6	6175.7	88.5	1435	370	25.8
1966	7184.0	6366.6	88.6	1122	272	24.2
1967	10348.7	9643.8	93.2	963	274	28.5
1968	6574.8	5828.2	88.6	847	123	14.5
1969	11994.8	11157.0	93.0	1074	301	28.0
1970	15514.2	13639.1	87.9	1691	448	26.5
1971	16235.0	14704.6	90.6	1585	574	36.2
1972	13146.0	11485.9	87.4	1499	490	32.7
1973	11925.4	10463.5	87.7	1662	542	32.6
1974	8644.1	7223.5	83.6	1604	418	26.1
1975	9036.9	7196.7	79.6	1784	453	25.4
1976	10074.3	8308.9	82.5	1675	471	28.1
1977	12950.5	11205.6	86.5	1901	606	31.9
1978	13889.5	11189.7	80.6	2183	625	28.6
1979	14627.9	10570.1	72.3	3313	832	25.1
1980	9747.7	5620.5	57.7	3577	425	11.9
1981	7859.8	3497.6	44.5	3724	332	8.9
1982	6621.1	2082.4	31.5	3513	194	5.5

Table 5. Autumn NEFC bottom trawl survey stratified mean catch per tow indices, mean weights, and mean lengths of redfish in the Gulf of Maine - Georges Bank region.

	INSHORE [1]				OFFSHORE [2]				COMBINED [3]	
	Stratified Mean Catch per Tow		Ave. Wt.	Ave. Length	Stratified Mean Catch per Tow		Ave. Wt.	Ave. Length	Stratified Mean Catch per Tow	
Year	Number	kg	kg	cm	Number	kg	kg	cm	Number	kg
1963	86.3	7.6	.088	17.4	87.5	27.0	.309	26.4	87.3	24.1
1964	81.3	13.5	.166	20.2	122.3	61.8	.505	30.8	116.3	54.6
1965	189.5	22.3	.118	17.7	33.9	11.5	.339	25.3	57.0	13.1
1966	172.8	17.0	.098	16.2	77.8	31.2	.401	27.4	91.9	29.1
1967	62.9	5.3	.084	17.7	107.1	27.6	.258	23.6	100.5	24.3
1968	41.1	4.7	.114	18.3	161.3	46.6	.289	25.1	143.4	40.4
1969	105.9	16.0	.151	20.7	65.2	24.8	.380	27.4	71.2	23.5
1970	18.2	2.8	.154	20.3	107.2	38.2	.356	26.3	94.0	32.9
1971	20.7	4.7	.227	21.8	52.8	26.7	.506	29.7	48.0	23.4
1972	36.4	6.6	.181	20.8	58.9	27.8	.472	29.2	55.6	24.6
1973	26.2	2.1	.080	15.6	41.4	19.7	.476	29.7	39.2	17.0
1974	44.4	4.7	.106	18.0	49.0	27.6	.563	30.1	48.3	24.2
1975	45.7	6.0	.131	19.6	79.9	45.9	.574	30.6	74.8	39.9
1976	11.6	2.5	.216	22.6	31.9	17.5	.549	30.2	28.9	15.3
1977	54.6	12.3	.225	23.4	37.9	18.1	.478	28.5	40.4	17.3
1978	20.4	5.5	.270	24.6	49.5	23.4	.473	29.0	45.2	20.7
1979	6.2	2.1	.339	26.5	32.8	18.4	.561	30.5	28.9	16.0
1980	20.6	6.2	.301	24.6	20.6	13.8	.670	31.8	20.6	12.6
1981	6.8	1.9	.279	24.9	22.7	14.0	.617	31.8	20.4	12.2
1982	28.2	4.6	.162	21.2	5.6	3.2	.571	31.5	9.0	3.4

1. Strata Set: 26, 27, 39, 40

2. Strata Set: 24, 28-30, 36-38

3. Strata Set: 24, 26-30, 36-40

Table 6. Spring NEFC bottom trawl survey stratified mean catch per tow indices, mean weights and mean lengths of redfish in the Gulf of Maine - Georges Bank region.

	INSHORE [1]				OFFSHORE [2]				COMBINED [3]	
	Stratified Mean Catch per Tow		Ave. Wt.	Ave. Length	Stratified Mean Catch per Tow		Ave. Wt.	Ave. Length	Stratified Mean Catch per Tow	
Year	Number	kg	kg	cm	Number	kg	kg	cm	Number	kg
1968	7.9	1.2	.152	17.9	51.7	19.8	.383	26.4	45.2	17.0
1969	59.0	8.3	.141	20.3	44.2	21.7	.491	30.6	46.4	19.7
1970	29.7	9.3	.313	24.4	59.1	20.6	.349	26.4	54.7	18.9
1971	49.9	13.3	.267	24.9	176.0	81.7	.464	29.8	157.2	71.6
1972	23.8	4.6	.193	18.6	114.7	51.3	.447	28.9	101.2	44.4
1973	14.4	4.6	.319	22.0	49.6	28.9	.583	31.4	44.4	25.3
1974	25.7	6.1	.237	19.7	35.8	21.0	.587	31.5	34.3	18.8
1975	50.9	18.9	.371	25.5	37.4	17.4	.465	28.5	38.9	17.6
1976	45.9	6.4	.139	19.8	65.1	29.6	.455	29.2	62.2	26.2
1977	79.1	24.0	.303	25.3	15.6	9.4	.603	32.1	25.1	11.6
1978	33.7	10.4	.309	25.0	22.3	12.5	.561	30.2	24.0	12.2
1979	27.5	8.5	.309	25.4	67.5	36.4	.539	30.0	61.6	32.3
1980	8.5	2.2	.259	25.3	33.5	23.5	.701	32.4	29.8	20.3
1981	3.0	1.0	.333	22.5	38.9	21.7	.558	30.5	33.6	18.6
1982	5.0	1.4	.289	24.7	18.9	10.8	.568	30.1	16.9	9.4

1. Strata Set: 26, 27, 39, 40

2. Strata Set: 24, 28-30, 36-38

3. Strata Set: 24, 26-30, 36-40

Table 7. Redfish CPUE at age (Number of fish landed per day fished) from the Gulf of Maine - Georges Bank region, 1969-1980.

	YEAR											
AGE	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
3	0	0	0	0	0	76	1	0	0	0	0	0
4	9	0	0	0	0	26	145	42	0	0	3	0
5	166	35	0	0	0	0	15	1927	44	0	0	0
6	173	969	12	0	0	4	2	94	3166	46	26	21
7	397	967	310	142	39	2	0	0	59	4187	109	27
8	2386	253	708	501	411	43	6	0	0	37	3056	174
9	989	2316	245	1124	1326	468	26	4	0	0	20	2656
10	2643	770	1263	260	1402	1173	405	10	0	6	15	33
11	1046	1996	442	1151	368	731	908	100	15	6	6	7
12	1564	653	1039	423	1226	605	449	582	402	31	22	7
13	1293	1124	493	438	347	424	402	726	239	288	70	34
14	874	639	682	303	518	277	300	366	758	253	158	77
15	1109	550	588	536	397	323	210	371	345	502	254	130
16	530	834	462	372	338	232	280	298	519	298	167	192
17	295	425	352	183	301	361	283	265	277	223	203	135
18	207	392	442	194	231	226	257	251	225	148	127	104
19	238	94	215	341	144	159	197	306	201	153	109	89
20	168	186	186	111	156	164	232	131	87	219	130	71
21	178	88	89	154	69	146	127	165	133	153	103	74
22	136	126	167	178	99	181	185	146	102	125	77	58
23	184	137	89	109	71	67	102	69	22	85	69	55
24	15	117	45	82	49	71	61	144	108	33	69	46
25	39	15	22	194	48	62	62	20	192	90	55	42
26+	333	416	390	437	330	436	267	432	408	378	323	206
Total	14970	13073	8241	7232	7869	6260	4922	6453	7304	7260	5169	4238

Table 8. Results of catch curve analyses of redfish commercial age composition data, 1969-1980.

Yearclass	Estimated Z	Age Groups	r^2
1964	0.31	9-16	0.90
1963	0.25	9-17	0.75
1961	0.29	9-19	0.90
1960	0.20	9-20	0.90
1959	0.29	10-21	0.93
1958	0.20	11-22	0.87
1957	0.28	12-23	0.94
1956	0.26	13-24	0.97
1955	0.24	14-25	0.91
1954	0.34	15-25	0.84
1953	0.22	16-25	0.86
1952	0.10	17-25	0.23
1951	0.26	18-25	0.72
1950	0.21	19-25	0.72
1949	0.20	20-25	0.57
1948	0.31	21-25	0.96
Mean	0.25	9-25	-
Pooled	0.21	9-25	0.99

Table 9. VPA estimates of instantaneous fishing mortality (F) for redfish in the Gulf of Maine - Georges Bank region, 1969 - 1980.

AGE	YEAR 1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
	FISHING MORTALITY											
1	0.002	0.002	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000
2	0.000	0.002	0.002	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000
3	0.000	0.000	0.002	0.002	0.000	0.001	0.000	0.001	0.001	0.000	0.000	0.000
4	0.001	0.000	0.022	0.002	0.002	0.037	0.004	0.021	0.001	0.001	0.000	0.022
5	0.008	0.006	0.000	0.001	0.002	0.002	0.027	0.049	0.027	0.001	0.019	0.055
6	0.007	0.082	0.003	0.000	0.001	0.040	0.025	0.196	0.105	0.033	0.161	0.110
7	0.034	0.074	0.044	0.044	0.046	0.004	0.003	0.002	0.176	0.187	0.119	0.170
8	0.103	0.038	0.092	0.084	0.135	0.038	0.018	0.003	0.003	0.151	0.234	0.190
9	0.093	0.201	0.062	0.186	0.251	0.124	0.029	0.013	0.003	0.003	0.129	0.220
10	0.165	0.140	0.212	0.077	0.280	0.197	0.154	0.012	0.001	0.105	0.405	0.220
11	0.104	0.268	0.146	0.271	0.115	0.127	0.237	0.043	0.022	0.023	0.179	0.220
12	0.133	0.126	0.290	0.182	0.381	0.153	0.110	0.192	0.235	0.053	0.136	0.220
13	0.146	0.195	0.173	0.171	0.170	0.121	0.148	0.212	0.109	0.250	0.188	0.220
14	0.123	0.144	0.230	0.137	0.236	0.111	0.121	0.160	0.349	0.154	0.245	0.220
15	0.176	0.154	0.255	0.254	0.204	0.125	0.118	0.176	0.218	0.390	0.265	0.220
16	0.082	0.288	0.249	0.227	0.192	0.098	0.156	0.200	0.389	0.281	0.250	0.220
17	0.050	0.126	0.251	0.132	0.219	0.174	0.171	0.178	0.282	0.272	0.369	0.220
18	0.096	0.125	0.248	0.190	0.186	0.140	0.186	0.185	0.220	0.226	0.283	0.220
19	0.091	0.083	0.122	0.275	0.162	0.105	0.179	0.285	0.216	0.217	0.301	0.220
20	0.078	0.116	0.312	0.077	0.149	0.152	0.228	0.142	0.119	0.365	0.337	0.220
21	0.120	0.077	0.116	0.407	0.048	0.113	0.173	0.205	0.206	0.298	0.340	0.220
22	0.036	0.170	0.273	0.316	0.368	0.097	0.209	0.251	0.184	0.287	0.277	0.220
23	0.295	0.066	0.231	0.257	0.153	0.242	0.075	0.093	0.053	0.218	0.293	0.220
24	0.088	0.470	0.036	0.305	0.135	0.124	0.374	0.118	0.201	0.099	0.323	0.220
25	0.120	0.177	0.196	0.193	0.225	0.138	0.157	0.166	0.222	0.244	0.277	0.220
MEAN F FOR AGES	0.120 9+	0.177 9+	0.196 9+	0.193 9+	0.225 9+	0.138 9+	0.157 9+	0.166 9+	0.222 9+	0.244 9+	0.277 9+	0.220 9+

Table 10. VPA stock size estimates (Thousands of fish) for redfish in the Gulf of Maine - Georges Bank region, 1969 - 1980.

