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STATUS OF THE SILVER HAKE RESOURCE OFF THE NORTHEAST COAST OF THE UNITED STATES - 1981

by

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INTRODUCTION

This document presents an update of the status of the silver hake (Merluccius bilinearis, Mitchell) stocks inhabiting the waters off the northeast coast of the United States (USA) from Cape Hatteras, NC, to the Fundian Channel. For management purposes, three stocks are assessed separately throughout this distributional range: Gulf of Maine (NAFO Div. 5Y), Georges Bank (NAFO Subdiv. 5Ze), and Southern New England - Middle Atlantic (NAFO Subdiv. 5Zw and Sub area 6).

The data base utilized throughout the report includes USA and foreign commercial catch statistics, estimated USA recreational catches (Southern New England - Middle Atlantic stock only) for 1955-1980, and USA research vessel bottom trawl survey results for 1963-1981.

For the Georges Bank and Southern New England - Middle Atlantic stocks, estimates of past levels of stock size and fishing mortality (F) utilizing virtual population analysis (VPA) are presented, accompanied by estimates of recruitment in recent years predicted from relationships between research vessel mean catch per tow at age 1 and estimates of year-class size at age 1 obtained from VPA. Catch levels in 1982 at varying levels of F and the resulting 1983 stock sizes were projected under assumptions of estimated catch and recruitment in 1981.

Due to low levels of catch in both 1979 and 1980, as well as very limited sampling of the catch in those years, it was not

possible to determine the catch-at-age in numbers necessary for performing a VPA for those year for the Gulf of Maine stock. Estimates of stock size after 1978 were derived utilizing relationships between VPA estimates in previous years and abundance indices from commercial fishery and research vessel survey data. It was also not possible to make catch and stock size projections for this stock.

GULF OF MAINE STOCK

Catch and Management History

Total catch during 1955-1964 varied between 21,500 and 37,000 tons and averaged 29,700 tons (Table 1, Figure 1). Catches dropped from 31,700 tons in 1964 to 22,600 tons in 1965, and ranged from 24,700 to 11,400 tons during 1965-1970 while averaging 18,300 tons. During 1971-1978, catches averaged 7,400 tons while ranging from 9,800 tons to 4,600 tons. Catches dropped sharply to only 2,600 tons in 1979, a 58% decrease from 1978, then improved somewhat to 3,812 tons in 1980. Although the 1980 catch represented a 45% increase over 1979, it was still the second lowest in the time series and substantially below the catch levels in past years (83% lower than the 1960-1970 average of 22,200 tons and 49% lower than the 1971-1978 average).

This fishery has been conducted almost exclusively by the USA. In 1963, 1971-1975, and 1977, small catches were reported by the USSR, Poland, FRG, GDR, and Bulgaria, which averaged about 9% of the total annual catch in those years (Table 1).

from VPA.

Abundance Indices

Commercial catch per effort

The USA commercial catch-per-day index fluctuated considerably during 1956-1965, ranging between 15.3 and 31.7 tons/day and averaging 21.8 tons/day (Table 1, Figure 1). The index dropped from 24.3 tons/day in 1965 to a series low of 6.3 tons/day in 1974, but increased sharply to 16.7 tons/day in 1976. After 1976, the index dropped steadily to only 6.4 tons/day in 1979, but increased to 7.7 tons/day in 1980, a level approximately equal to the 1970-1975 average. In spite of the annual fluctuations in this index, it has been reasonably consistent over time with changes in stock biomass calculated from VPA (Figure 1).

Research vessel mean catch per tow

Both the spring and autumn USA bottom trawl survey catch-per-tow (weight) indices have reflected the same trends as the commercial catch-per-effort index in recent years, reaching high levels in the mid 1970's, dropping to low levels in 1978-1979, and increasing in 1980. The USA spring bottom trawl survey catch-per-tow index (kg. linear scale) (Table 4, Figure 2) after reaching 14.5 kg in 1970, decreased drastically to 1.0 kg in 1971 and averaged 3.6 kg during 1971-1974. the index increased to averaged 14.6 kg during 1975-1976, declined to 1.4 kg in 1978, then increased to 6.8 kg in 1980. In 1981, the index dropped to 3.7 kg. Catch per tow in numbers (linear) increased from a low of

9.9 in 1971 to a series high of 345.2 in 1975, then steadily declined to 19.3 in 1978. The index then increased steadily through 1980 but dropped in 1981 (Table 5).

The catch-per-tow indices from the autumn survey (Tables 4 and 5, Figure 3) have shown similar patterns of year-to-year fluctuations in recent years as the spring survey. After reaching a low of 1.9 kg in 1968, the catch-per-tow index (kg. linear) increased steadily, except for decreases in 1973-1974, to 10.9 kg in 1976. After 1976, the index dropped to 6.2 kg in 1978 but increased to 7.7 kg in 1980. Catch per tow in numbers (linear) increased from a low in 1968 of 6.4 to 69.1 in 1975, except for decreases in 1973-1974. The index dropped in 1976-1978, increased in 1979 but decreased again in 1980.

The precision of the catch-per-tow indices, both weight and number was evaluated by calculating coefficients of variation (CV) (defined as the ratio of the standard deviation to the mean) on a linear scale (Tables 4 and 5). The CV's for the spring mean weight-per-tow indices averaged 0.26 for 1968-1981 and 0.18 for 1973-1981 (the 1968-1972 indices were determined from No. 36 Yankee trawl catches adjusted to equivalent No. 41 Yankee trawl catches and had substantially higher CV's, averaging 0.39). Coefficients of variation for the mean number-per-tow indices averaged 0.21 for 1968-1981. For the autumn surveys, which used a No. 36 Yankee trawl throughout, the CV's averaged 0.23 and 0.21 for mean weight and numbers, respectively. These results indicate that during the survey period proportional changes in absolute abundance, in terms of weight, less than $\pm$36% for the spring

series (1973-1981) and ±46% for the autumn survey or could not be detected on the linear scale with a high degree of probability. In terms of numbers, proportional changes of less than ±42% could not be detected with a high degree of probability.

Mean catch per tow at age

Mean catch per tow at age (numbers, linear scale) for 1973-1981 was determined by applying age-length keys to the appropriate length frequency data from spring and autumn bottom trawl surveys (Table 5). Data prior to 1973 were not utilized due to a difference in the ageing technique. Ages ranged from 1 to 14 in the spring surveys and 0 to 13 in the autumn (ages 12 and older are combined in the table). The data indicate that the 1972-1974 year classes were quite strong, with 1974 being the strongest. These year classes were also well represented in the commercial landings-at-age data. The 1975-1976 cohorts appear to be relatively weak in comparison to previous years, while the 1977 and 1978 year classes improved sharply in strength. The 1979 and 1980 year classes, for which only two years of survey data exist, appear to be of at least average strength, with the 1980 year class potentially being quite strong. These estimates, however, should be interpreted with caution since neither the autumn survey indices at age 0 nor the spring survey indices at age 1 have shown any signficant correlations with themselves or with estimates calculated from virtual population analysis.

Fishing Mortality

Fishing mortality (F) for fully-recruited ages in 1978 was

estimated from a power curve regression between fishing mortality from VPA and fishing effort. Fishing effort was calculated by dividing the total international catch by USA catch per day (Table 1) and was expressed as USA days fished. Fishing mortality was determined for each year as the weighted (by stock size) mean F for fully-recruited ages obtained from VPA. Natural mortality (M) was assumed to be 0.4 for all ages. The F value for 1978 was selected following an iterative process consisting of alternate computations of VPA and the fishing mortality-fishing effort regression until the F value predicted from the regression and the starting F in the VPA reached convergence. The F value for 1978 was 0.400 ($r=0.699$, $p<0.01$) for ages 3 and older (Table 7, Figure 4).

Fishing mortality for fully-recruited ages determined by VPA (Table 8) ranged between 0.24 and 0.55 during 1955-1967 and averaged 0.40. F increased from 0.32 in 1967 to 1.23 in 1971 and then dropped to 0.23 in 1974 as catches decreased to low levels. Fishing mortality increased sharply in 1975 to 0.61 but decreased to average 0.38 during 1976-1978. Based on the relationship used to predict F in 1978, F in 1979-1980 was estimated to be 0.20 and 0.24, respectively.

Recruitment

The sizes of the 1954-1975 year classes at age 1 estimated from VPA (Table 9) ranged from 628 million fish (1954 year class) to a low of 47 million (1975 year class) and averaged 317 mil-

lion. The median size was 264 million. Since 1964, year-class sizes have all been well below the 1954-1975 mean, averaging 109 million fish. The 1973 year class (197 million) was the strongest since 1964, but the 1975 year class (47 million) was the weakest in the series.

Estimates of the sizes of the 1976-1980 year classes were obtained from a power curve relationship ($r=0.616$, $p>0.05$) between spring survey catch per tow at age 1 (numbers) and year class size of age 1 (millions) from VPA (Table 10, Figure 5). Year class strength increased steadily from 1975 to an average of about 89 million fish during 1976-1979. The 1980 estimate of 110 million was the highest since 1974.

Stock Size

Stock size estimates (in numbers) for 1955-1979 were computed from VPA (Table 9). Mean weights at age (Table 3) were applied to stock numbers at age to obtain annual stock biomass values which were then adjusted using the appropriate observed/calculated catch ratios from Table 2.

Spawning stock biomass (age 2+) decreased from a series high of 193,500 tons in 1955 to only 15,900 tons in 1971 (Table 9, Figure 6). Biomass increased to average 37,900 tons during 1975-1976, reflecting strong 1973-1974 year classes, declined to 30,900 tons in 1978, then increased to 31,700 tons in 1979.

Spawning stock size (in numbers) in 1980 was estimated utilizing linear regressions between spring ($r=0.920$, $p<0.05$) and

autumn ($r=0.876$, $p<0.05$) survey catch per tow for ages 2 and older and spawning stock size (ages 2 and older) from VPA (Table 11). The average of the two stock size estimates derived from the regressions (144.6 and 157.2 million fish), was apportioned into age classes based on the percentage age composition of the survey catch per tow at age data (ages 2 and older), with mean weights at age applied to each age class. The resulting biomass-at-age estimates were then summed to obtain a total spawning stock biomass estimate of 36,200 tons for 1980.

Total stock biomass (age 1+) decreased from a high of 218,000 tons in 1955 to only 20,400 tons in 1971 (Table 9, Figure 1). Biomass then increased to 51,000 tons in 1974, declined to 41,600 tons in 1977, then increased to 44,900 tons in 1979. Biomass in 1980 was estimated to be 46,900 tons. This value was obtained by applying the 1978 estimate of mean weight at age 1 (the most recent year in which mean weights at age were available) to the estimated size of the 1979 year class at age 1 from Table 10 and adding this amount to the spawning stock biomass of 36,200 tons indicated above.

Discussion

The Gulf of Maine stock has been subjected to relatively little fishing pressure in recent years, with total catch in 1979-1980 being the lowest in the 1955-1980 time series (Table 1). As a result, fishing mortality estimates in 1979-1980 were also among the lowest observed. Research vessel abundance indices for both the spring and autumn have shown steady inprovement

since 1978, although a decrease did occur in the spring of 1981.

A catch of about 4,400 tons was projected for 1981 based on reported catches through September and the assumption that catch rates for the remainder of the year would be similar to those in 1980. Although the projected catch for 1981 is approximately 15% greater than in 1980, it is still the third lowest in the time series (after 1979 and 1980).

Given this continued low level of catch, it is likely that the stock will continue its gradual upward trend in biomass.

GEORGES BANK STOCK

Catch and Management History

Catches by country for the period 1955-1978 are listed in Table 12. Total catch increased from an average of 19,000 tons during 1955-1961 to nearly 239,000 tons in 1965 followed by a rapid decline to 18,400 tons in 1969. Catches increased again and stabilized at an average of about 68,000 tons during 1971-1975, but decreased in 1976-1977 to an average of 45,000 tons. Since 1977, catches have dropped sharply to only 1,664 tons in 1980, the lowest in the time series (Figure 7).

USA catches averaged 18,200 tons during 1955-1963, but declined to average only 3,600 tons during 1968-1978. The catch dropped to 893 tons in 1979 but increased in 1980 to 1,166 tons, a 31% increase over 1979, but still the third lowest in the time series.