AGE	YEAR 1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
	STOCK SIZE (NUMBERS, 1000'S)											
1	573.3	576.5	3307.6	233028.3	11391.8	1799.1	1654.1	1726.8	1726.8	1726.8	23302.8	23302.8
2	2278.8	545.8	548.7	3204.3	222922.6	10792.7	1738.2	1577.8	1642.6	1642.6	1642.6	22166.3
3	5396.4	2181.8	518.3	523.6	3107.2	212078.9	10517.0	1627.8	1508.2	1562.5	1562.5	1562.5
4	25641.4	5396.4	2092.8	493.4	498.2	2977.3	200499.6	9793.2	1553.9	1444.5	1454.0	1454.0
5	55620.3	24492.0	5396.4	1972.1	468.6	475.1	2729.8	190298.5	9124.7	1486.3	1391.5	1309.1
6	61624.1	52504.1	23176.1	5396.4	1899.0	445.6	451.7	2526.5	172315.5	8451.8	1415.7	1298.6
7	31280.6	58232.6	45994.5	21982.2	5325.0	1838.9	407.3	419.0	1975.6	147590.1	7777.7	1146.8
8	63567.4	28776.1	51448.9	41868.4	20000.7	4835.8	1744.1	387.4	397.9	1576.2	116450.9	6571.2
9	29086.2	54557.6	26335.7	44622.0	36614.6	16625.5	4430.4	1630.7	368.0	378.8	1289.8	87654.8
10	45121.2	25218.3	42453.8	23554.8	35234.3	27096.6	13977.4	4094.8	1530.7	350.2	359.7	1078.8
11	27675.2	36374.7	20850.1	32679.5	20737.7	25342.9	21172.2	11401.9	3848.8	1458.3	300.0	228.2
12	32668.5	23732.8	26466.9	17137.7	23702.8	17581.8	21237.6	15891.9	10388.3	3582.9	1355.3	238.6
13	24759.0	27201.0	19911.8	18841.2	13591.7	15403.1	14332.1	18102.4	12480.5	7809.5	3231.3	1125.5
14	19612.9	20349.2	21293.6	15931.9	15111.9	10904.2	12986.5	11769.7	13931.5	10641.8	5783.3	2546.7
15	17906.1	16492.8	16753.7	16098.1	13211.6	11354.8	9284.8	10947.5	9537.2	9345.3	8677.0	4304.9
16	17535.5	14285.2	13445.4	12352.1	11873.7	10252.3	9531.5	7848.6	8732.7	7296.3	6019.4	6332.9
17	15848.4	15367.5	10190.3	9969.8	9363.6	9322.7	8841.1	7757.0	6113.3	5632.4	5237.9	4460.5
18	5876.6	14345.7	12885.5	7544.5	8309.3	7154.2	7451.5	7084.5	6177.4	4387.4	4081.7	3443.9
19	7113.7	5077.3	12048.4	9563.8	5933.5	6559.7	5918.7	5884.9	5602.9	4716.8	3329.8	2925.3
20	5790.7	6176.1	4446.6	10148.1	6910.6	4802.4	5616.0	4709.3	4210.8	4293.1	3611.0	2344.4
21	4097.8	5092.9	5230.0	3097.0	8938.0	5664.4	3924.0	4254.9	3886.8	3556.3	2834.5	2453.3
22	9955.2	3458.4	4486.1	4429.4	1961.7	8102.0	4814.2	3140.2	3298.1	3009.4	2511.2	1919.1
23	1881.1	9134.9	2774.3	3246.5	3072.0	1291.6	6995.6	3715.2	2323.6	2610.1	2147.8	1810.1
24	464.1	1332.6	8132.8	2094.4	2388.7	2507.2	964.6	6174.8	3219.2	2096.3	1995.8	1524.9
25	904.3	404.5	792.6	7460.6	1468.3	1984.7	2107.3	631.3	5218.7	2505.9	1807.0	1374.5
26+	4393.1	9040.4	12650.3	14906.5	10254.0	9102.6	6649.3	10430.4	11187.6	11514.4	12997.8	6784.2
NUMBERS												
AGE 1+	516672.0	460347.4	393631.4	562146.7	494291.0	426296.1	379996.6	343826.7	302301.4	250666.1	222567.9	191361.9
AGE 5+	482782.1	451646.9	387164.0	324897.1	256371.2	198648.1	165587.7	329101.1	295869.9	244289.7	194606.0	142876.3
AGE 9+	270689.7	287642.1	261148.1	253678.0	228677.9	191052.7	160254.8	135469.7	112056.2	85185.3	67570.2	132550.6

Table 11. VPA stock biomass estimates (Metric tons) for redfish in the Gulf of Maine - Georges Bank region, 1969 - 1980.

AGE	YEAR 1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
	STOCK BIOMASS (TONS)											
1	5.7	5.8	33.1	2330.3	113.9	18.0	16.5	17.3	17.3	17.3	233.1	233.1
2	45.6	10.9	11.0	64.1	4458.5	215.9	34.8	31.6	32.9	32.9	32.9	443.3
3	280.6	113.5	27.0	27.2	161.6	13573.1	410.2	84.6	78.4	81.3	81.3	81.3
4	2897.5	496.5	192.5	45.4	45.8	238.2	19649.0	744.3	143.0	132.9	133.8	133.8
5	6396.3	4212.6	728.5	266.2	63.3	64.1	439.5	25690.3	821.2	200.7	187.8	176.7
6	8750.6	8820.7	3986.3	922.8	324.7	86.9	99.8	502.8	29810.6	1141.0	283.1	140.2
7	5286.4	9899.5	11130.7	4330.5	862.7	275.8	79.4	81.7	569.0	30846.3	1485.5	200.7
8	12395.6	5438.7	12553.5	10048.4	4260.1	1126.7	668.0	94.9	97.5	472.9	29229.2	1235.4
9	6369.9	12057.2	6979.0	11467.9	9409.9	4488.9	1546.2	562.6	101.9	104.9	392.1	24806.3
10	11731.5	5951.5	12906.0	6807.3	9900.8	8833.5	4430.8	1138.3	454.6	108.9	106.1	400.2
11	8856.1	10548.7	6943.1	10915.0	7113.0	8388.5	7240.9	3374.9	1347.1	558.5	74.4	96.1
12	11074.6	8045.4	9766.3	6289.5	8082.7	6645.9	8367.6	5514.5	4290.4	1676.8	544.8	86.4
13	9061.8	9683.6	7944.8	7517.6	5219.2	6145.8	5726.5	7150.4	5142.0	3139.4	1641.5	477.2
14	7923.6	7468.2	9305.3	6802.9	6075.0	4656.1	5454.3	4578.4	5684.1	4607.9	2729.7	1156.2
15	7610.1	5607.6	7455.4	7260.2	6368.0	5098.3	4271.0	4433.7	4129.6	3953.1	4112.9	2178.3
16	8294.3	5971.2	6292.5	5830.2	5390.6	4531.5	4470.3	3351.3	3964.6	3341.7	3394.9	3027.1
17	7845.0	6561.9	4432.8	4885.2	4681.8	4689.3	4712.3	3963.8	2824.4	3103.5	2755.2	2225.8
18	2685.6	6283.4	5785.6	3885.4	4088.2	3770.3	3926.9	3322.6	3298.7	2211.2	2216.4	1784.0
19	4190.0	2655.4	6518.2	4868.0	3103.2	3542.2	3089.5	3189.6	3008.7	2481.0	1834.7	1620.6
20	2878.0	3576.0	2459.0	5703.2	3628.1	2713.3	3088.8	2434.7	2568.6	2348.3	2228.0	1394.9
21	2110.4	2571.9	2688.2	1799.4	4728.2	2973.8	2354.4	2204.0	1811.2	1859.9	1882.1	1587.3
22	5913.4	1556.3	2440.4	2502.6	1257.5	4683.0	2633.4	1733.4	1962.4	1616.1	1499.2	1274.3
23	1108.0	4238.6	1611.9	1960.9	1944.6	755.6	4162.4	2396.3	1419.7	1652.2	1217.8	1138.6
24	327.2	634.3	3911.9	1024.2	1356.8	1607.1	585.3	3562.9	1751.2	1155.1	1207.4	913.4
25	640.3	139.5	374.9	4177.9	958.8	1256.3	1397.1	396.4	2880.7	1518.6	1024.6	936.0
26+	2596.3	4890.9	6831.2	9957.5	6357.5	5843.9	4401.8	6571.2	6768.5	7380.7	8409.6	4715.0
BIOMASS												
AGE 1+	137274.2	127439.9	133308.9	121689.9	99954.5	96222.3	93257.1	87126.7	84978.4	75743.2	68938.1	52462.1
AGE 5+	134044.8	126813.2	133045.3	119222.9	95174.7	82176.9	73146.6	86248.9	84706.8	75478.8	68457.0	51570.6
AGE 9+	101215.9	98441.7	104646.3	103655.0	89663.9	80623.4	71859.9	59879.2	53408.5	42817.9	37271.4	49817.6

Table 12. Summary of VPA stock size and biomass estimates and commercial CPUE indices from 1969 to 1980.

Year	AGE 1+	5+	6+	7+	8+	9+	CPUE (Tons/Day)
	Stock Biomass (Metric tons)						
1969	137274.2	134044.8	127648.5	118897.9	113611.5	101215.9	4.9
1970	127439.9	126813.2	122600.6	113779.9	103880.4	98441.7	4.0
1971	133308.9	133045.3	132316.8	128330.5	117199.8	104646.3	3.2
1972	121689.9	119222.9	118956.7	118033.9	113703.4	103655.0	2.9
1973	99954.5	95174.7	95111.4	94786.7	93924.0	89663.9	2.9
1974	96222.3	82176.9	82112.8	82025.9	81750.1	80623.4	2.6
1975	93257.1	73146.6	72707.1	72607.3	72527.9	71859.9	2.2
1976	87126.7	86248.9	60558.6	60055.8	59974.1	59879.2	2.3
1977	84978.4	84706.8	83885.6	54075.0	53506.0	53408.5	2.5
1978	75743.2	75478.8	75278.1	74137.1	43290.8	42817.9	2.4
1979	68938.1	68457.0	68269.2	67986.1	66500.6	37271.4	1.9
1980	52462.1	51570.6	51393.9	51253.7	51053.0	49817.6	1.6

Year			Stock Size (Numbers, 1000's)				CPUE (1000's Fish/Day)
1969	516672.0	482782.1	427161.8	365537.7	334257.1	270689.7	14.97
1970	460347.4	451646.9	427154.9	374650.8	316418.2	287642.1	13.07
1971	393631.4	387164.0	381767.6	358591.5	312597.0	261148.1	8.24
1972	562146.7	324897.1	322925.0	317528.6	295546.4	253678.0	7.24
1973	494291.0	256371.2	255902.6	254003.6	248678.6	228677.9	7.89
1974	426296.1	198648.1	198173.0	197727.4	195888.5	191052.7	6.26
1975	379996.6	165587.7	162857.9	162406.2	161998.9	160254.8	4.92
1976	343826.7	329101.1	138802.6	136276.1	135857.1	135469.7	6.45
1977	302301.4	295869.9	286745.2	114429.7	112454.1	112056.2	7.31
1978	250666.1	244289.7	242803.4	234351.6	86761.5	85185.3	7.26
1979	222567.9	194606.0	193214.5	191798.8	184021.1	67570.2	5.17
1980	191361.9	142876.3	141567.2	140268.6	139121.8	132550.6	4.24
$\frac{\Sigma \text{ CPUE}}{\Sigma \text{ Stock Size}}$	.00002047	.00002678	.00002926	.00003267	.00003686	.00004255	

Year	Geometric Mean Stock Size (Numbers, 1000's) 1+	5+	9+	CPUE (1000's Fish/Day)
1969	487391.8	454117.5	251184.3	14.97
1970	423892.1	415239.9	259888.3	13.07
1971	359932.4	353588.7	233654.8	8.24
1972	521018.4	288343.6	220731.1	7.24
1973	458066.6	225401.5	199718.9	7.89
1974	401604.2	179865.0	172541.8	6.26
1975	360550.7	151604.8	146452.5	4.92
1976	321474.1	307194.0	123005.6	6.45
1977	274325.9	268026.5	97483.8	7.31
1978	223492.7	217256.3	75140.6	7.26
1979	193402.6	165981.4	55078.3	5.17
Correlation Between Mean Stock Size and CPUE				
r^2	0.26	0.80	0.49	
$\frac{\Sigma \text{ CPUE}}{\Sigma \text{ Stock Size}}$	.00002206	.00002933	.00004838	

Table 13. Catch and stock size projections for the Gulf of Maine - Georges Bank redfish fishery, 1981-1984.

	Year			
	1981	1982	1983	1984
Reported Landings (Metric tons)	7,917	6,731	-	-
Fishing Effort (Days fished)	5,655	4,487	-	-
Predicted F [1]	0.20	0.17	-	-
PROJECTIONS				
Stock Size (Numbers, 1000's)	155,307	130,197	110,137	97,565
Stock Biomass (Metric tons)	47,158	41,523	32,467	30,174
Catch (Metric tons)	8,002	6,807	3,400	3,221
F	0.20	0.20	0.13	0.13

[1]Fishing mortality predicted from regression of 1969-79 F on effort.

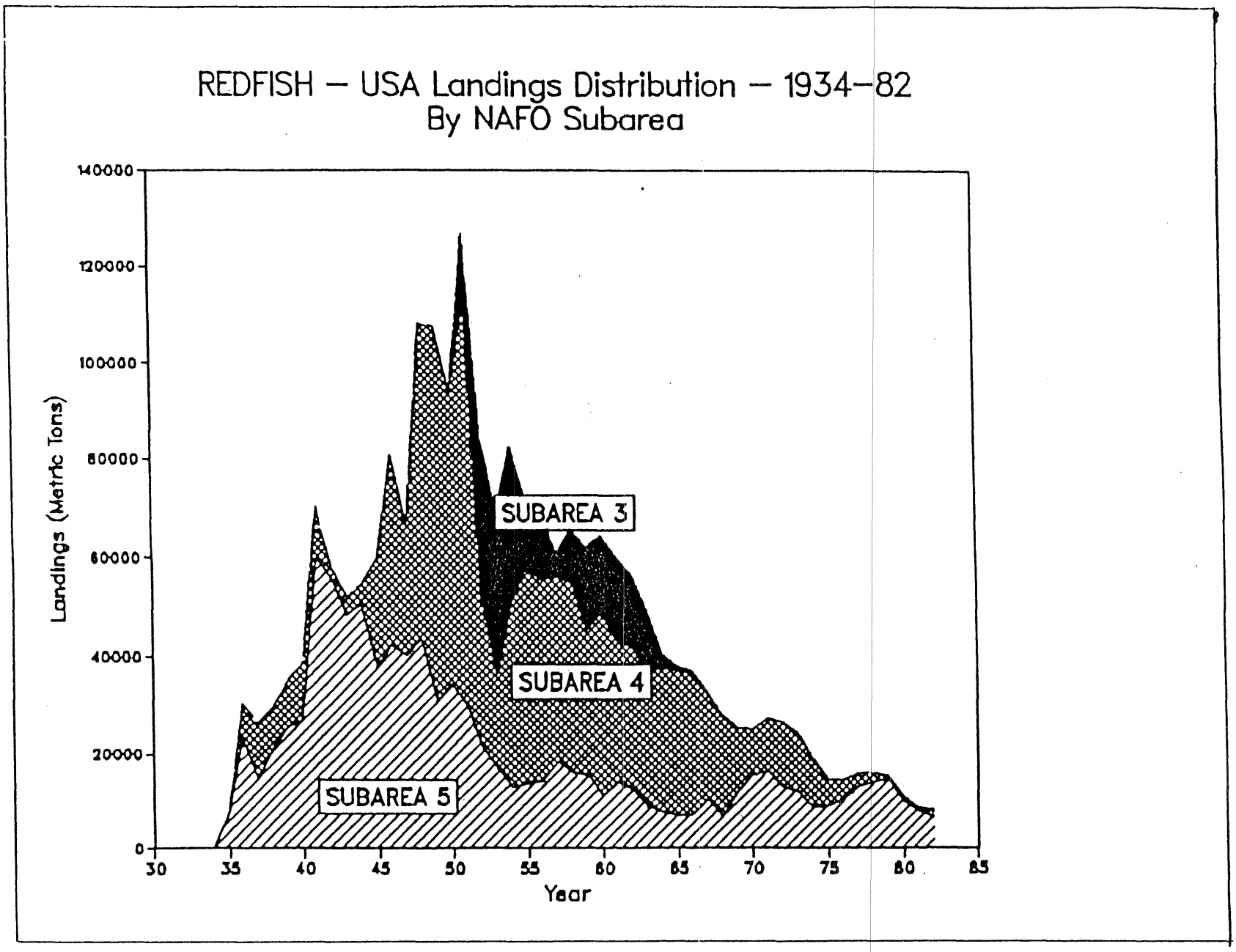


Figure 1. USA redfish landings (metric tons) by NAFO Subarea.

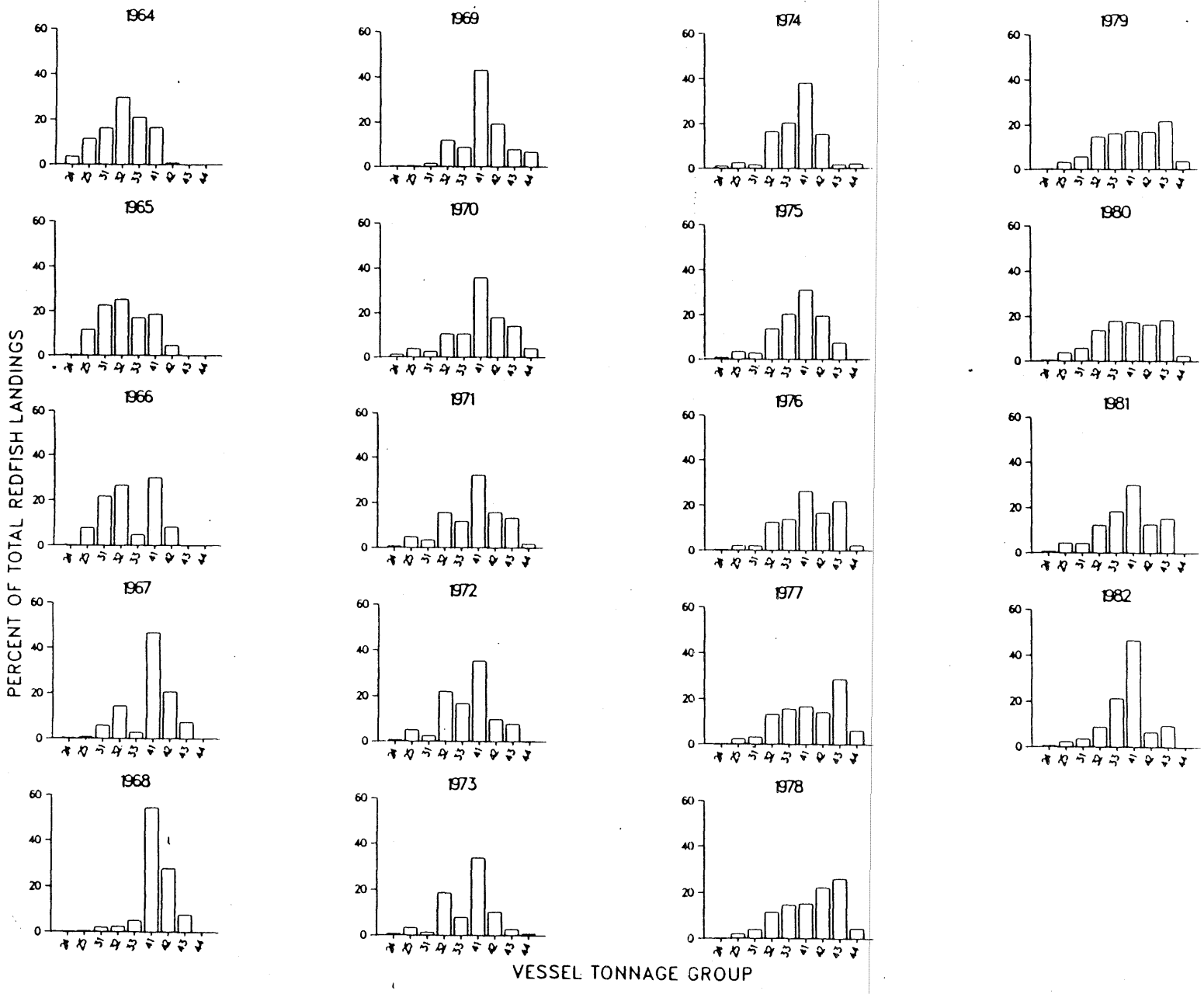


Figure 2. Distribution of USA redfish landings from the Gulf of Maine - Georges Bank region by vessel tonnage group, 1964-1982.