Since its introduction in 1962, the distant water fleet (DWF) consistently reported landings, through 1977, that far exceeded the USA catch. The 1978 DWF catch of 3,600 tons was, by far, the lowest catch reported in the time-series and represented a 91% decrease from 1977. In 1978, the catch dropped further to 1,022 tons and by 1980, the catch was only 498 tons, with no catch reported by the USSR, the country which had accounted for most of the catch since 1962.

The ICNAF TAC was 80,000 tons each year during 1973-1975 and 50,000 tons in 1976. An optimum yield (OY) of 70,000 tons was set for 1977, of which 15,000 tons was designated as the domestic aallowable harvest (DAH) and 55,000 tons as the total allowable level of foreign fishing (TALFF). The 1978-1979 OY was reduced to 58,800 tons of which 26,000 was allotted to the USA and 32,800 as the TALFF. In 1980, the OY was reduced to 35,000 tons, with 9,000 tons allotted to the USA and 26,000 tons designated as TALFF. In 1981, the OY was further reduced to 25,000 tons, with 9,000 tons designated as DAH, 10,000 tons allotted as TALFF and 6,000 tons placed in reserve.

Commercial Catch Composition

The estimated catch at age (in numbers) during 1955-1980 is given in Table 13. During 1955-1971, age 3-4 fish dominated the catch, but 2-3 fish were predominant during 1972-1975. During 1976-1978, ages 3-4 were again dominant, averaging 76% of the catch in each year. The majority of the fish caught in 1979 and in 1980 were again ages 2-3, comprising 47% and 78% of the catch

in each year, respectively.

Mean weights at age (Table 14) were applied to the numbers-at-age data in Table 13 to obtain calculated catches. Ratios between observed and calculated catches ranged from 1.002 to 0.865 and averaged 0.937 (Table 14) during the time series. The 1980 mean weights were used for the 1981-1983 catch and stock size projections.

Abundance Indices

Commercial catch per effort

The USA commercial catch-per-day index (Table 12), although fluctuating considerably from year to year, has roughly paralleled changes in stock abundance during 1955-1980 determined from VPA (Figure 7). The index reached its highest levels in the 1950's (averaging 49.8 tons/day during 1956-1959) and then declined to a low of 8.7 tons/day in 1972. In 1976, the index increased to 46.1 tons/day, the highest point since 1959, but declined steadily thereafter to 17.4 tons/day in 1979. The index increased slightly in 1980 to 21.0 tons/day which is roughly equivalent to levels observed during the early 1970's.

Research vessel mean catch per tow

The USA spring bottom trawl survey catch-per-tow index (kg, linear) underwent a generally increasing trend from 1968 to a peak in 1977 of 7.8 kg , before declining to 2.1 kg in 1979 (Table 15, Figure 8). The index again increased to reach a 1968-1981 time series high of 8.8 kg in 1981. Catch per tow in

numbers (linear) also underwent an increasing trend from 1968 (2.3) to 1973 (36.6), then fluctuated up and down in the succeeding years before reaching a series high of 41.0 in 1980 and 1981 (Table 16).

The autumn bottom trawl survey index (kg), although exhibiting more fluctuation than the spring index, reached a high level in 1976 (4.4 kg), dropped until 1979 (1.7 kg), and increased in 1980 to 2.1 kg (Table 15, Figure 9). The increase in 1980 was only to a level slightly higher than the average observed in the 1960's. The catch-per-tow index in numbers (Table 16) increased from a low of 5.3 in 1964 to 40.1 in 1971, then declined to 16.4 in 1973. The index increased dramatically in 1974 to a series high of 176.6 before dropping to an average of 28.9 during 1976-1979. In 1980, the index increased to 50.2, the third highest level in the series (after 1974 and 1975).

Coefficients of variation for the mean weight per tow indices averaged 0.33 for the spring survey and 0.19 for the autumn survey (Table 15), incidicating that, on an absolute basis, changes in abundance of ±66% and ±38% in the spring and autumn, respectively, would not normally be detected by the surveys. The CV's for catch per tow in numbers averaged 0.34 and 0.24 for the spring and autumn surveys, respectively (Table 17), similar to those obtained for catch per tow in weight.

Mean catch per tow at age

Mean catch per tow at age (numbers, linear scale) for

1973-1981 are given in Table 17. Ages ranged from 1 to 10 years in the spring and 0 to 10 in the autumn. The data from both surveys indicate that the 1973 and 1974 year classes were quite strong and dominated the stock through about 1978. Since 1975, no year classes have consistently shown any substantial strength although the 1978 and 1980 year classes appear stronger than the 1975-1977 or 1979 year classes. The 1980 year class could potentially be quite strong in that both The 1980 autumn survey catch per tow at age 0 and the 1981 spring catch per tow at age 1 were the highest since 1974.

Fishing Mortality

Fishing mortality (F) in 1980, the terminal year for virtual population analysis, was estimated to be 0.12 for fully recruited ages (age 3+) from a power curve regression between fishing effort and fishing mortality from VPA ($r=0.820$, $p<0.01$) (Table 18, Figure 10). The iterative method used to derive F in 1980 is described for the Gulf of Maine stock.

Fishing mortality for fully-recruited ages of 0.14 was at a low in 1961, rose to 1.27 in 1965 at the peak of the USSR fishery and then declined to 0.27 in 1969 (Table 19). After increasing sharply to 1.44 in 1971, F decreased to an average of 0.87 during 1974-1976, but increased again to 1.33 in 1977. Since 1977, F has dropped sharply to an estimated 0.12 in 1980.

Recruitment

The sizes of the 1954-1977 year classes at age 1, estimated

from VPA (Table 20), ranged between 48 million fish (1976 year class) and 3,257 million fish (1962 year class), with an average of 1,006 million and a median of 600 million.

Year-class sizes increased from 339 million fish in 1954 to a high of 3,257 million in 1962 before declining steadily to 436 million for the 1969 year class. This decline was followed first by a brief increase to 1,153 million fish for the 1971 cohort and then a decrease to 64 and 48 million fish for the 1975 and 1976 cohorts, respectively. These poor year classes were confirmed by the research vessel catch-per-tow-at-age data in Table 17.

Estimates of the size of the 1978-1980 year classes at age 1 were obtained from power curve regressions between spring survey catch per tow (numbers) at age 1 and year-class size at age 1 from VPA ($r=0.714$, $p>0.05$) and between autumn survey catch per tow (numbers) at age 1 (($r=0.685$, $p>0.05$) and year-class size at age 1 from VPA (Table 21, Figure 11). The estimates of year-class size from each of the regressions were averaged and rounded to 230, 100, and 175 million fish for 1978-1980, respectively, for purposes of catch and stock size projections.

Stock Size

Estimates of stock size for 1955-1980 were obtained by VPA (Table 20). Mean weights at age (Table 14) were applied to stock numbers at age to obtain stock biomass values, and the yearly biomass values were then corrected using the appropriate ratios between observed and calculated catch (Table 13). Stock size at each age in 1981 was determined from the relationship: $N_{81}=N_{80}e^{-Z80}$.

Total stock biomass (age 1+) increased from 109,000 tons in 1955 to a high of about 800,000 tons in 1963 before declining to 167,000 tons in 1970. Biomass increased again to 277,000 tons in 1973 but decreased to a low of only 33,600 tons in 1978. The stock has remained at a relatively low level during 1977-1980 (average of 53,200 tons) compared to 1966-1976 when the stock averaged 213,000 tons. The total stock biomass in 1981 was estimated to be 47,400 tons, a 16% increase over 1980, but still the third lowest level in the 1955-1981 time series (Table 20, Figure 7).

Spawning stock biomass (age 2+) increased from about 93,000 tons in 1957 to 595,000 tons in 1964, decreased to 131,000 tons in 1971, and then increased to 199,000 tons in 1974 (Table 20, Figure 12). Biomass decreased to a low of only 25,600 tons in 1978 before increasing to an estimated 32,300 at the beginning of 1981. As with total stock biomass, the levels during 1977-1981 (average 38,700 tons) were well below previous levels.

Partial Recruitment

Age specific fishing mortality rates from VPA (Table 19) indicate that silver hake have generally been fully recruited to the fishery in recent years by about age 3, although in the past (i.e. 1955-1964), full recruitment was not reached until age 4. Partial recruitment of an age group to the fishery is defined here as the ratio between fishing mortality at a given age (in a given year) and the mean fishing mortality at the fully recruited ages in that year. Partial recruitment was estimated to be 4% at

age 1, 22% at age 2, and 100% at ages 3 and older in 1980. These estimates were used in the projections of catch and stock size for 1981-1983.

Catch and Stock Size Projections.

A total stock biomass of 47,400 tons was estimated to be available at the beginning of 1981, a 16% increase from 1980. Spawning stock biomass was estimated to be 32,300 tons in 1981, about the same as in 1980.

Total catch in 1981 was projected to be approximately 1,300 tons based on reported catches through September and the assumption that catch rates for the remainder of 1981 would be similar to those in 1980. This level of catch would require an F of about 0.06 for ages 3 and older and leave a spawning stock biomass of 43,400 tons at the beginning of 1982 (a 34% increase from 1981). Catches in 1981 ranging between 1,000 and 5,000 tons, requiring F's ranging between 0.05 and 0.24, were also considered. Spawning stock biomass at the beginning of 1982 at these catch levels would range from 39,300 to 43,700 tons (increases from 1981 ranging from 22% to 35%) assuming a 1981 year class equal to the average of the 1975-1980 year classes of 125 million fish.

Catch options for 1982 and the resultant spawning stock biomass levels in 1983, under three levels of catch in 1981 (1,000, 2,000, and 5,000 tons) were calculated for values of F ranging from 0.05 to 1.00 (Table 22). Fishing at $F_{0.1}$ in 1982 (0.65) would result in a catch of between 11,700 and 13,400 tons and leave a spawning stock biomass in 1983 of between 31,000 and

33,000 tons, averaging approximately a 23% decrease from 1982.

Catch levels in 1982 that would maintain the same spawning stock in 1983 as in 1982 would range between 2,700 and 3,400 tons requiring F values between 0.11 and 0.16. If the catch in 1982 remains at the projected 1981 level (about 1,300 tons), it will require an F of about 0.05 and result in a spawning stock size in 1983 of 45,000 tons, about a 4% increase from 1982.

SOUTHERN NEW ENGLAND - MIDDLE ATLANTIC STOCK

Catch and Management History

Catches by country for the period 1955-1980, including estimates of USA recreational catch, are listed in Table 23. Marine angler surveys provided estimates of the 1960, 1965, 1970, and 1974-1977 recreational catches. Catches in the remaining years were estimated using ratios between commercial and recreational catch (Almeida and Anderson 1979).

Total catches averaged about 16,800 tons during 1955-1959, declined to 9,952 tons in 1960, and then, with the introduction of the distant-water-fleet (DWF), increased steadily to 137,400 tons in 1966. Catches dropped sharply to 50,900 tons in 1967 and have since fluctuated between 15,500 and 67,000 tons. Catches increased from 19,200 tons in 1970 to 66,000 tons in 1973, declined to average 27,200 tons during 1976-1978, and have since dropped to 15,500 tons in 1980. The 1980 catch is the lowest reported since the introduction of the DWF (Figure 13).

USA commercial catches during 1955-1965 ranged between 8,200 and 25,000 tons and averaged 14,800 tons per year. Catches during 1966-1977 were much lower, ranging between 5,000 and 9,800 tons and averaging approximately 7,400 tons or 18% of the international total per year, before increasing to average 12,000 tons during 1978-1980 (average of 61% of the international total per year). The 1980 catch was 11,483 tons. Estimated recreational catches during 1955-1978 ranged from 197 to 4,000 tons and averaged about 1,975 tons per year. The results of the NMFS Marine Recreational Fishery Statistics Survey conducted in 1979 (NOAA 1980) were not utilized because the estimated catch of hake was much less than that determined from any of the previous surveys and was considered by those knowledgeable of the hake recreational fishery in the mid-Atlantic area to be unrepresentative of actual levels of harvest. Therefore, the recreational catch in both 1979 and 1980 was estimated to be about 3,000 tons

The distant-water-fleet catch in 1980 was only 973 tons, compared to 3,888 tons in 1979, and was by far the lowest level since the DWF fishery began in 1963 and the first year since then without a reported catch by the USSR.