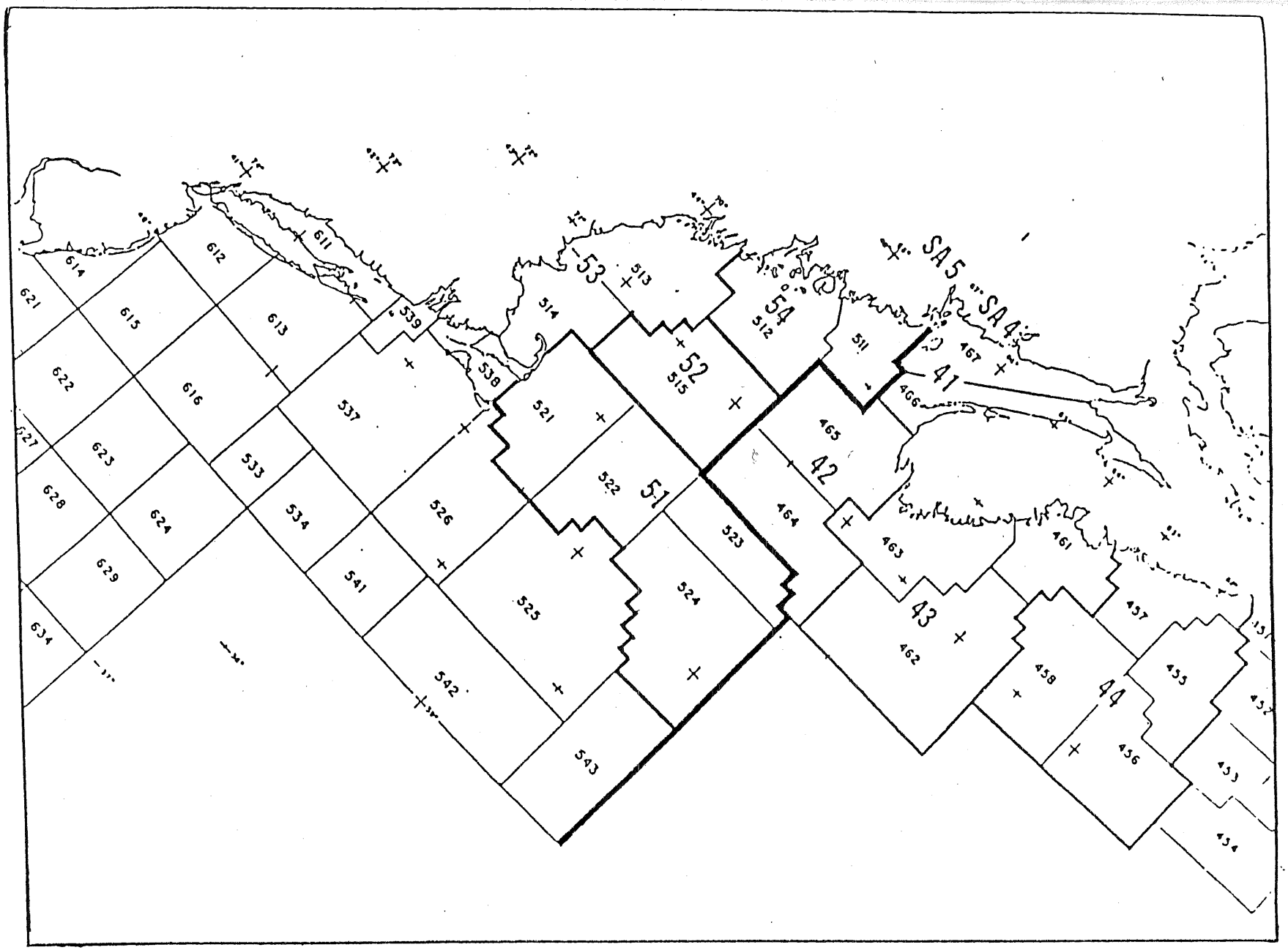


Figure 3. Geographic fishing areas for redfish in the Gulf of Maine - Georges Bank region.

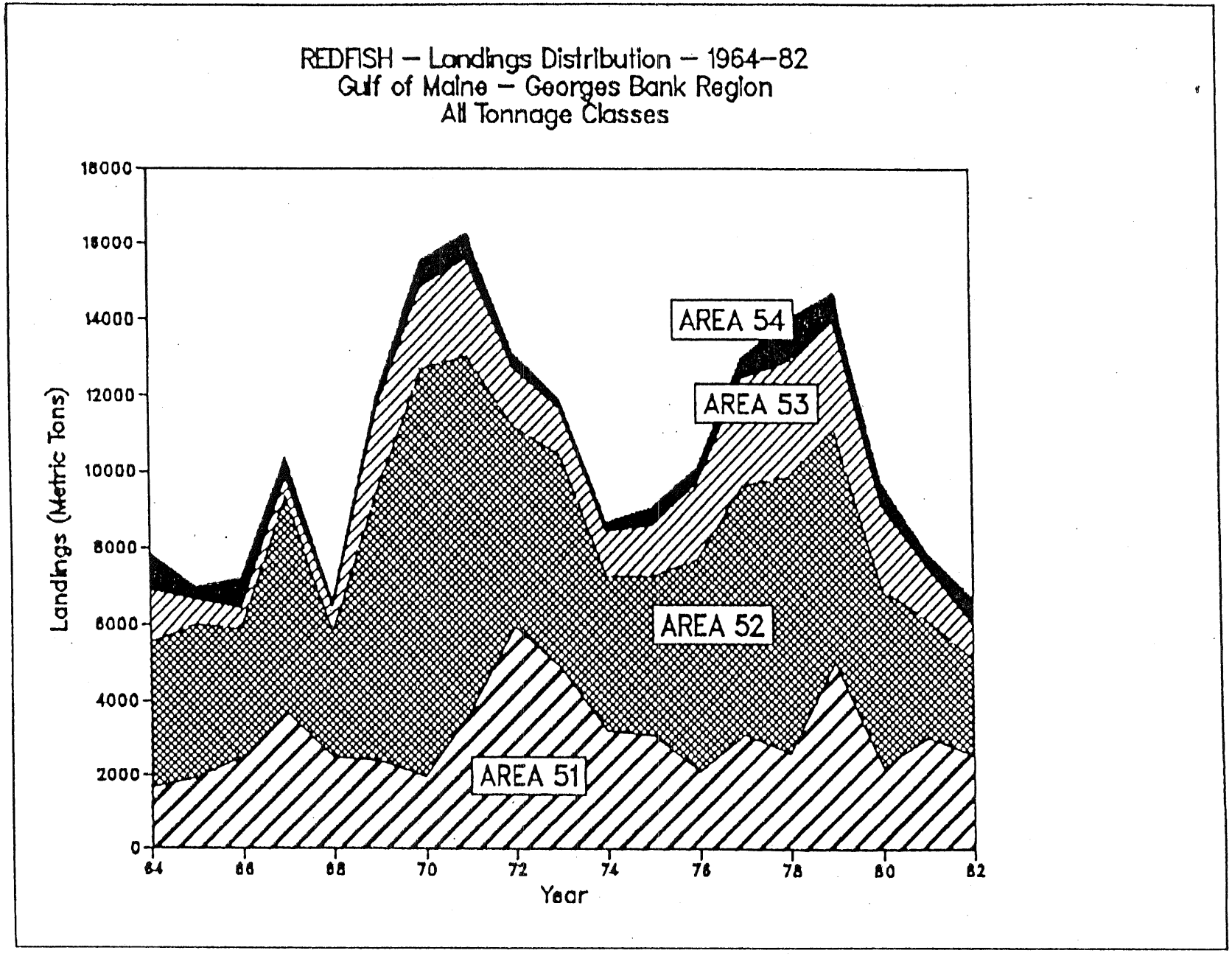


Figure 4. Distribution of redfish landings (metric tons) by geographic fishing area in the Gulf of Maine - Georges Bank region, 1964-1982.

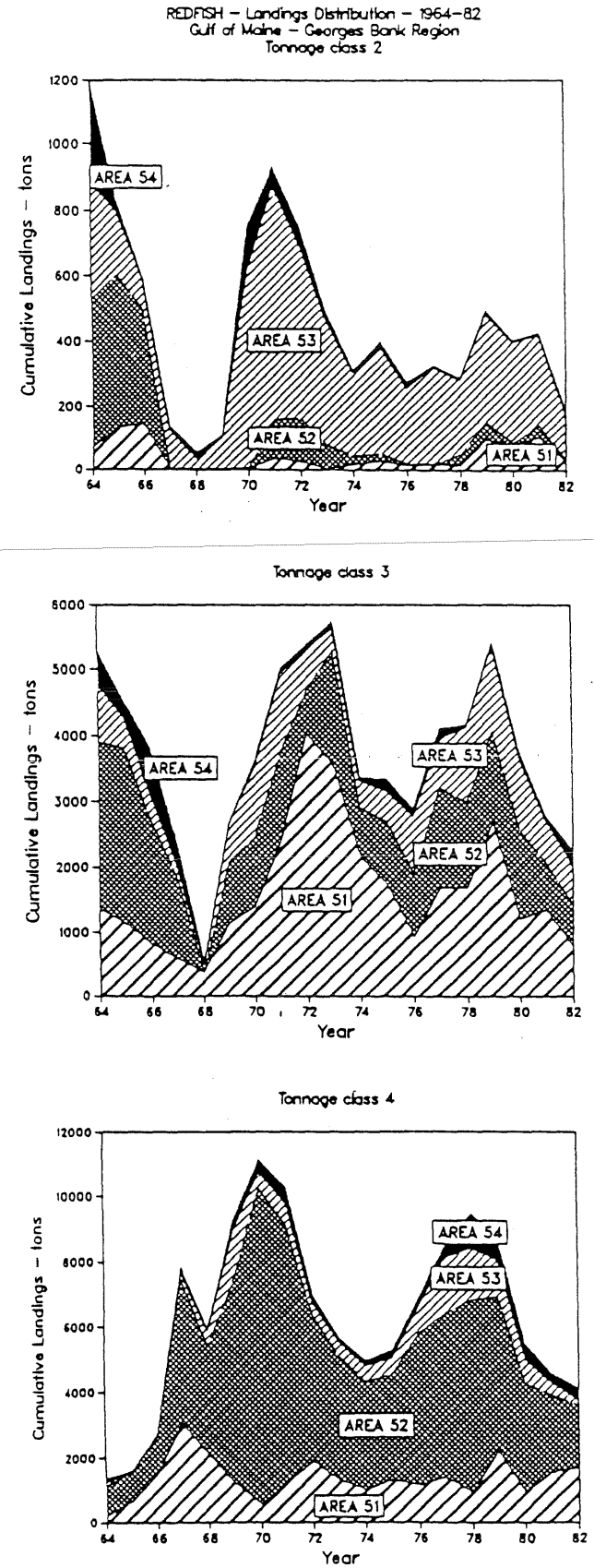


Figure 5. Distribution of redfish landings (metric tons) by geographic fishing area in the Gulf of Maine - Georges Bank region for tonnage class 2, 3, and 4 vessels, 1964-1982.

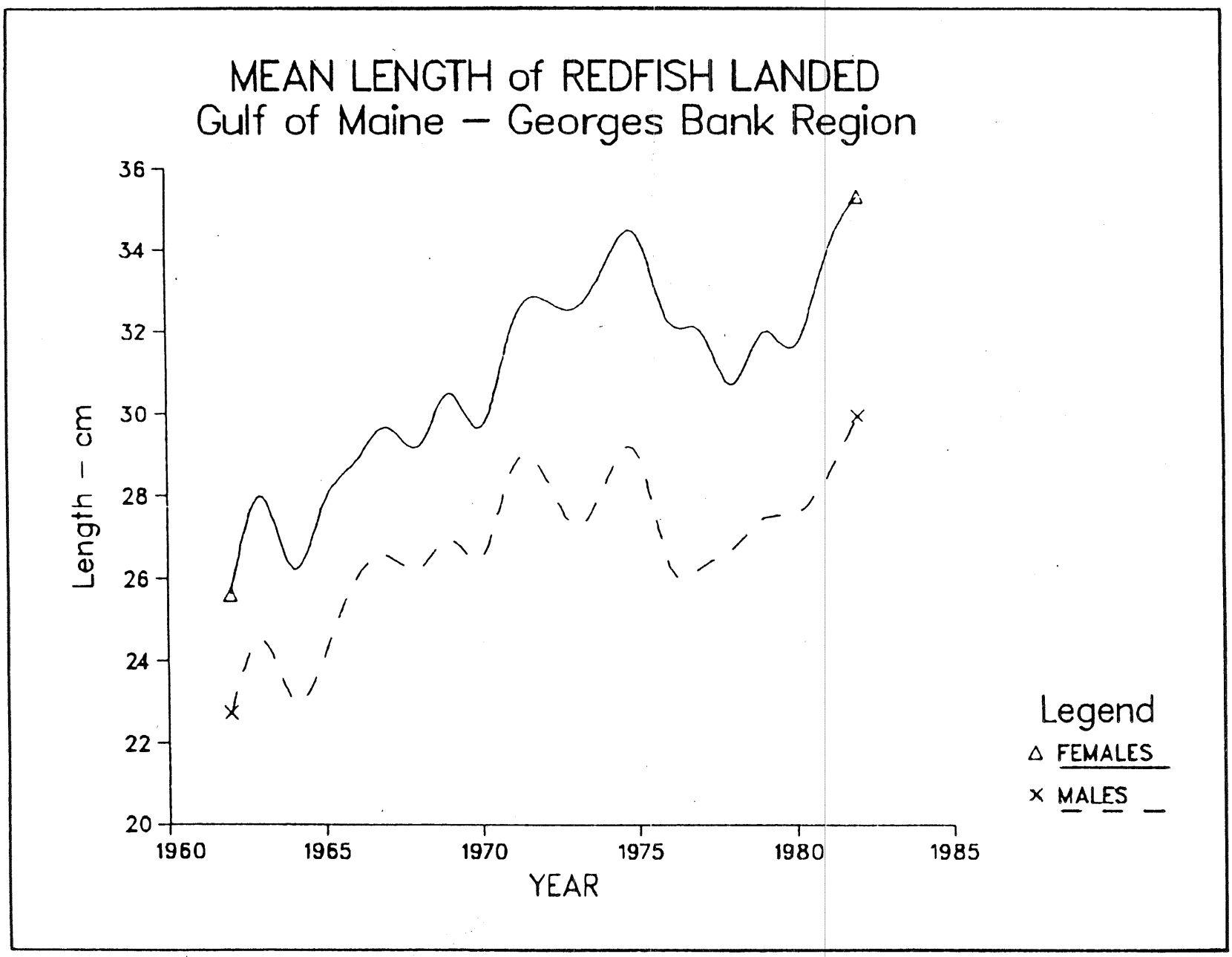


Figure 6. Mean length (cm) of redfish landed in the Gulf of Maine - Georges Bank fishery, 1962-1982.

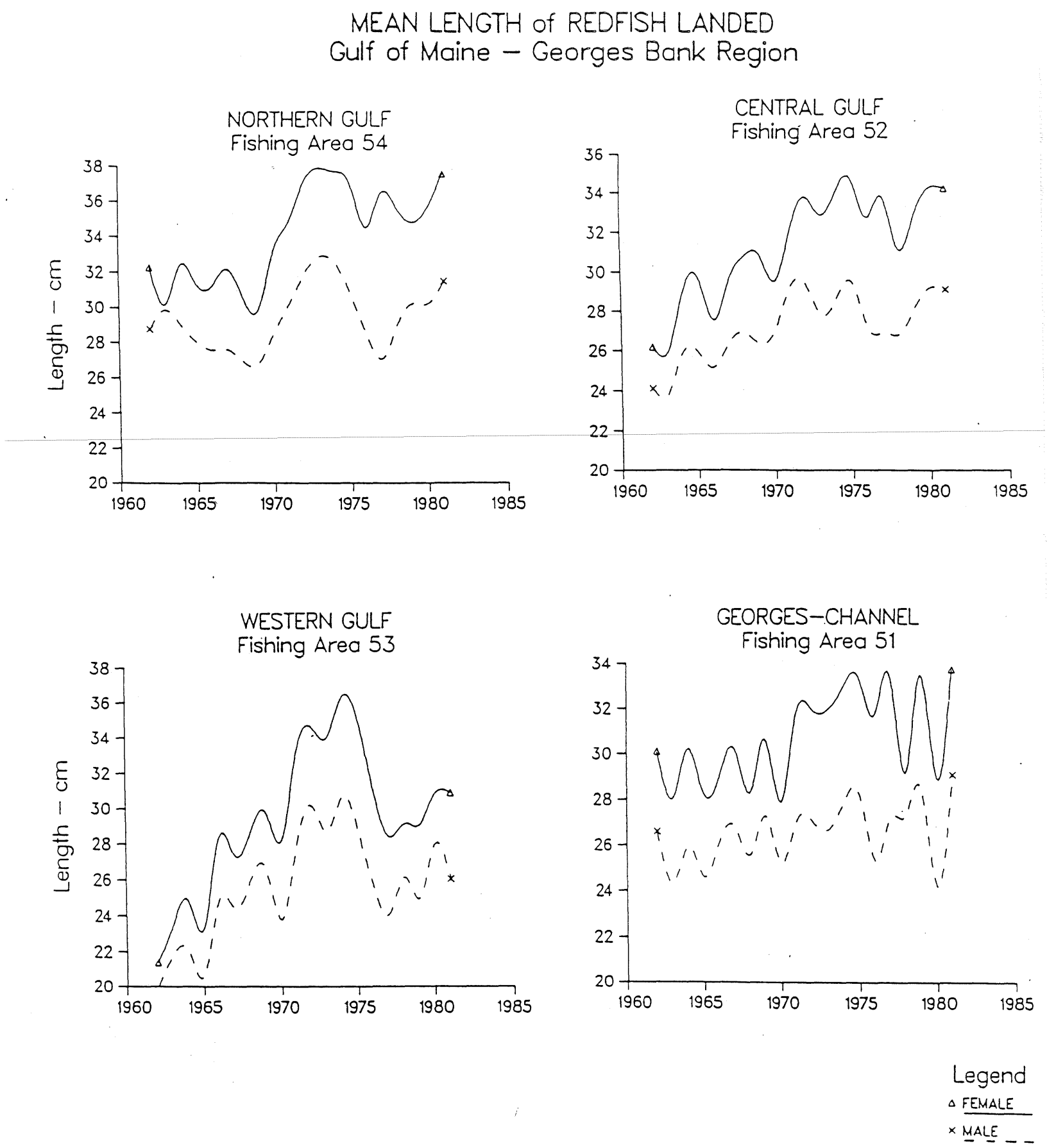


Figure 7. Mean length (cm) of male and female redfish landed by geographic fishing area in the Gulf of Maine - Georges Bank fishery, 1962-1982.

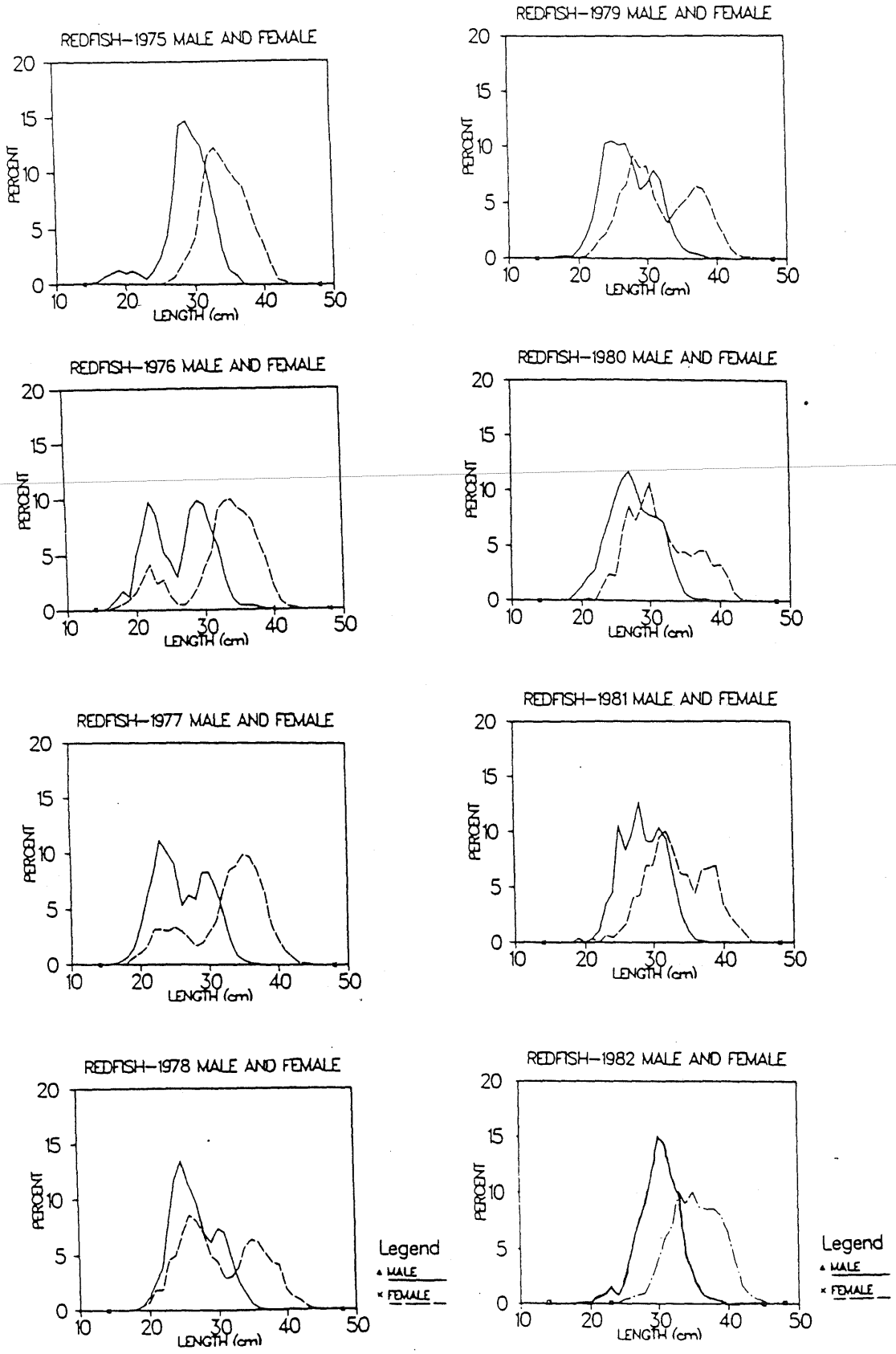


Figure 8. Length frequency distributions of male and female redfish landings from the Gulf of Maine - Georges Bank fishery, 1975-1982.