The ICNAF TAC was 80,000 tons annually during 1973-1975 but was reduced to 43,000 tons in 1976. An OY of 45,000 tons was set for 1977 and reduced to 33,200 tons in 1978, of which 17,600 tons was allocated as TALFF. The 1978 OY was increased by 5,000 tons in mid-year, all of which was allocated as TALFF. In 1979 the OY was increased to 40,000 tons, of which 19,400 tons was allocated as TALFF. In 1980 the OY was increased further to 55,000 tons,

with 34,400 tons allocated as TALFF. The 1981 OY was reduced to 30,000 tons, of which 20,600 tons was designated as domestic allowable harvest (DAH) and 9,400 tons allotted to TALFF.

Catch Composition

The estimated catch-at-age (in numbers) data for 1955-1980 are listed in Table 24. The dominance of age 3-4 fish in the catch during the 1960's was replaced by a shift towards age 2-3 fish in the early 1970's. In 1977, the trend was again towards ages 3-4 and in 1978, ages 2-4 dominated with 37%, 25%, and 25% of the catch, respectively. In 1979 and 1980, ages 2-3 were again dominant in the fishery averaging 38% and 23%, respectively. During 1979-1980, age 1 fish became more prevalent in the catch, with 15% of the catch in 1979 being age 1 and 19% in 1980 (compared to an average of less than 4% during 1974-1978).

Mean weights at age for the 1955-1980 catches (Table 25) were applied to the numbers at age in Table 24 to obtain calculated catches. The ratios between observed and calculated catches ranged between 0.861 and 1.014 and averaged 0.958 (Table 24). The 1980 mean weights at age (unadjusted) were used in the projections of the 1981-1983 catch and stock size.

Abundance Indices

Commercial catch per effort

USA commercial catch per day increased steadily from 4.3 tons in 1974 to 8.4 tons in 1978 (Table 23, Figure 13), the highest observed in the series (1964-1980), but dropped to 6.0 tons in

1980. Yearly values have fluctuated between 4.3 and 8.4 but have not shown any long-term trends nor have they been totally consistent with changes in stock biomass calculated from VPA (Figure 13).

Research vessel mean catch per tow

The USA spring bottom trawl survey catch-per-tow index (kg. linear) increased from 4.0 kg in 1970 to a series high of 19.1 kg in 1975 and then underwent a general decline to a low of 3.9 in 1980. The index increased in 1981 to 6.4 kg (Table 26, Figure 14). Catch per tow in numbers (linear) increased from 27.3 in 1972 to a series high of 171.0 in 1975 before declining to 32.8 in 1980. In 1981, the index increased slightly to 40.7 (Table 27).

The autumn bottom trawl survey index (kg) exhibited a general decline from 7.6 kg in 1965 to a low of 1.4 kg in 1974, increased to 4.6 kg in 1978, but decreased to 3.1 kg in 1980 (Table 26, Figure 15). The catch per tow in numbers also showed a general decline, although with cnsiderable fluctuations, from 190.3 in 1966 to 36.2 in 1973 before increasing to 168.8 in 1976. The index then declined to 40.4 in 1979 but increased again to 53.2 in 1980 (Table 27).

Coefficients of variation averaged 0.23 and 0.20 for the spring and autumn survey mean weight per tow indices, respectively, indicating that changes of ±40-46% on an absolute basis would not normally be detected by the surveys. The CV's for catch per tow in numbers averaged 0.25 and 0.30 for the spring and

autumn surveys, respectively, indicating that changes in abundance of ±50-60% would not normally be detected.

Mean catch per tow at age

Mean catch per tow at age (numbers, linear scale) for 1973-1981 are given in Table 28. The ages present in this stock ranged from 1 to 9 in the spring surveys and 0 to 8 in the autumn surveys. The data from both surveys indicate that the 1973-1974 year classes were stronger than the other year classes in the series. Of the year classes produced since 1974, the 1976 and 1978 cohorts appear stronger than the others, and the 1980 year class appears to be of average strength.

Fishing Mortality

Fishing mortality in 1980, the terminal year for virtual population analysis, was estimated for fully recruited ages (ages 3+) to be 0.45 from a power curve regression between fishing effort and fishing mortality ($r=0.589$, $p<0.05$) (Table 29, Figure 16). This F value was derived using the iterative method described for the Gulf of Maine stock.

Fishing mortality for fully-recruited ages determined by VPA ranged between 0.32 and 0.80 during 1955-1968, averaging about 0.52. F then fluctuated between 0.50 and 1.05 during 1969-1971, averaged 0.61 during 1972-1974, increased to 1.03 in 1975, and decreased to average 0.49 in 1976-1980 (Table 29).

Recruitment

The sizes of the 1954-1977 year classes at age 1, estimated from VPA (Table 31) ranged between 174 million fish (1975 year class) and 2,002 million (1962 year class), with an average of 616 million and a median of 406 million.

Year-class sizes have shown two distinct peaks since 1954, increasing from 304 million for the 1956 cohort to a series high of 2,002 million in 1963, then declining steadily to only 229 million in 1967. Year-class strength then increased to 767 million in 1972 before declining to a low of 174 million fish for the 1975 year class.

Year-class sizes at age 1 for 1978-1980 were estimated from a power curve regression ($r=0.804$, $p<0.05$) between the spring survey catch per tow (numbers) at age 1 and year-class size at age 1 from VPA (Table 32, Figure 17). The 1978-1980 estimates of year-class size were set at 250, 220, and 220 million fish, respectively. Recent recruitment, which has averaged 208 million fish for the 1975-1980 year classes is well below the mean 1954-1974 year-class size of 731 million fish (Table 31, Figure 18).

Stock Size

Total stock biomass (age 1+) increased from an average of 76,000 tons during 1955-1959 to a period high of 453,000 tons in 1965 and then decreased to 81,000 tons in 1970. Biomass increased again to 213,000 tons in 1973, and then decreased steadily to 82,100 tons in 1980. Biomass at the beginning of 1981 was

estimated to be 82,900 tons, slightly above the 1980 level, but approximately 26% below the average of 111,400 tons estimated for 1975-1979, and 76% below the 1962-1967 average (350,900 tons), (Table 31, Figure 13).

Spawning stock biomass (age 2+) averaged about 60,000 tons during 1955-1960 before increasing to a high of 375,000 tons in 1965. Spawning biomass declined to average 63,900 tons in 1970-1971, increased to an average of 147,900 tons in 1973-1974, and then declined steadily to 60,100 tons in 1980. The 1981 estimate of 60,900 tons, which represents a slight increase over 1980, is still the second lowest level since 1971 (Table 31, Figure 18).

Partial Recruitment

Since 1965, silver hake have been considered fully recruited to the fishery by about age 3 as indicated by age specific fishing mortality rates obtained by VPA (Table 30). Partial recruitment in 1981 was estimated to be 18% at age 1 and 49% at age 2, with full recruitment at ages 3 and older. These estimates were used in projections of catch and stock size for 1981-1983.

Catch and Stock Size Projections

A total stock (age 1+) biomass of 82,900 tons was estimated to be available at the beginning of 1981. Spawning stock (age 2+) biomass was estimated to be 60,900 tons. These estimates represent no appreciable change from 1980.

Total catch in 1981 was projected to be approximately 14,000 tons based on reported catches through September and the assumption that catch rates for the remainder of 1981 would be similar to those in 1980. This level of catch would require an F for ages 3 and older of about 0.34 and leave a spawning stock biomass of 70,200 tons at the beginning of 1982 (a 15% increase from 1981). Catch levels in 1981 ranging between 10,000 and 20,000 tons, requiring F's ranging between 0.23 and 0.52 were also considered. Spawning stock biomass at the beginning of 1982 at these catch levels was estimated to range from 64,100 to 74,300 tons (increases ranging between 5% and 22%) assuming a 1981 year class equal to the 1975%-1980 average of 200 million fish.

Catch options for 1982 and the resultant spawning stock biomass levels in 1983, under three levels of 1981 catch (10,000, 15,000, and 20,000 tons) were calculated for values of F ranging from 0.05 to 1.00 (Table 33). Fishing at $F_{0.1}$ in 1982 (0.55) would result in a catch of between 20,100 and 23,500 tons, and would leave a spawning stock biomass in 1983 of between 59,300 and 64,00 tons, approximately a 11% decrease from 1982. If the catch in 1982 remains at the projected 1981 level (about 14,000 tons), it will require an F of about 0.32, and result in a spawning stock size in 1983 of 70,200 tons, the same as in 1982.

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Table 1. Silver hake catch statistics from the Gulf of Maine stock.

Year	Catch (tons)							USA catch/day (tons)	International effort as USA days fished
	Bulgaria	FRG	GDR	Poland	USSR	USA	Total		
1955	-	-	-	-	-	33,833	33,833	-	-
1956	-	-	-	-	-	21,448	21,448	15.29	1,403
1957	-	-	-	-	-	36,980	36,980	31.72	1,166
1958	-	-	-	-	-	35,522	35,522	22.20	1,600
1959	-	-	-	-	-	34,750	34,750	22.63	1,536
1960	-	-	-	-	-	23,628	23,628	18.99	1,244
1961	-	-	-	-	-	26,576	26,576	23.02	1,154
1962	-	-	-	-	-	26,253	26,253	20.30	1,293
1963	-	-	-	-	3,660	22,978	26,638	16.50	1,614
1964	-	-	-	-	-	31,722	31,722	22.86	1,388
1965	-	-	-	-	-	22,649	22,649	24.28	933
1966	-	-	-	-	-	21,495	21,495	18.19	1,182
1967	-	-	-	-	-	14,653	14,653	17.11	856
1968	-	-	-	-	-	24,706	24,706	17.83	1,386
1969	-	-	-	-	-	14,632	14,632	10.05	1,456
1970	-	-	-	-	-	11,384	11,384	7.66	1,486
1971	-	-	-	-	53	8,263	8,316	8.55	973
1972	-	131	93	-	857	5,570	6,651	7.14	932
1973	3	29	34	-	483	8,347	8,896	9.87	901
1974	-	-	-	-	578	4,635	5,213	6.28	830
1975	-	11	-	243	845	8,042	9,141	7.84	1,166
1976	-	-	-	-	-	9,760	9,760	16.71	584
1977	-	-	-	-	2	8,728	8,730	15.90	549
1978	-	-	-	-	-	6,220	6,220	7.61	817
1979	-	-	-	-	-	2,635	2,635	6.44	409
1980	-	-	-	-	-	3,812	3,812	7.74	493

Table 2. Silver hake catch at age (millions of fish) from the Gulf of Maine stock (+ denotes less than 0.1 million).

Year	Age 0	1	2	3	4	5	6	7	8	9	10	11	12+	Total	Observed weight	Calculated weight[1]	Obs./Calc.
1955	0.1	16.1	19.9	32.9	40.7	20.6	12.9	5.8	3.1	0.9	0.3	0.3	+	153.6	33,833	39,422	.858
1956	0.1	16.4	11.1	21.2	27.6	13.2	8.6	3.4	1.6	0.6	0.1	0.1	+	104.0	21,448	24,446	.877
1957	0.1	47.6	16.2	34.5	47.3	22.7	15.6	5.7	2.9	0.9	0.2	0.2	+	193.9	36,980	40,929	.904
1958	+	20.1	17.9	30.2	43.9	20.3	16.6	5.2	2.7	0.9	0.2	0.2	+	158.2	35,522	40,787	.871
1959	+	7.9	27.2	40.8	40.0	19.6	12.0	5.7	3.0	0.8	0.2	0.2	+	157.4	34,750	40,887	.850
1960	-	2.7	30.2	37.8	26.1	10.5	6.0	3.1	1.6	0.5	0.2	0.1	+	118.8	23,628	26,663	.886
1961	-	0.7	21.9	39.1	35.4	14.8	7.3	3.5	1.6	0.5	0.2	0.1	+	125.1	26,576	30,083	.883
1962	-	1.0	18.3	37.7	35.1	15.0	7.6	3.5	1.7	0.6	0.2	0.1	+	120.8	26,253	30,289	.867
1963	-	0.5	15.5	37.3	34.9	13.8	8.0	3.2	1.7	0.6	0.2	0.2	0.1	116.0	26,638	30,901	.862
1964	+	1.1	21.5	34.6	38.4	18.2	9.4	4.8	2.7	0.9	0.3	0.4	0.1	132.4	31,722	37,593	.844
1965	-	0.2	16.6	28.8	27.1	12.5	6.6	3.5	2.0	0.8	0.2	0.2	0.1	98.6	22,649	27,718	.817
1966	-	0.1	9.5	30.5	33.1	14.0	5.4	2.5	1.3	0.5	0.2	0.1	0.1	97.3	21,495	26,517	.811
1967	-	0.2	3.7	16.4	24.8	11.9	4.8	2.0	0.7	0.3	0.1	+	+	64.9	14,653	17,809	.823
1968	-	0.6	2.7	14.9	35.7	21.3	12.0	4.6	1.8	0.8	0.1	0.1	+	94.6	24,706	29,769	.830
1969	-	3.0	2.5	6.6	17.3	11.4	7.6	3.4	1.7	0.7	0.2	0.1	+	54.5	14,632	17,661	.828
1970	-	0.7	5.7	10.0	11.0	5.9	4.9	2.5	1.6	0.5	0.2	0.1	+	43.1	11,384	13,583	.838
1971	-	1.8	11.7	13.6	10.4	4.0	1.9	1.0	0.4	0.1	0.1	0.1	-	45.1	8,316	9,647	.862
1972	0.1	13.6	9.2	6.6	1.3	1.0	0.5	0.1	0.1	0.1	0.1	0.1	+	32.8	6,651	7,631	.872
1973	0.1	9.9	26.4	8.7	0.8	0.6	0.4	0.1	0.1	0.1	0.1	+	-	47.3	8,896	10,317	.862
1974	+	5.9	12.6	6.1	0.7	0.5	0.3	0.1	+	+	+	+	-	26.2	5,213	5,190	1.004
1975	-	1.4	12.9	20.3	5.6	1.9	0.5	0.1	0.1	+	-	-	-	42.8	9,141	9,243	.989
1976	-	0.9	13.9	18.6	5.4	2.4	1.3	0.1	+	-	-	-	-	42.6	9,760	9,856	.990
1977	-	1.2	8.0	14.5	8.6	1.9	0.4	0.2	+	+	-	-	-	34.8	8,730	8,809	.991
1978	+	1.4	3.6	4.2	5.4	4.9	1.0	0.4	+	+	+	+	-	20.9	6,220	6,079	1.023

[1] Using mean weights at age from Table 3.

Table 3. Mean weights (kg) at age of silver hake catches from the Gulf of Maine stock.

Year	Age 0	1	2	3	4	5	6	7	8	9	10	11	12+
1955	.004	.048	.136	.215	.279	.331	.401	.510	.543	.523	.607	.760	1.201
1956	.005	.036	.133	.215	.276	.311	.378	.451	.537	.513	.670	.799	1.192
1957	.007	.026	.126	.212	.278	.308	.366	.425	.478	.462	.554	.750	1.093
1958	.007	.044	.133	.225	.296	.332	.388	.474	.515	.474	.596	.757	1.334
1959	.005	.051	.135	.204	.287	.347	.414	.508	.543	.547	.621	.765	1.132
1960	-	.059	.137	.185	.254	.308	.412	.500	.609	.600	.705	.723	1.242
1961	-	.060	.152	.196	.248	.287	.391	.491	.593	.581	.677	.738	1.858
1962	-	.059	.156	.203	.256	.297	.385	.484	.606	.667	.771	.769	1.272
1963	-	.044	.152	.207	.261	.308	.420	.567	.716	.862	1.038	.991	1.278
1964	.005	.073	.158	.212	.268	.313	.437	.620	.784	.796	.924	1.142	1.412
1965	-	.077	.171	.210	.265	.320	.447	.583	.750	.816	.798	1.009	1.300
1966	-	.101	.195	.220	.255	.293	.406	.567	.731	.745	.949	1.034	1.763
1967	-	.073	.194	.236	.269	.293	.347	.404	.508	.513	.649	.726	1.374
1968	-	.066	.195	.266	.296	.317	.361	.430	.541	.578	.776	.965	1.413
1969	-	.063	.151	.274	.319	.346	.375	.431	.498	.538	.800	1.248	1.840
1970	-	.064	.158	.217	.315	.375	.437	.512	.536	.565	.808	.675	1.522
1971	-	.068	.132	.191	.251	.290	.396	.465	.549	.505	.589	.653	-
1972	.035	.096	.222	.335	.493	.567	.567	.920	1.078	1.163	1.238	1.376	1.746
1973	.022	.142	.197	.272	.459	.585	.491	.943	1.026	1.119	1.182	1.375	-
1974	.011	.103	.187	.256	.372	.418	.390	.778	.909	1.118	1.218	1.057	-
1975	-	.081	.135	.204	.319	.503	.622	.797	1.139	1.219	-	-	-
1976	-	.104	.151	.235	.294	.436	.431	.982	1.654	-	-	-	-
1977	-	.111	.176	.225	.305	.503	.658	.818	.604	.868	-	-	-
1978	.034	.129	.191	.224	.298	.376	.495	.809	1.306	1.402	1.078	1.078	-

Table 4. Stratified mean catch (kg, linear) per tow of silver hake from the Gulf of Maine stock from USA bottom trawl surveys in the spring (strata 21-30, 36-40) and autumn (strata 24, 26-30, 36-40) with accompanying estimates of precision.

Year	Mean	Variance	Standard deviation	2 S.D.	S.D./Mean	Mean ± 2 S.D.	No. of tows
			Spring				
1968	.09[1]	.002	.04	.09	.50	<.001-.18	73
1969	.46[1]	.02	.14	.28	.31	.18-.74	73
1970	14.47[1]	54.48	7.38	14.76	.51	-.29-29.23	75
1971	1.02[1]	.12	.35	.69	.34	.33-1.71	81
1972	4.08[1]	1.57	1.25	2.51	.31	1.57-6.59	80
1973	4.53	.82	.91	1.81	.20	2.72-6.34	71
1974	4.57	.74	.86	1.72	.19	2.85-6.29	68
1975	14.92	11.20	3.35	6.69	.22	8.23-21.61	75
1976	14.23	5.53	2.35	4.70	.17	9.53-18.93	87
1977	6.17	1.41	1.19	2.37	.19	3.80-8.54	91
1978	1.36	.06	.24	.49	.18	.87-1.85	94
1979	2.92	.49	.70	1.40	.24	1.52-4.32	117
1980	6.79	.68	.82	1.65	.12	5.14-8.44	71
1981	3.73	.26	.51	1.02	.14	2.71-4.75	73
			Autumn				
1963	26.45	30.44	5.52	11.03	.21	15.42-37.48	68
1964	4.65	.62	.79	1.57	.17	3.08-6.22	53
1965	7.89	7.90	2.81	5.62	.36	2.27-13.51	54
1966	4.28	.91	.95	1.91	.22	2.37-6.19	51
1967	2.42	.43	.66	1.31	.27	1.11-3.73	53
1968	1.88	.72	.85	1.70	.45	.18-3.58	56
1969	2.45	.41	.64	1.28	.26	1.17-3.73	57
1970	3.01	.72	.85	1.70	.28	1.31-4.71	61
1971	2.74	.62	.79	1.57	.29	1.17-4.31	62
1972	6.50	.66	.81	1.62	.12	4.88-8.12	61
1973	4.17	.36	.60	1.20	.14	2.97-5.37	61
1974	3.78	.56	.75	1.50	.20	2.28-5.28	63
1975	9.09	1.28	1.13	2.26	.12	6.83-11.35	72
1976	10.87	5.37	2.32	4.63	.21	6.24-15.50	60
1977	7.20	3.52	1.88	3.75	.26	3.45-10.95	83
1978	6.20	.44	.66	1.33	.11	4.87-7.53	143
1979	6.51	.86	.93	1.85	.14	4.66-8.36	152
1980	7.67	4.13	2.03	4.06	.26	3.61-11.73	57

[1]Adjusted from No. 36 "Yankee" trawl catches to equivalent No. 41 "Yankee" trawl catches using a 1.61:1 ratio (Sissenwine and Bowman 1978).

Table 5. Stratified mean catch (numbers, linear) per tow of silver hake from the Gulf of Maine stock from USA bottom trawl surveys in the spring (strata 21-30,36-40) and autumn (strata 24,26-30,36-40) with accompanying estimates of precision.

Year	Mean	Variance	Standard deviation	2 S.D.	S.D./Mean	Mean ± 2 S.D.
			Spring			
1968	.89[1]	.05	.22	.45	.25	.44 - 1.34
1969	10.77[1]	2.87	1.69	3.39	.16	7.38 - 14.16
1970	38.37[1]	215.27	14.67	29.34	.38	9.03 - 67.71
1971	9.90[1]	5.42	2.33	4.66	.24	5.24 - 14.56
1972	68.29[1]	262.00	16.19	32.37	.24	35.92 -100.66
1973	46.76	65.61	8.10	16.20	.17	30.56 - 62.96
1974	109.83	538.27	23.20	46.40	.21	63.43 -156.23
1975	345.15	6632.91	81.44	162.89	.24	182.26 -508.04
1976	138.66	323.75	17.99	35.99	.13	102.67 -174.65
1977	48.73	47.26	6.87	13.75	.14	34.98 - 62.48
1978	19.30	24.78	4.98	9.96	.26	9.34 - 29.26
1979	60.64	203.34	14.26	28.52	.24	32.12 - 89.16
1980	82.71	139.51	11.81	23.62	.14	59.09 -106.33
1981	57.66	71.56	8.46	16.92	.15	40.74 - 74.58
			Autumn			
1963	210.09	1586.17	39.83	79.65	.19	130.44 -289.74
1964	26.08	16.26	4.03	8.06	.15	18.02 - 34.14
1965	41.48	272.62	16.51	33.02	.40	8.46 - 74.50
1966	16.48	8.26	2.87	5.75	.17	10.73 - 22.23
1967	9.80	7.12	2.67	5.34	.27	4.46 - 15.14
1968	6.37	6.43	2.54	5.07	.40	1.30 - 11.44
1969	13.45	11.43	3.38	6.76	.25	6.69 - 20.21
1970	17.63	27.96	5.29	10.58	.30	7.05 - 28.21
1971	20.37	14.23	3.77	7.54	.19	12.83 - 27.91
1972	54.21	47.55	6.90	13.79	.13	40.42 - 68.00
1973	24.02	9.79	3.13	6.26	.13	17.76 - 30.28
1974	26.45	29.11	5.40	10.79	.20	15.66 - 37.24
1975	69.09	84.61	9.20	18.40	.13	50.69 - 87.49
1976	55.06	91.90	9.59	19.17	.17	35.89 - 74.23
1977	32.75	53.59	7.32	14.64	.22	18.11 - 47.39
1978	32.60	12.40	3.52	7.04	.11	25.56 - 39.64
1979	53.13	63.82	7.99	15.98	.15	37.15 - 69.11
1980	39.97	97.74	9.89	19.77	.25	20.20 - 59.74

[1]Adjusted from No. 36 "Yankee" trawl catches to equivalent No. 41 "Yankee" trawl catches using a 2.36:1 ratio (Sissenwine and Bowman 1978).

Table 6. Stratified mean catch (numbers, linear) per tow at age for silver hake from the Gulf of Maine stock from USA bottom trawl surveys in the spring (Strata 21-30, 36-40) and autumn (Strata 24, 26-30, 36-40).