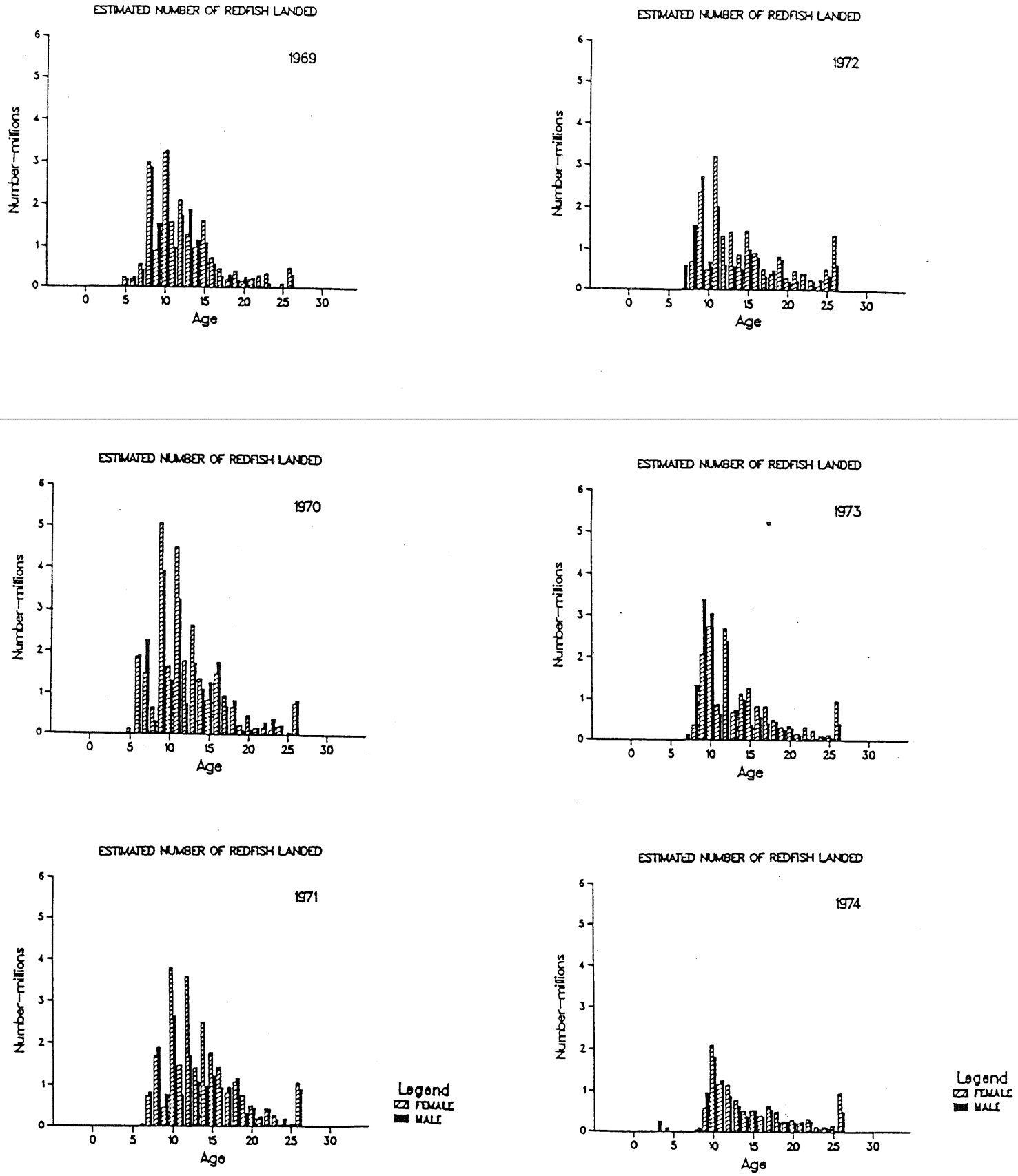
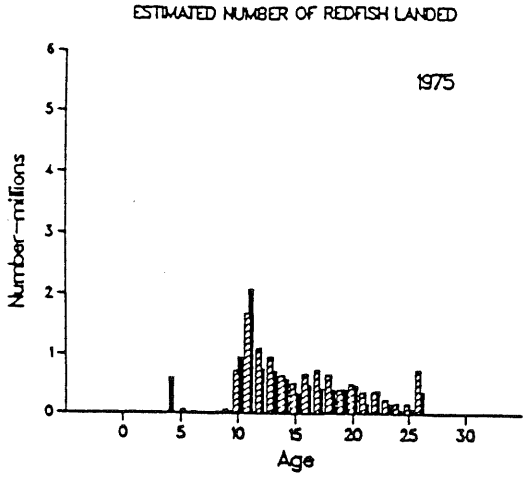
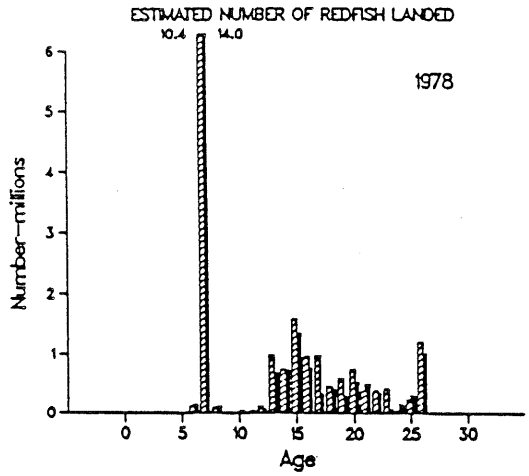
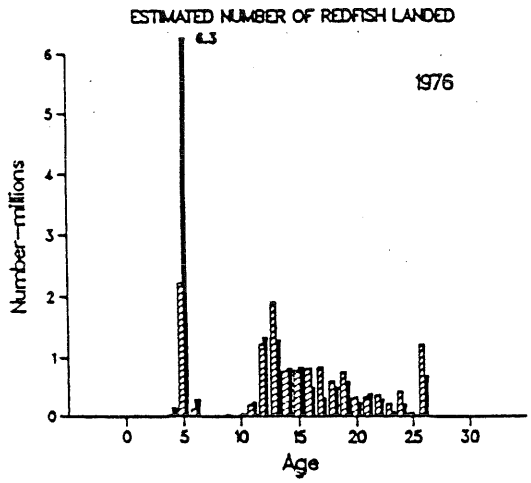
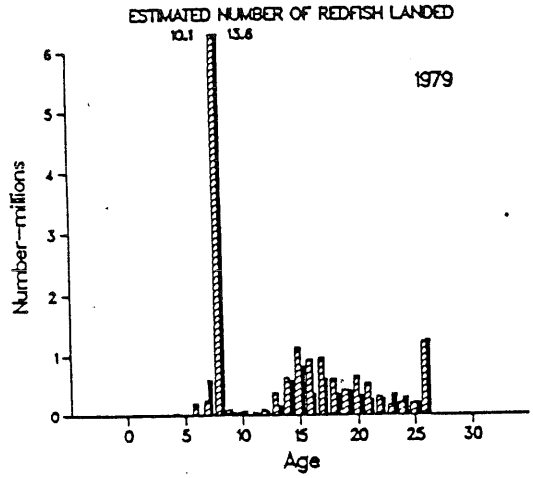


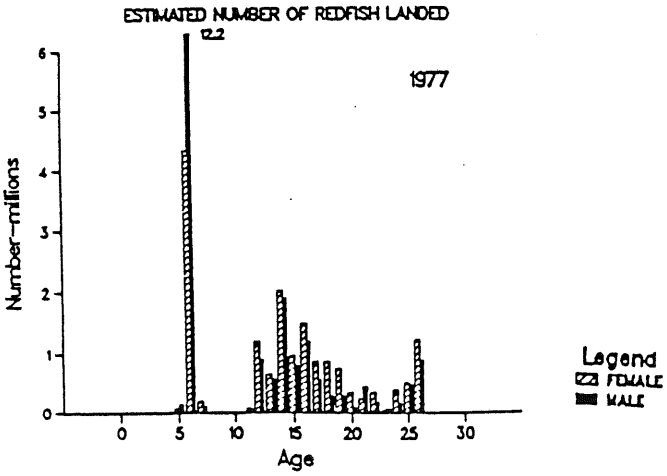
Figure 9. Age composition of male and female redfish landings from the Gulf of Maine - Georges Bank fishery, 1969-1980.

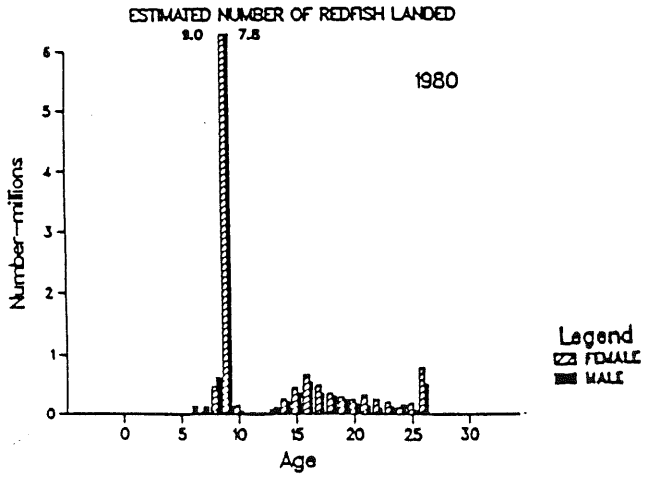

ESTIMATED NUMBER OF REDFISH LANDED
1975
Number-millions
Age


ESTIMATED NUMBER OF REDFISH LANDED
10.4
14.0
1978
Number-millions
Age


ESTIMATED NUMBER OF REDFISH LANDED
6.3
1976
Number-millions
Age


ESTIMATED NUMBER OF REDFISH LANDED
10.1
13.6
1979
Number-millions
Age


ESTIMATED NUMBER OF REDFISH LANDED
12.2
1977
Number-millions
Age
Legend
FEMALE
MALE


ESTIMATED NUMBER OF REDFISH LANDED
9.0
7.5
1980
Number-millions
Age
Legend
FEMALE
MALE

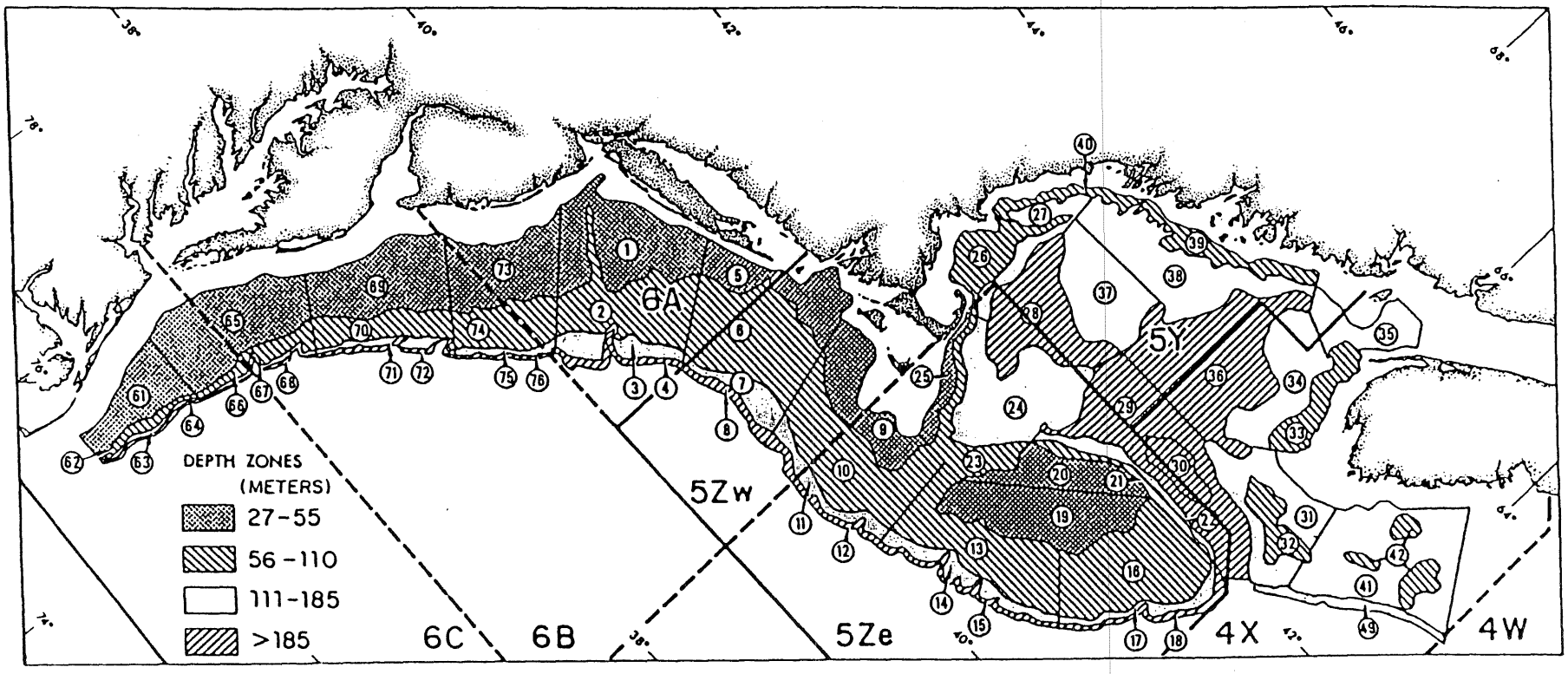


Figure 10. Sampling strata used in NEFC offshore (>27 m) spring, summer and autumn bottom trawl surveys.