Year	Age													Total		
	0	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII+	0+	I+	II+
Spring																
1973	-	13.28	29.92	3.01	.39	.13	.02	-	-	-	-	-	.01	46.76	46.76	33.48
1974	-	93.66	10.08	4.70	1.08	.21	.02	.03	.01	.02	-	-	.02	109.83	109.83	16.17
1975	-	123.72	195.92	20.81	3.45	1.10	.15	-	-	-	-	-	-	345.15	345.15	221.43
1976	-	29.80	66.59	35.69	4.20	1.49	.76	.08	.03	.02	-	-	-	138.66	138.66	108.86
1977	-	14.91	14.37	12.52	5.11	1.00	.38	.37	.04	.03	-	-	-	48.73	48.73	33.82
1978	-	11.96	5.15	.99	.51	.52	.12	.02	.01	-	.01	.01	-	19.30	19.30	7.34
1979	-	23.02	35.61	1.15	.24	.25	.14	.15	.08	-	-	-	-	60.64	60.64	37.62
1980	-	10.91	51.93	17.56	1.24	.36	.32	.24	.04	.05	.04	-	.02	82.71	82.71	71.80
1981[1]	-	36.16												57.66	57.66	
Autumn																
1973	4.63	7.59	7.89	2.94	.48	.32	.11	-	-	-	.01	.02	.03	24.02	19.39	11.80
1974	8.49	10.70	4.35	2.12	.20	.20	.19	.07	.08	.05	-	-	-	26.45	17.96	7.26
1975	3.35	18.46	34.76	8.29	2.54	.96	.44	.09	.04	.16	-	-	-	69.09	65.74	47.28
1976	4.37	4.46	19.67	18.71	4.62	1.35	1.00	.16	.01	-	.03	-	-	54.38	50.01	45.55
1977	3.26	6.21	5.82	9.69	6.46	1.06	.21	.03	-	.01	-	-	-	32.75	29.49	23.28
1978	6.39	11.81	3.48	2.00	3.30	4.20	.89	.26	.27	-	-	-	-	32.60	26.21	14.40
1979	.65	28.78	18.22	1.98	.75	1.05	1.54	.14	.01	-	-	-	.01	53.13	52.48	23.70
1980	2.38	5.09	14.67	12.07	2.22	.51	1.04	1.44	.55	-	-	-	-	39.97	37.59	32.50

[1]Provisional estimate; survey ages currently being analyzed.

Table 7. Estimation of F in 1978 for the Gulf of Maine silver hake fishery.

Year	Fishing effort[1]	Fishing mortality[2]
1964	1,388	.552
1965	933	.411
1966	1,182	.411
1967	856	.324
1968	1,386	.724
1969	1,456	.754
1970	1,486	.931
1971	973	1.228
1972	932	.654
1973	901	.496
1974	830	.228
1975	1,166	.607
1976	584	.399
1977	549	(.268)[3,4]
1978	817	(.400)[3]
1979	409	(.201)[3]
1980	493	(.241)[3]

[1] Expressed as USA days fished.

[2] Weighted mean F for fully-recruited ages.

[3] Calculated from power curve relationship of fishing effort on fishing mortality for 1964-1977:

$$Y = .00058X^{.9725}, \quad r = .699.$$

[4] Value calculated from VPA was .327.

[5] Not used in calculation of power curve relationship because F value appeared excessively high for the amount of fishing effort in comparison to other years.

Table 8. Fishing mortality rates for the Gulf of Maine silver hake stock derived from virtual population analysis (M=.40).

	AGE													
YEAR	1	2	3	4	5	6	7	8	9	10	11	12+	100% RECRUITMENT MEAN F[2]	AGE
	FISHING MORTALITY													
1955	.032	.056	.147	.339	.389	.531	.564	.679	.484	–	–	–	.395	4+
1956	.037	.034	.096	.221	.218	.352	.325	.377	.334	.110	–	–	.244	4+
1957	.100	.057	.171	.402	.360	.553	.536	.659	.482	.221	(.422)[1]	–	.422	4+
1958	.041	.061	.177	.433	.381	.631	.459	.690	.568	.232	(.455)[1]	–	.455	4+
1959	.017	.088	.240	.475	.447	.523	.600	.689	.581	.296	(.488)[1]	–	.488	4+
1960	.006	.102	.210	.298	.274	.299	.310	.425	.287	.351	(.297)[1]	–	.297	4+
1961	.002	.077	.232	.392	.348	.394	.361	.328	.285	.222	(.376)[1]	–	.376	4+
1962	.003	.067	.229	.428	.362	.383	.423	.378	.245	.219	.205	–	.400	4+
1963	.001	.060	.237	.434	.376	.426	.347	.479	.278	.149	.452	(.411)[1]	.411	4+
1964	.003	.079	.230	.523	.547	.618	.638	.726	.658	.273	.640	(.552)[1]	.552	4+
1965	.001	.068	.179	.357	.407	.502	.643	.803	.640	.373	.373	(.411)[1]	.411	4+
1966	.001	.053	.213	.406	.401	.392	.460	.692	.621	(.411)[1]	(.411)[1]	(.411)[1]	.411	4+
1967	.003	.040	.150	.338	.314	.292	.309	.282	.426	.300	–	–	.324	4+
1968	.008	.052	.277	.725	.710	.790	.651	.655	.789	.308	(.724)[1]	–	.724	4+
1969	.059	.054	.215	.784	.709	.797	.714	.703	.765	.599	(.754)[1]	–	.754	4+
1970	.016	.188	.394	.876	.923	1.061	.907	1.268	.596	.675	(.931)[1]	–	.931	4+
1971	.029	.502	1.247	1.300	1.381	1.274	.864	.443	.282	.282	(1.228)[1]	–	1.228	3+
1972	.130	.250	.785	.451	.498	.831	.235	.235	.235	(.654)[1]	(.654)[1]	–	.654	3+
1973	.086	.506	.508	.248	.497	.487	(.496)[1]	(.496)[1]	(.496)[1]	(.496)[1]	–	–	.496	2+
1974	.037	.185	.260	.084	.304	.649	.269	–	–	–	–	–	.228	3+
1975	.014	.131	.657	.516	.432	.738	(.607)[1]	(.607)[1]	–	–	–	–	.607	3+
1976	.024	.229	.355	.463	.564	.787	(.399)[1]	–	–	–	–	–	.399	3+
1977	.016	.299	.400	.279	.304	.155	(.327)[1]	–	–	–	–	–	.327	2+
1978	.020	.077	(.400)[3]	(.400)[3]	(.400)[3]	(.400)[3]	(.400)[3]	–	–	–	–	–	.400	3+

[1]Mean F for fully recruited ages in that year.
[2]Weighted by stock size at age (Table 9).
[3]Estimated.

Table 9. Stock size estimates for the Gulf of Maine silver hake stock derived from VPA.

	AGE															
YEAR	1	2	3	4	5	6	7	8	9	10	11	12+	AGE 1+ TOTAL	AGE 1+ WGT[1]	AGE 2+ TOTAL	AGE 2+ WGT[1]
	STOCK SIZE (MILLIONS)															
1955	628.3	443.2	289.9	170.0	76.5	37.3	16.0	7.5	2.8	-	-	-	1671.5	218.1	1045.5	193.5
1956	549.8	408.2	281.0	167.7	81.2	34.8	14.7	6.1	2.5	1.2	-	-	1547.1	202.7	997.9	185.8
1957	602.6	355.2	264.6	171.2	90.1	43.8	16.4	7.1	2.8	1.2	.7	-	1555.8	199.6	953.1	185.4
1958	608.4	365.4	225.0	149.5	76.8	42.2	16.9	6.4	2.5	1.2	.7	-	1494.8	196.6	886.4	173.3
1959	569.3	391.6	230.4	126.4	65.0	35.2	15.0	7.1	2.2	.9	.6	-	1443.8	183.6	874.5	159.0
1960	536.8	375.2	240.5	121.5	52.7	27.9	14.0	5.5	2.4	.8	.5	-	1377.8	176.2	841.0	148.1
1961	506.0	358.0	227.0	130.7	60.5	26.9	13.8	6.9	2.4	1.2	.4	-	1333.7	179.2	827.7	152.4
1962	480.1	339.6	222.2	120.6	59.2	28.6	12.1	6.5	3.3	1.2	.7	-	1274.1	172.8	794.0	148.3
1963	510.1	321.8	212.8	118.5	52.7	27.6	13.1	5.3	3.0	1.7	.7	.4	1267.7	164.5	757.6	145.2
1964	457.7	342.1	203.1	112.5	51.5	24.2	12.1	6.2	2.2	1.5	1.0	.3	1214.5	172.6	756.8	144.4
1965	332.6	305.9	211.9	108.2	44.7	20.0	8.8	4.3	2.0	.8	.8	.4	1040.3	152.1	707.7	131.2
1966	171.0	223.6	191.6	118.7	50.8	20.0	8.1	3.1	1.3	.7	.4	.4	789.5	134.4	618.6	120.4
1967	96.4	115.0	142.2	103.8	53.0	22.8	9.0	3.4	1.0	.5	-	-	547.2	99.2	450.8	93.4
1968	87.1	64.6	74.1	82.0	49.6	26.0	11.4	4.4	1.7	.5	.2	-	401.7	80.0	314.6	75.2
1969	63.4	57.9	41.1	37.7	26.6	16.4	7.9	4.0	1.5	.5	.2	-	257.2	48.3	193.9	45.0
1970	53.6	40.1	36.8	22.2	11.5	8.8	4.9	2.6	1.3	.5	.2	-	182.5	31.9	128.9	29.1
1971	76.7	35.4	22.2	16.6	6.2	3.1	2.0	1.3	.5	.5	.2	-	164.7	20.4	88.0	15.9
1972	134.8	50.0	14.3	4.3	3.0	1.0	.6	.6	.6	.2	.2	-	209.7	31.2	74.9	19.9
1973	146.0	79.3	26.1	4.4	1.8	1.2	.3	.3	.3	.3	-	-	260.1	41.8	114.1	23.9
1974	196.5	89.9	32.1	10.5	2.3	.7	.5	-	-	-	-	-	332.5	51.0	136.0	30.7
1975	123.7	126.9	50.1	16.6	6.5	1.1	.3	.3	-	-	-	-	325.4	46.6	201.7	36.7
1976	46.9	81.8	74.6	17.4	6.6	2.8	.4	-	-	-	-	-	230.5	43.9	183.7	39.1
1977	(90)	30.7	43.6	35.1	7.3	2.5	.9	-	-	-	-	-	210.1	41.6	120.1	31.7
1978	(90)	58.7	15.3	19.6	17.8	3.6	1.5	-	-	-	-	-	206.5	42.7	116.5	30.9
1979	(100)	59.1	36.4	6.9	8.8	8.0	1.6	.7	-	-	-	-	221.5	44.9	121.5	31.7

[1]Adjusted using ratios of observed/calculated catch (in thousands of tons).
[2]Estimated.

Table 10. Relationship between spring survey catch per tow (numbers) at age 1 and year-class size (millions) at age 1 from virtual population analysis for the Gulf of Maine silver hake stock.

Year-class	Spring Survey Age 1[1]	Stock Size Age 1
1968	6.02	63.4
1969	3.83	53.6
1970	3.13	76.7
1971	39.93	134.8
1972	13.57	146.0
1973	93.66	196.5
1974	123.72	123.7
1975	29.80	46.9
1976	14.91	(89.1)[2]
1977	11.96	(84.7)[2]
1978	23.02	(98.4)[2]
1979	10.91	(82.9)[2]
1980	36.16	(109.1)[2]

[1]Indices before 1973 estimated from length frequency analysis, 1973-1980 indices from Table 5.

[2]Calculated from a power curve relationship of spring survey catch per tow on VPA year-class size for 1968-1975:

$$Y=47.993x^{.229}, \quad r=.616$$

Table 11. Relationship between survey catch per tow (numbers, age 2+) and spawning stock size (millions, age 2+) from virtual population analysis for the Gulf of Maine silver hake stock.

Year	Spring survey Age 2+	Autumn survey Age 2+	Stock size Age 2+
1973	33.48	11.80	114.1
1974	16.17	7.26	136.0
1975	221.43	47.28	201.7
1976	108.86	45.55	183.7
1977	33.82	23.28	120.1
1978	7.34	14.40	116.5
1979	37.62	23.70	121.5
1980	71.80	32.50	(144.6)[1] (157.2)[2]

[1] Calculated from a linear regression of spring survey catch per tow on VPA spawning stock size for 1973-1979:

$$Y=113.607 + .432x,\ r= .921$$

[2] Calculated from a linear regression of autumn survey catch per tow on VPA spawning stock size for 1973-1979:

$$Y=93.284 + 1.966x,\ r= .876$$

Table 12. Silver hake catch statistics from the Georges Bank stock[1]

Year	Catch (tons)														USA catch/day (tons)	International effort as USA days fished
	Bulgaria	Canada	Cuba	FRG	GDR	Italy	Japan	Poland	Romania	Spain	USSR	USA	Other	Total		
1955	-	-	-	-	-	-	-	-	-	-	-	19,595	-	19,595	-	-
1956	-	-	-	-	-	-	-	-	-	-	-	20,729	-	20,729	51.50	403
1957	-	-	-	-	-	-	-	-	-	-	-	25,856	-	25,856	51.40	503
1958	-	-	-	-	-	-	-	-	-	-	-	14,498	-	14,498	42.76	339
1959	-	-	-	-	-	-	-	-	-	-	-	15,899	-	15,899	53.51	297
1960	-	-	-	-	-	-	-	-	-	-	-	22,070	-	22,070	35.89	615
1961	-	-	-	-	-	-	-	-	-	-	-	14,468	-	14,468	42.21	343
1962	-	-	-	-	-	-	-	-	-	-	41,900	16,339	-	58,239	39.46	1,476
1963	-	-	-	-	-	-	-	-	-	-	103,697	14,007	-	117,704	29.90	3,937
1964	-	-	-	-	-	-	-	-	-	-	164,763	5,522	-	170,285	41.52	4,101
1965	-	-	-	-	-	-	-	-	-	-	230,666	8,208	-	238,874	24.00	9,953
1966	-	-	-	-	-	-	-	-	-	-	88,086	12,713	-	100,799	26.09	3,864
1967	-	-	-	-	3	-	16	-	-	-	47,348	12,300	-	59,667	31.83	1,875
1968	-	-	-	-	-	-	37	887	-	-	28,013	6,451	14	35,402	25.31	1,399
1969	-	-	-	-	42	-	148	292	7	-	16,144	1,654	119	18,406	13.34	1,380
1970	-	-	-	-	-	-	31	15	73	-	20,548	4,238	-	24,905	23.81	1,046
1971	1,393	-	265	-	-	-	82	124	-	-	66,809	3,069	-	71,742	17.38	4,128
1972	1,914	-	354	226	111	-	104	-	42	-	73,882	879	-	77,512	8.66	8,951
1973	879	-	-	-	145	-	188	251	4	-	55,042	5,698	-	62,207	22.60	2,753
1974	740	1	-	49	36	-	43	70	204	-	62,938	2,283	-	66,364	15.02	4,418
1975	1,021	2	1,304	26	29	-	1	125	122	133	55,795	4,588	49	63,195	22.85	2,766
1976	-	-	3,658	81	-	-	6	102	172	5	37,992	3,793	-	45,809	46.07	994
1977	1,305	-	-	-	-	-	-	-	-	9	39,200	3,749	-	44,263	31.60	1,401
1978	-	-	-	-	-	-	5	-	-	-	3,602	6,394	-	10,001	20.19	495
1979	-	-	-	-	-	-	137	-	-	22	861	893	2	1,915	17.37	110
1980	-	-	2	-	-	-	278	-	-	218	-	1,166	-	1,664	20.97	79

[1]Non-USA catches before 1968 are estimated.

Table 13. Silver hake catch at age (millions of fish) from the Georges Bank stock (+ denotes less than 0.1 million).

Year	Age 0	1	2	3	4	5	6	7	8	9	10	11	12+	Total	Observed weight (tons)	Calculated weight[1] (tons)	Obs/Calc
1955	+	3.6	3.1	25.0	39.0	14.5	2.9	1.7	0.7	0.2	+	+	-	90.7	19,595	22,106	0.886
1956	+	2.3	3.5	20.8	42.8	17.2	2.9	1.4	0.6	0.2	+	+	+	91.7	20,729	23,916	0.867
1957	+	11.4	5.7	31.3	47.4	23.7	4.4	1.8	0.6	0.2	+	+	+	126.5	25,856	29,179	0.886
1958	+	4.4	5.5	16.3	22.5	12.5	2.9	1.6	0.5	0.1	+	+	+	66.3	14,498	16,756	0.865
1959	+	3.8	7.7	26.9	23.0	11.5	3.0	1.5	0.7	0.1	+	+	+	78.2	15,899	18,018	0.882
1960	-	2.2	11.7	46.9	33.0	12.6	3.8	2.1	1.0	0.2	+	+	-	113.5	22,070	23,868	0.925
1961	-	0.6	5.1	31.2	25.3	7.1	1.8	1.1	0.5	0.2	+	+	-	72.9	14,468	16,013	0.904
1962	-	1.8	19.1	106.9	109.7	40.5	6.7	3.6	1.0	0.2	+	+	+	289.5	58,239	61,296	0.950
1963	-	17.1	48.8	246.2	240.3	61.0	9.9	4.0	2.1	0.5	0.1	+	+	630.0	117,704	122,128	0.964
1964	+	0.9	80.1	313.6	268.8	98.4	31.9	18.7	9.0	2.3	0.1	0.2	+	824.0	170,285	181,068	0.940
1965	-	31.2	160.0	770.2	460.5	57.0	10.6	5.0	1.8	0.4	0.1	+	+	1,496.8	238,874	255,541	0.935
1966	-	17.1	173.7	264.3	160.1	29.3	8.5	4.1	2.6	0.5	0.1	0.1	+	660.4	100,799	108,727	0.927
1967	-	4.2	11.5	106.9	136.9	31.0	4.8	2.0	1.0	0.2	0.1	+	+	298.6	59,667	64,946	0.919
1968	-	1.6	4.8	76.1	56.5	31.0	6.2	1.9	0.8	0.3	+	0.1	-	179.3	35,402	39,028	0.907
1969	-	1.2	12.8	20.7	15.2	14.4	6.0	5.3	1.9	1.3	0.1	+	+	78.9	18,406	19,701	0.934
1970	-	38.0	27.1	33.0	37.9	14.6	4.2	3.3	1.3	0.3	0.1	+	+	159.9	24,905	25,397	0.981
1971	-	3.3	21.9	110.4	98.1	55.3	21.6	8.9	7.8	3.8	0.7	0.3	-	332.1	71,742	75,261	0.953
1972	0.4	148.2	148.4	102.1	28.2	5.7	3.4	2.2	0.8	0.4	0.2	0.1	0.1	440.2	77,512	82,821	0.936
1973	+	20.5	240.0	78.4	12.2	2.6	1.6	0.9	0.3	0.1	+	+	+	356.6	62,207	63,949	0.973
1974	+	12.0	150.3	122.5	25.3	3.5	3.8	1.6	0.4	0.2	0.1	+	+	319.7	66,364	68,096	0.975
1975	-	17.2	110.7	134.4	42.6	13.8	2.0	0.7	0.1	0.3	0.1	-	-	321.9	63,195	64,685	0.977
1976	-	1.6	20.0	114.2	85.8	7.9	0.9	0.1	-	-	+	-	-	230.5	45,809	45,941	0.997
1977	-	0.7	12.7	106.8	63.6	5.0	1.1	0.7	-	-	-	-	-	190.6	44,263	47,644	0.929
1978	-	0.4	5.9	7.5	12.4	10.1	1.5	0.3	+	+	+	-	-	38.1	10,001	10,101	0.990
1979	-	0.9	1.6	1.8	1.0	0.9	0.8	0.2	+	-	-	-	-	7.2	1,915	1,912	1.002
1980	-	0.4	3.2	5.4	0.9	0.3	0.3	0.4	0.1	+	+	-	-	11.0	1,664	1,742	0.955

[1] Using mean weights at age from Table 14.

Table 14. Mean weights (kg) at age of silver hake catches from the Georges Bank stock.

Year	Age												
	0	1	2	3	4	5	6	7	8	9	10	11	12+
1955	.005	.034	.105	.180	.237	.332	.485	.597	.708	.919	.971	1.068	1.410
1956	.006	.048	.110	.192	.250	.337	.481	.616	.798	.972	1.090	1.217	1.709
1957	.007	.024	.101	.172	.241	.336	.450	.542	.683	.968	1.020	1.200	1.745
1958	.008	.049	.107	.183	.256	.357	.481	.559	.718	.979	1.114	1.161	1.688
1959	.006	.052	.107	.169	.239	.350	.497	.571	.708	.857	.971	1.023	1.576
1960	-	.069	.107	.159	.217	.330	.466	.529	.644	.813	.847	.896	1.529
1061	-	.073	.110	.170	.222	.335	.490	.599	.772	.912	.998	.944	1.316
1962	-	.075	.113	.161	.219	.303	.396	.556	.668	.866	.914	.758	1.454
1963	-	.080	.107	.161	.208	.288	.415	.518	.748	1.006	.954	.810	1.425
1964	.006	.077	.104	.155	.218	.322	.486	.552	.641	.831	1.007	.849	1.518
1965	-	.064	.102	.155	.200	.302	.424	.499	.616	.859	.865	.957	1.439
1966	-	.060	.093	.151	.209	.308	.483	.590	.754	.889	1.178	1.053	1.967
1967	-	.030	.105	.175	.225	.311	.446	.567	.821	1.062	1.537	1.276	1.652
1968	-	.068	.099	.152	.218	.315	.443	.552	.720	.969	1.527	1.328	1.163
1969	-	.058	.113	.161	.217	.289	.380	.475	.664	.933	1.206	1.183	1.424
1970	-	.062	.101	.162	.198	.262	.322	.388	.491	.771	1.260	1.155	1.406
1971	-	.086	.112	.159	.206	.275	.342	.425	.557	.792	.977	1.155	-
1972	.024	.085	.178	.269	.338	.427	.416	.568	.978	1.110	1.105	1.664	.909
1973	.028	.118	.157	.215	.334	.447	.492	.643	.939	1.096	1.073	-	.808
1974	.029	.061	.176	.239	.298	.407	.323	.457	.942	1.075	1.191	1.305	.791
1975	-	.091	.151	.207	.288	.349	.420	.343	1.085	.621	1.236	-	-
1976	-	.097	.159	.188	.217	.236	.649	.689	-	-	1.272	-	-
1977	-	.126	.191	.242	.265	.342	.399	.402	.577	-	-	-	-
1978	-	.061	.207	.231	.285	.289	.354	.462	.927	1.123	1.192	-	-
1979	-	.153	.192	.272	.307	.364	.333	.382	.410	-	-	-	-
1980	-	.090	.129	.139	.204	.281	.339	.341	.367	-	.660	-	-

Table 15. Stratified mean catch per tow (kg, linear) of silver hake from the Georges Bank stock from USA bottom trawl surveys in the spring (strata 13-20) and autumn (strata 13-23, 25) with accompanying estimates of precision.

Year	Mean	Variance	Standard deviation	2 S.D.	S.D./Mean	Mean ± 2 S.D.	No. of Tows
			Spring				
1968	.87[1]	.23	.48	.96	.55	.09-1.83	45
1969	1.24[1]	.25	.50	1.00	.40	.24-2.24	51
1970	1.74[1]	.15	.39	.77	.22	.97-2.51	46
1971	1.80[1]	.16	.40	.80	.22	1.00-2.60	49
1972	1.22[1]	.10	.32	.63	.26	.59-1.85	51
1973	5.05	1.91	1.38	2.76	.27	2.29-7.81	48
1974	2.09	.46	.68	1.36	.32	.73-3.45	45
1975	2.47	.30	.55	1.10	.22	1.37-3.57	48
1976	2.45	.60	.77	1.55	.32	.90-4.00	46
1977	7.84	6.25	2.50	5.00	.32	6.29-9.39	47
1978	4.46	6.77	2.60	5.20	.58	.74-9.66	51
1979	2.08	.78	.88	1.77	.42	.31-3.85	82
1980	6.85	5.70	2.39	4.77	.35	2.08-11.62	47
1981	8.76	2.81	1.68	3.35	.19	5.41-12.11	44
			Autumn				
1963	3.60	.26	.51	1.02	.14	2.58-4.62	46
1964	1.25	.07	.26	.53	.21	.72-1.78	57
1965	1.51	.07	.26	.53	.18	.98-2.04	60
1966	1.48	.06	.24	.49	.17	.99-1.97	61
1967	1.01	.04	.20	.40	.20	.61-1.41	62
1968	2.49	.12	.35	.69	.14	1.80-3.18	63
1969	1.69	.10	.32	.63	.19	1.06-2.32	67
1970	1.29	.06	.24	.49	.19	.80-1.78	62
1971	1.21	.05	.22	.45	.18	.76-1.66	66
1972	1.34	.11	.33	.66	.25	.68-2.00	67
1973	1.74	.15	.39	.77	.22	.97-2.51	66
1974	1.09	.05	.22	.45	.21	.64-1.54	68
1975	1.97	.11	.33	.66	.17	1.31-2.63	66
1976	4.42	1.17	1.08	2.16	.24	2.26-6.58	62
1977	1.92	.17	.41	.82	.21	1.10-2.74	89
1978	3.04	.29	.54	1.08	.18	1.96-4.12	133
1979	1.66	.09	.30	.60	.18	1.06-2.26	122
1980	2.11	.13	.36	.72	.17	1.39-2.83	86

[1]Adjusted from No. 36 "Yankee" trawl catches to equivalent No. 41 "Yankee" trawl catches using a 1.61:1 ratio (Sissenwine and Bowman, 1978).