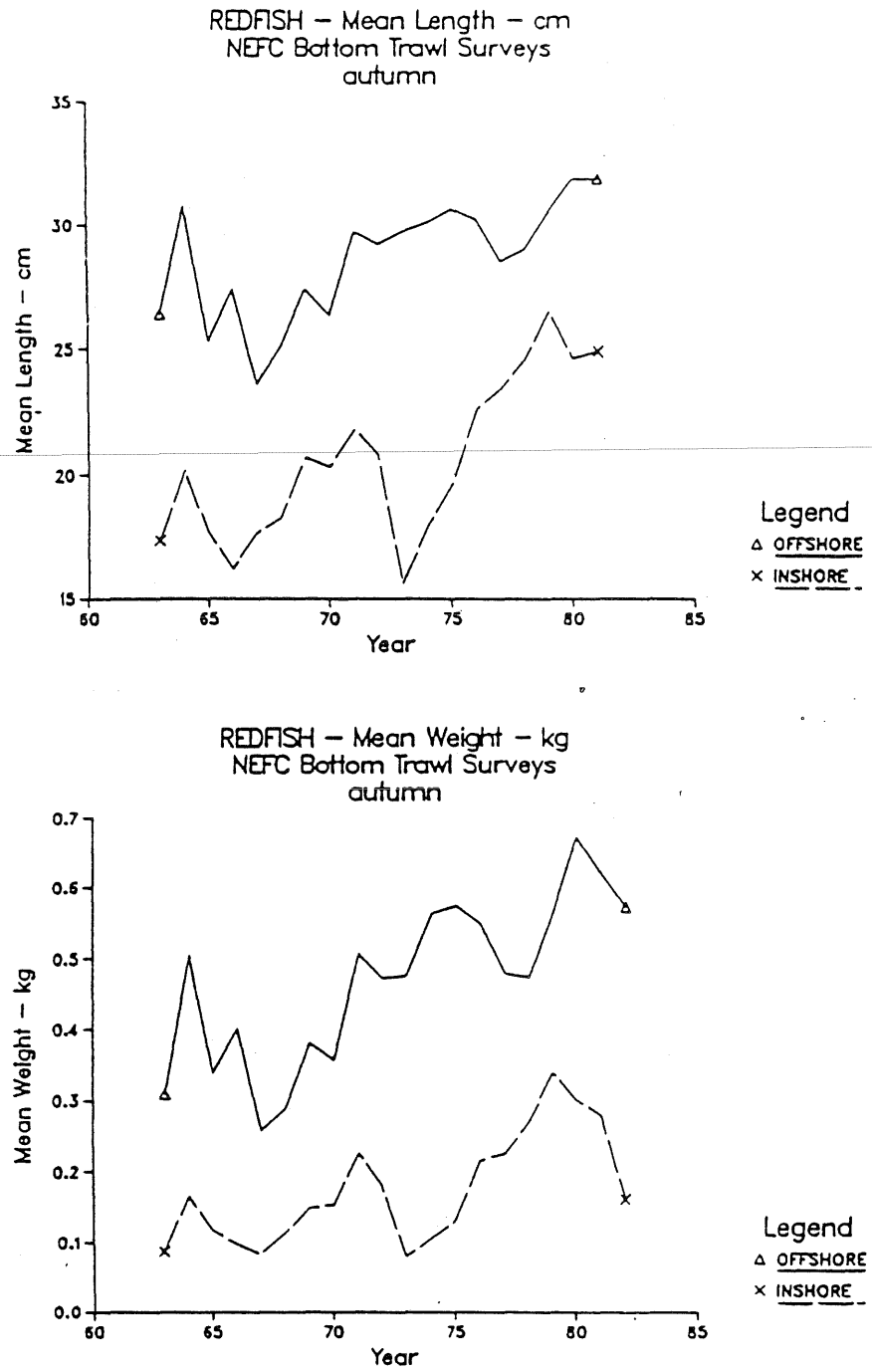


Figure 11. Mean length (cm) and weight (kg) of redfish from inshore (strata 26, 27, 39, and 40) and offshore (strata 24, 28-30, and 36-38) strata sets on NEFC autumn bottom trawl surveys, 1963-1982.

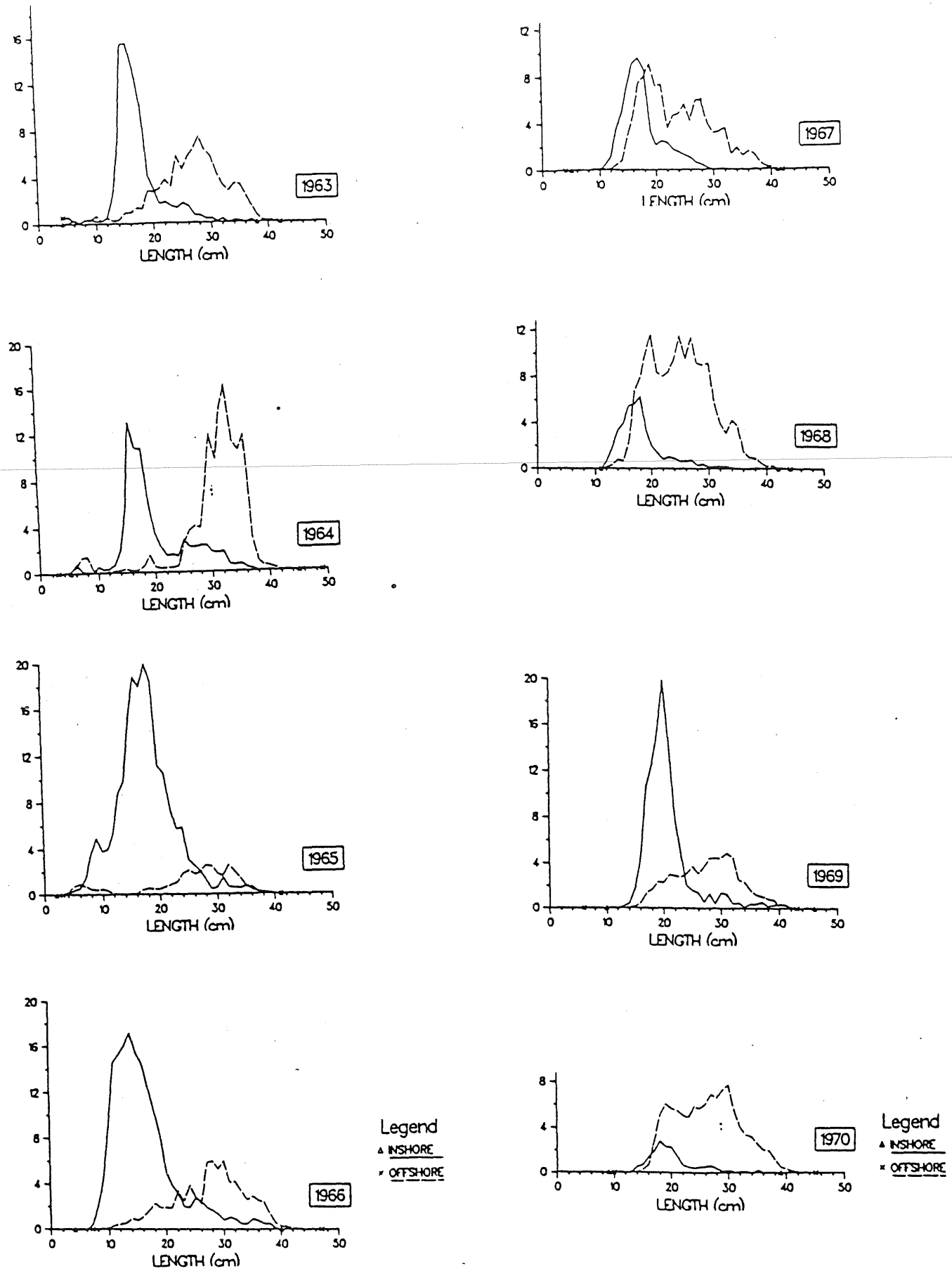
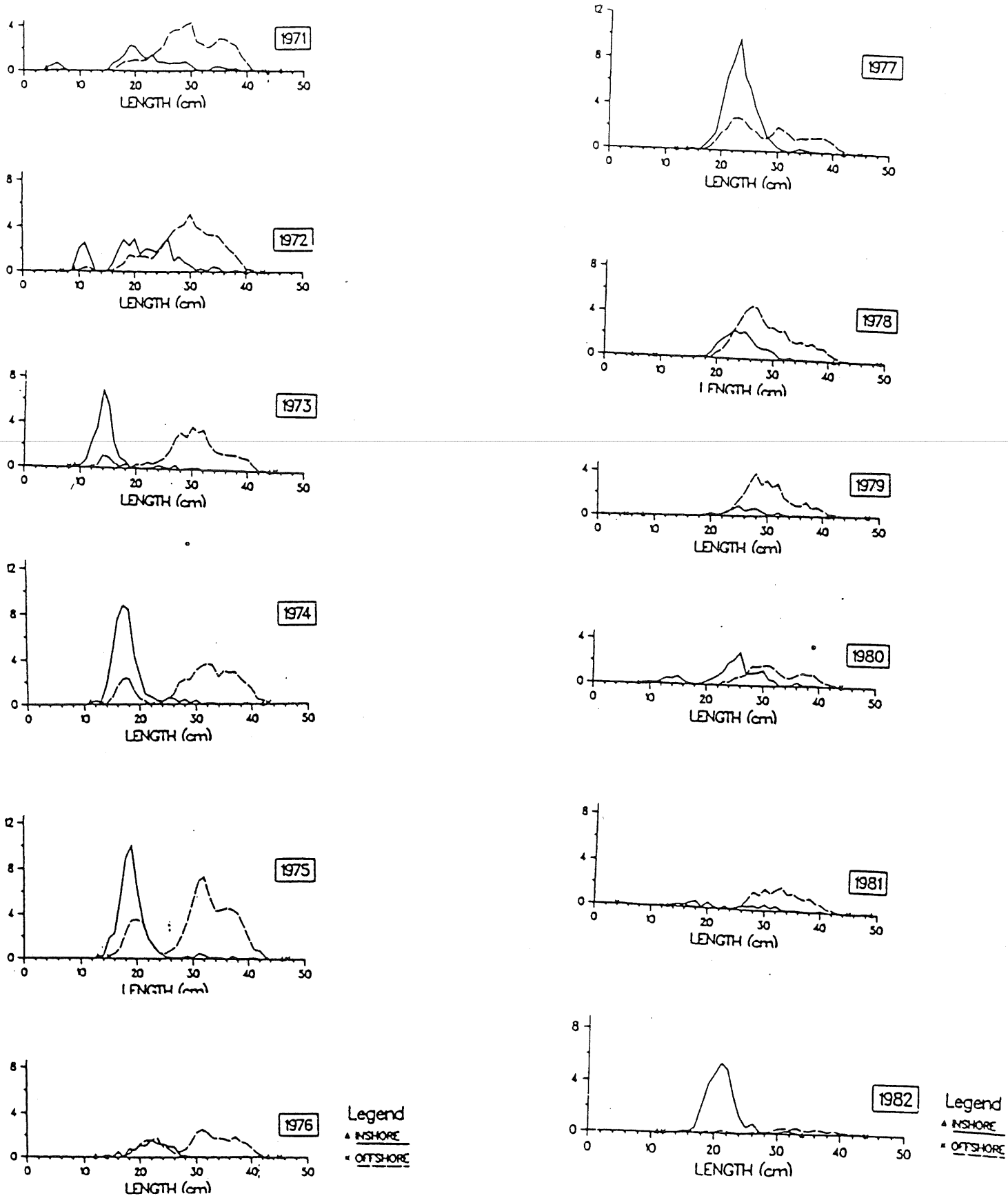