Table 16. Stratified mean catch (numbers, linear) per tow of silver hake from the Georges Bank stock from USA bottom trawl surveys in the spring (strata 13-20) and autumn (strata 13-23,25) with accompanying estimates of precision.

Year	Mean	Variance	Standard deviation	2 S.D.	S.D./Mean	Mean+ 2 S.D.
			Spring			
1968	2.30[1]	.96	.98	1.96	.43	.34- 4.26
1969	5.03[1]	3.75	1.94	3.87	.38	1.16- 8.90
1970	6.11[1]	3.16	1.78	3.56	.29	2.55- 9.67
1971	6.00[1]	2.10	1.45	2.90	.24	3.10- 8.90
1972	5.03[1]	1.31	1.14	2.29	.23	2.74- 7.32
1973	36.60	84.70	9.20	18.41	.25	18.19-55.01
1974	22.24	95.49	9.77	19.54	.44	2.70-41.78
1975	27.20	47.66	6.90	13.81	.25	13.39-41.01
1976	13.71	20.47	4.52	9.05	.33	4.66-22.76
1977	36.58	141.89	11.91	23.82	.33	12.76-60.40
1978	18.02	103.73	10.18	20.37	.57	2.35-38.39
1979	8.36	12.03	3.47	6.94	.41	1.42-15.30
1980	40.96	265.75	16.30	32.60	.40	8.36-73.56
1981	40.99	66.78	8.17	16.34	.20	24.65-57.33
			Autumn			
1963	18.22	4.88	2.21	4.42	.12	13.80-22.64
1964	5.32	.91	.95	1.91	.18	3.41- 7.23
1965	6.27	.91	.95	1.91	.15	4.36- 8.18
1966	8.47	2.96	1.72	3.44	.20	5.03-11.91
1967	6.03	2.06	1.44	2.87	.24	3.16- 8.90
1968	21.36	29.48	5.43	10.86	.25	10.50-32.22
1969	15.94	13.67	3.70	7.39	.23	8.55-23.33
1970	6.76	2.04	1.43	2.86	.21	3.90- 9.62
1971	40.14	250.72	15.83	31.67	.39	8.47-71.81
1972	20.19	18.83	4.34	8.68	.21	11.51-28.87
1973	16.35	9.94	3.15	6.31	.19	10.04-22.66
1974	176.61	2715.90	52.11	104.23	.30	73.38-280.84
1975	77.72	1089.35	33.01	66.01	.42	11.71-143.73
1976	27.78	43.10	6.57	13.13	.24	14.65-40.91
1977	24.36	52.95	7.28	14.55	.30	9.81-38.91
1978	37.01	56.04	7.49	14.97	.20	22.04-51.98
1979	26.52	57.12	7.56	15.12	.28	11.40-41.64
1980	50.18	202.65	14.24	28.47	.28	21.71-78.65

[1]Adjusted from No. 36 "Yankee" trawl catches to equivalent No. 41 "Yankee" trawl catches using a 2.36:1 ratio (Sissenwine and Bowman 1978).

Table 17. Stratified mean catch per tow (numbers, linear) at age for silver hake from the Georges Bank stock from USA bottom trawl surveys in the spring (Strata 13-20) and autumn (Strata 13-23, 25).

Year	Age											Total		
	0	I	II	III	IV	V	VI	VII	VIII	IX	X+	0+	I+	II+
Spring														
1973	-	6.01	20.42	8.88	1.01	.10	.09	.07	-	-	.02	36.60	36.60	30.59
1974	-	12.68	1.98	4.92	2.31	.35	-	-	-	-	-	22.24	22.24	9.56
1975	-	2.14	17.27	5.68	1.56	.49	.03	-	-	.03	-	27.20	27.20	25.06
1976	-	1.01	1.25	6.72	4.31	.33	.07	.02	-	-	-	13.71	13.71	12.70
1977	-	1.23	.43	19.10	14.46	.96	.08	.26	.06	-	-	36.58	36.58	35.35
1978	-	.28	.60	2.77	8.00	5.53	.84	-	-	-	-	18.02	18.02	17.74
1979	-	.92	1.82	1.76	.76	1.47	1.59	.03	.01	-	-	8.36	8.36	7.44
1980	-	.57	15.63	16.93	3.88	.89	1.23	1.21	.44	.18	-	40.96	40.96	40.39
1981[1]	-	1.59										40.99	40.99	
Autumn														
1973	9.15	1.00	4.25	1.86	.34	.18	.04	.01	-	-	.02	16.35	7.20	6.20
1974	172.46	1.44	1.98	.51	.12	.06	.01	.01	.02	-	-	176.61	4.15	2.71
1975	68.46	2.22	3.54	2.41	.79	.19	.07	.03	-	-	.02	77.73	9.27	7.05
1976	12.83	.18	.75	5.74	7.05	.82	.28	.05	-	-	.08	27.78	14.95	14.77
1977	16.82	.79	1.04	2.97	1.75	.23	.05	.34	.38	-	-	24.37	7.55	6.76
1978	26.70	1.13	1.83	2.21	2.38	1.87	.29	.06	.54	-	-	37.01	10.31	9.18
1979	19.73	1.95	1.48	.38	2.48	.23	.21	.04	.01	.01	-	26.52	6.79	4.84
1980	39.65	.40	2.06	5.45	1.12	.51	.28	.60	.07	.04	-	50.18	10.53	10.13

[1]Provisional estimate; survey age samples currently being analyzed.

Table 18. Estimation of F in 1980 for the Georges Bank silver hake fisheries.

Year	Fishing effort[1]	Fishing mortality[2]
1959	297	.357
1960	615	.342
1961	343	.143
1962	1,476	.436
1963	3,937	.712
1964	4,101	1.192
1965	9,953	1.275
1966	3,864	.646
1967	1,875	.591
1968	1,399	.476
1969	1,380	.269
1970	1,046	.310
1971[5]	4,128	1.438
1972	8,951	1.217
1973	2,753	.604
1974	4,418	.853
1975	2,766	.805
1976	994	.960
1977	1,401	(.484)[3,4]
1978	495	(.291)[3,4]
1979	110	(.140)[3]
1980	79	(.119)[3]

[1]Expressed as USA days fished.

[2]Weighted mean F for fully recruited ages.

[3]Calculated from power curve relationship of fishing effort on fishing mortality for 1959-1976:

$$Y = .0141X^{.4878}, \quad r = .820.$$

[4]Values calculated from VPA were 1.331 and .793 respectively.

[5]Not used in calculation of power curve because F value appeared excessively high for the amount of fishing effort when compared to other years.

Table 19. Fishing mortality rates for the Georges Bank silver hake stock derived from virtual population analysis (M=.40).

	AGE													
YEAR	1	2	3	4	5	6	7	8	9	10	11	12+	100% RECRUITMENT MEAN F[2]	AGE
	FISHING MORTALITY													
1955	.013	.014	.149	.583	.805	.517	.684	.699	(.629)[1]	–	–	–	.629	4+
1956	.007	.019	.147	.520	.730	.467	.664	.727	(.568)[1]	–	–	–	.568	4+
1957	.024	.026	.294	.751	.817	.532	.788	.910	(.756)[1]	–	–	–	.756	4+
1958	.006	.018	.116	.453	.585	.268	.481	.691	(.469)[1]	–	–	–	.469	4+
1959	.004	.016	.142	.299	.571	.338	.270	.516	(.357)[1]	–	–	–	.357	4+
1960	.001	.016	.157	.324	.335	.479	.540	.367	(.342)[1]	–	–	–	.342	4+
1961	<.001	.005	.068	.148	.132	.089	.311	.296	(.143)[1]	–	–	–	.143	4+
1962	.001	.015	.156	.452	.471	.220	.324	.670	.231	–	–	–	.436	4+
1963	.006	.030	.350	.807	.637	.250	.248	.403	1.204	.216	–	–	.712	4+
1964	.001	.046	.339	1.097	1.367	1.150	1.469	2.209	1.530	(1.192)[1]	(1.192)[1]	–	1.192	4+
1965	.034	.158	1.052	1.856	1.002	.655	.716	.678	.819	.280	–	–	1.275	3+
1966	.034	.340	.540	.870	.754	.494	.759	1.563	.517	(.646)[1]	(.646)[1]	–	.646	3+
1967	.009	.035	.462	.796	.520	.327	.256	.538	(.591)[1]	.228	–	–	.591	3+
1968	.003	.015	.427	.616	.535	.230	.260	.192	.387	–	(.476)[1]	–	.476	3+
1969	.003	.042	.100	.175	.395	.231	.397	.577	.701	(.269)[1]	–	–	.269	4+
1970	.111	.100	.182	.335	.317	.238	.240	.198	.206	.126	–	–	.310	4+
1971	.006	.107	.975	1.830	1.760	1.574	1.677	2.296	2.273	1.454	.888	–	1.438	3+
1972	.168	.502	1.392	.992	.635	.611	.900	.908	(1.217)[1]	(1.217)[1]	(1.217)[1]	(1.217)[1]	1.217	3+
1973	.024	.575	.714	.795	.273	.468	.408	.360	.330	–	–	–	.604	2+
1974	.017	.309	.882	.696	.736	1.097	1.908	.406	.558	(.853)[1]	–	–	.853	3+
1975	.052	.262	.648	1.293	1.593	2.196	(.805)[1]	(.805)[1]	(.805)[1]	(.805)[1]	–	–	.805	3+
1976	.031	.097	.609	1.823	1.314	.501	(.960)[1]	–	–	–	–	–	.960	3+
1977	.018	.452	1.515	1.155	.631	.851	(1.331)[1]	–	–	–	–	–	1.331	3+
1978	.004	.253	.691	.980	.738	.503	(.793)[1]	–	–	–	–	–	.793	3+
1979	.005[3]	.022	.141	.225	.204	.141	.141	–	–	–	–	–	.164	3+
1980	.005[3]	.026[3]	(.120)[4]	(.120)[4]	(.120)[4]	(.120)[4]	(.120)[4]	(.120)[4]	–	–	–	–	.120	3+

[1]Mean F for fully recruited ages in that year.
[2]Weighted by stock size at age (Table 20).
[3]Determined from assumed stock size and known catch.
[4]Estimated.

Table 20. Stock size estimates for the Georges Bank silver hake stock derived from VPA.