Figure 12. Length frequency distributions (stratified mean number per tow at length) of redfish caught from inshore (strata 26, 27, 39,and 40) and offshore (strata 24, 28-30, and 36-38) strata sets on NEFC autumn bottom trawl surveys, 1963-1982.


1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
LENGTH (cm)
Legend
INSHORE
OFFSHORE

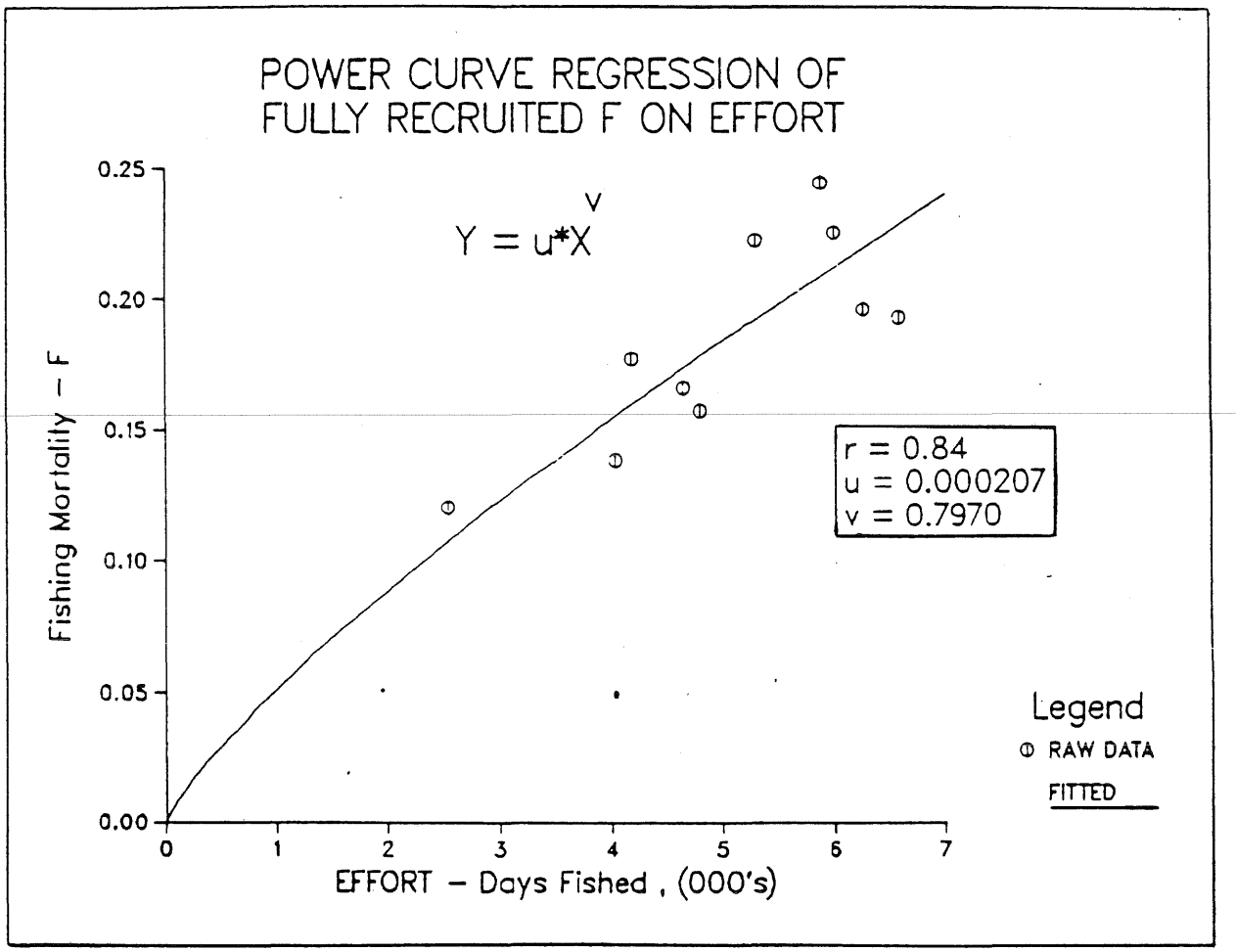
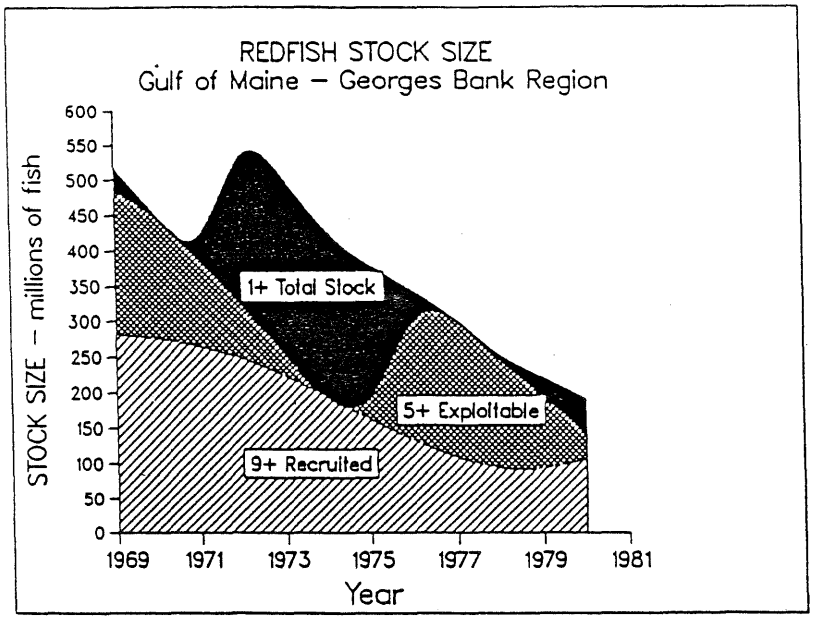
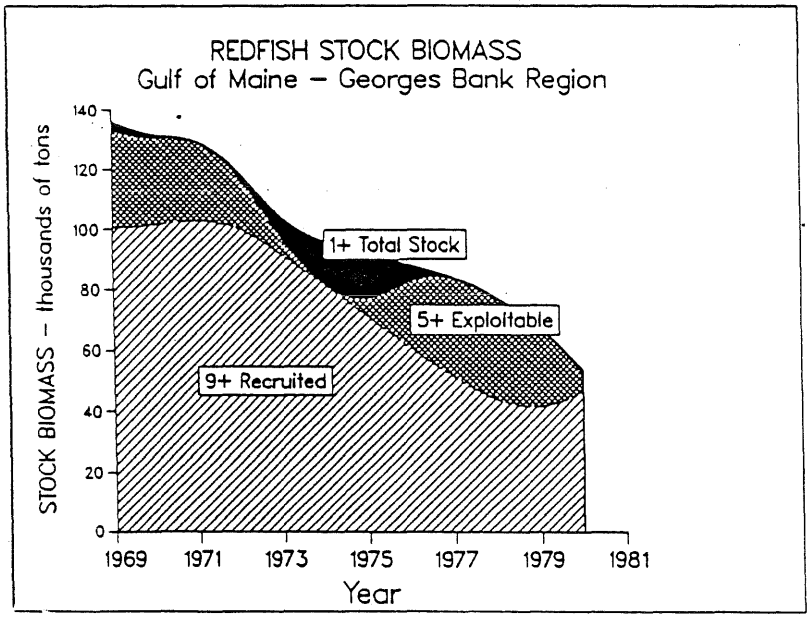


Figure 13. Regression of fully recruited (age 9+) instantaneous fishing mortality (F) from final VPA on total standardized fishing effort from 1969 to 1979.





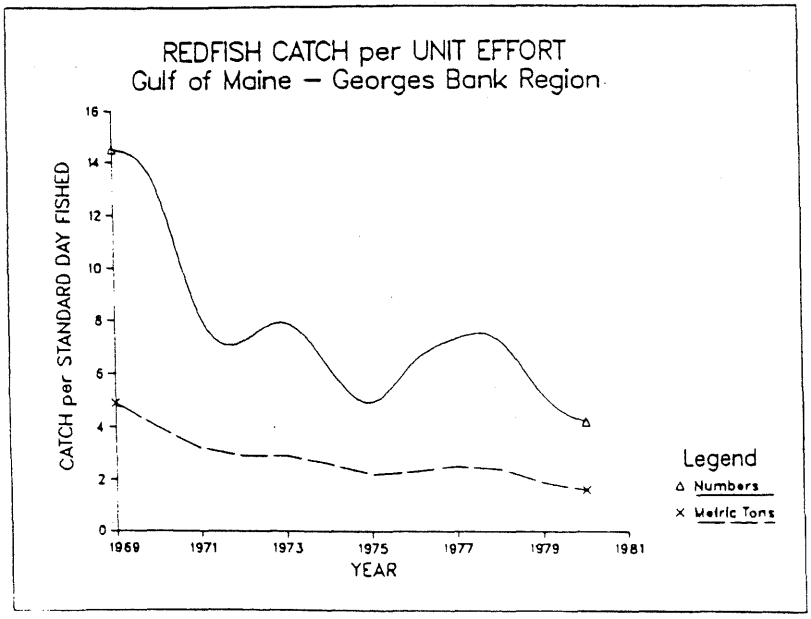


Figure 14. VPA stock size and biomass estimates and commercial CPUE indices from 1969 to 1980.