	AGE															
YEAR	1	2	3	4	5	6	7	8	9	10	11	12+	AGE 1+ TOTAL	AGE 1+ WGT[1]	AGE 2+ TOTAL	AGE 2+ WGT[1]
	STOCK SIZE (MILLIONS)															
1955	339.3	277.5	218.0	105.1	31.0	8.6	4.1	1.7	.5	–	–	–	985.7	109.3	646.4	99.0
1956	412.3	224.7	183.6	125.9	39.3	9.3	3.4	1.4	.5	–	–	–	1000.4	115.0	588.1	97.9
1957	571.3	274.1	147.8	106.2	50.2	12.7	3.9	1.2	.4	–	–	–	1167.8	104.9	596.5	92.7
1958	883.4	373.6	179.2	73.8	33.6	14.9	5.0	1.2	.3	–	–	–	1565.1	136.7	681.6	99.3
1959	1304.6	589.0	246.1	106.9	31.5	12.5	7.6	2.1	.4	–	–	–	2300.7	195.3	996.1	135.4
1960	1993.3	873.3	388.7	143.2	53.1	11.9	6.0	3.9	.8	–	–	–	3474.3	326.8	1481.0	199.6
1961	2206.8	1339.4	575.9	222.6	69.4	25.5	4.9	2.3	1.8	–	–	–	4448.7	450.1	2241.9	304.5
1962	2993.0	1514.7	894.0	360.8	128.8	40.8	15.6	2.4	1.2	–	–	–	5951.2	650.8	2958.2	437.6
1963	3256.6	2011.3	1000.3	512.8	153.9	53.9	21.9	7.6	.8	.6	–	–	7019.8	798.0	3763.2	546.8
1964	1950.7	2167.2	1309.0	472.6	153.4	54.6	28.1	11.5	3.4	.2	.3	–	6150.9	736.4	4200.2	595.2
1965	1117.6	1319.3	1387.9	625.2	105.8	26.2	11.6	4.3	.8	.5	–	–	4599.3	560.0	3481.7	493.1
1966	624.1	723.9	754.9	324.9	65.5	26.0	9.1	3.8	1.5	.2	.2	–	2534.2	305.0	1910.1	270.3
1967	600.5	404.5	345.5	294.9	91.2	20.6	10.7	2.9	.5	.6	–	–	1771.9	214.7	1171.4	198.1
1968	557.2	399.2	261.8	146.0	89.2	36.4	10.0	5.5	1.1	–	.3	–	1506.6	184.9	949.5	150.6
1969	513.4	373.0	263.6	114.5	52.8	35.0	19.4	5.2	3.1	.5	–	–	1380.3	171.3	867.0	143.4
1970	436.4	343.6	239.6	159.9	64.5	23.9	18.6	8.7	1.9	1.0	–	–	1298.2	166.9	861.8	140.3
1971	672.5	261.8	208.3	134.0	76.7	31.5	12.6	9.8	4.8	1.1	.6	–	1413.7	186.3	741.1	131.2
1972	1153.3	448.9	157.7	52.7	14.4	8.8	4.4	1.6	.7	.3	.2	.2	1843.1	236.2	689.8	144.5
1973	1038.6	653.3	182.2	26.3	13.1	5.1	3.2	1.2	.4	–	–	–	1923.4	277.0	884.8	157.7
1974	875.5	679.8	246.4	59.8	8.0	6.7	2.1	1.4	.6	.2	–	–	1880.5	251.1	1004.9	199.1
1975	409.3	577.3	334.7	68.3	20.0	2.6	1.5	.2	.6	.2	–	–	1414.7	217.3	1005.4	180.9
1976	64.2	260.4	297.7	117.3	12.6	2.7	.2	–	–	–	–	–	755.2	133.5	690.9	127.3
1977	48.2	41.8	158.3	108.5	12.7	2.3	1.1	–	–	–	–	–	372.9	80.7	324.7	75.0
1978	131.8	31.7	17.8	23.3	22.9	4.5	.6	–	–	–	–	–	232.7	33.6	101.0	25.6
1979	(230)[2]	88.0	16.5	6.0	5.9	7.3	1.8	–	–	–	–	–	355.6	63.8	125.6	28.6
1980	(100)[2]	153.4	57.7	9.6	3.2	3.2	4.3	1.1	–	–	–	–	332.5	40.7	232.5	32.1
1981	(175)[2]	66.7	100.2	34.3	5.7	1.9	1.9	2.6	.7	–	–	–	389.0	47.4	214.0	32.3

[1]Adjusted using ratios of observed/calculated catch (in thousands of tons).
[2]Estimated.

Table 21. Catch per tow (numbers) of age 1 silver hake from the Georges Bank stock in the spring (strata 13-20) and autumn (strata 13-23, 25) and year class size (millions of fish) at age 1 from VPA.

Year-class	Autumn Survey Age 1	Spring survey Age 1	VPA Age 1		
1973	1.44	12.68	875.5		
1974	2.22	2.14	409.3		
1975	.18	1.01	64.2		
1976	.79	1.23	48.2		
1977	1.13	.28	131.8		
1978	1.95	.92		(345.3)[1]	(122.0)[2]
1979	.40	.57		(86.0)[1]	(90.1)[2]
1980	-	1.59			(172.6)[2]

[1] Calculated from power curve relationship between autumn survey catch per tow and VPA year class size for 1973-1977:

$$Y = 192.184\ X^{.877},\ r = .685$$

[2] Calculated from power curve relationship between spring survey catch per tow and VPA year class size for 1973-1977:

$$Y = 128.637\ X^{.634},\ r = .714$$

Table 22. Projected catch (age 1+) in 1982 from the Georges Bank silver hake stock with fishing mortality ranging from 0.05 to 1.00 and under three options of 1981 catch ranging from 1,000 to 5,000 tons. Resulting stock size (age 2+) in 1983 and the percentage change (by weight) from 1982 are also given.

	1981 catch = 1,000 tons			1981 catch = 2,000 tons			1981 catch = 5,000 tons		
Fishing Mortality	1982 catch	1982 stock	% change in stock from 1982	1982 catch	1983 stock	% change in stock from 1982	1982 catch	1982 stock	% change in stock from 1982
.05	1.3	45.2	+3.4	1.3	44.3	+4.0	1.1	41.7	+6.1
.10	2.6	43.9	+0.5	2.5	43.1	+1.2	2.2	40.5	+3.1
.15	3.8	42.7	-2.3	3.6	41.9	-1.6	3.3	39.5	+0.5
.20	4.9	41.5	-5.0	4.8	40.7	-4.5	4.3	38.4	-2.3
.25	6.0	40.4	-7.6	5.8	39.6	-7.0	5.2	37.5	-4.6
.30	7.1	39.3	-10.1	6.8	38.6	-9.4	6.2	36.5	-7.1
.35	8.1	38.3	-12.4	7.8	37.6	-11.7	7.0	35.6	-9.4
.40	9.1	37.3	-14.6	8.8	36.6	-14.1	7.9	34.8	-11.5
.45	10.0	36.3	-16.9	9.7	35.7	-16.2	8.7	33.9	-13.7
.50	10.9	35.4	-19.0	10.6	34.9	-18.1	9.5	33.2	-15.5
.55	11.8	34.6	-20.8	11.4	34.0	-20.2	10.3	32.4	-17.6
.60	12.6	33.7	-22.9	12.2	33.2	-22.1	11.0	31.7	-19.3
*.65	13.4	33.0	-24.5	13.0	32.5	-23.7	11.7	31.0	-21.1
.70	14.2	32.2	-26.3	13.7	31.7	-25.6	12.4	30.3	-22.9
.75	14.9	31.5	-27.9	14.4	31.0	-27.2	13.0	29.7	-24.4
.80	15.6	30.8	-29.3	15.1	30.4	-28.6	13.6	29.1	-26.0
.85	16.3	30.1	-31.1	15.8	29.7	-30.3	14.2	28.5	-27.5
.90	17.0	29.5	-32.5	16.4	29.1	-31.7	14.8	27.9	-29.0
.95	17.6	28.9	-33.9	17.1	28.5	-33.1	15.4	27.4	-30.3
1.00	18.2	28.2	-35.5	17.7	27.9	-34.5	15.9	26.9	-31.6

*$F_{0.1}$

Table 23. Silver hake catch statistics from the Southern New England - Middle Atlantic stock[1].

Year	Catch (tons)													USA catch/day (tons)	International effort as USA days fished
	Bulgaria	Cuba	FRG	GDR	Japan	Poland	Romania	Spain	USSR	USA commercial	USA recreational	Other	Total		
1955	-	-	-	-	-	-	-	-	-	12,411	2,743	-	15,155	-	-
1956	-	-	-	-	-	-	-	-	-	13,390	2,959	-	16,349	-	-
1957	-	-	-	-	-	-	-	-	-	15,390	3,400	-	18,790	-	-
1958	-	-	-	-	-	-	-	-	-	12,039	2,660	-	14,699	-	-
1969	-	-	-	-	-	-	-	-	-	15,398	3,402	-	18,800	-	-
1960	-	-	-	-	-	-	-	-	-	8,151	1,801[2]	-	9,952	-	-
1961	-	-	-	-	-	-	-	-	-	10,562	2,334	-	12,896	-	-
1962	-	-	-	-	-	-	-	-	-	11,932	2,636	-	14,568	-	-
1963	-	-	-	-	-	-	-	-	4,191	17,666	2,451	-	24,308	-	-
1964	-	-	-	-	-	-	-	-	19,434	25,008	3,469	-	47,911	6.90	6,944
1965	-	-	-	-	-	-	-	-	68,493	20,998	2,717[2]	-	92,208	5.68	16,234
1966	-	-	-	-	-	--	-	-	126,211	9,840	1,365	-	137,416	4.60	29,873
1967	-	-	-	-	22	-	-	-	41,242	8,493	1,178	-	50,935	5.23	9,739
1968	-	-	-	-	44	121	-	-	30,812	8,163	1,132	-	40,272	5.25	7,671
1969	746	-	-	2	123	-	-	-	57,820	7,235	1,003	-	66,929	6.24	10,726
1970	439	-	-	-	299	-	40	-	11,493	6,005	950[2]	-	19,226	7.66	2,510
1971	621	-	-	-	70	24	432	-	21,714	4,989	692	-	28,542	4.85	5,885
1972	1,629	474	-	16	101	-	127	-	27,146	5,552	770	-	35,815	6.22	5,758
1973	668	-	1	15	268	92	45	-	57,928	6,098	846	-	65,961	4.77	13,828
1974	1,792	-	-	2	64	70	125	-	49,175	7,200	1,075[2]	-	59,503	4.29	13,870
1975	896	212	-	8	-	16	-	19	32,241	8,278	197[2]	44	41,911	5.26	7,968
1976	33	92	-	1	9	113	414	-	15,780	9,511	1,706[2]	-	27,661	6.61	4,185
1977	114	269	-	-	35	83	12	13	13,943	9,452	3,948[2]	11	27,880	7.65	3,644
1978	-	-	-	-	268	-	17	-	9,868	11,405	4,000	611	26,169	8.40	3,115
1979	-	-	-	-	562	-	45	358	2,215	12,974	3,000	708	19,862	7.63	2,603
1980	-	48	-	-	338	-	-	257	-	11,483	3,000	330	15,456	5.98	2,585

[1]Non-USA catches before 1968 are estimated.

[2]From angler survey; remaining years estimated (see text).

Table 24. Silver hake catch at age (millions of fish) from the Southern New England - Middle Atlantic stock (+ denotes less than 0.1 million).

Year	Age 0	1	2	3	4	5	6	7	8	9	10	11	12+	Total	Observed weight	Calculated weight[1]	Obs / calc
1955	0.4	19.8	10.9	22.7	24.5	9.9	2.1	0.8	0.3	0.1	+	-	-	91.5	15,155	15,696	.966
1956	-	68.5	51.7	22.7	16.9	6.0	1.4	0.8	0.2	0.1	+	+	-	168.3	16,349	16,536	.989
1957	-	2.8	25.6	36.1	26.1	11.1	3.0	1.2	0.4	0.1	+	+	+	106.4	18,790	19,843	.947
1958	-	23.5	31.8	28.4	17.8	6.2	1.6	0.8	0.2	+	+	+	-	110.3	14,699	15,457	.951
1959	-	13.8	13.4	42.8	28.8	10.2	2.3	0.8	0.2	+	+	+	+	112.3	18,800	20,025	.939
1960	-	13.7	19.3	14.2	11.9	5.5	1.8	1.0	0.4	0.1	+	+	+	67.9	9,952	10,363	.960
1961	-	0.5	6.3	27.0	22.1	5.7	1.5	1.0	0.4	0.2	+	+	+	64.7	12,896	13,788	.935
1962	-	0.6	6.4	29.0	27.0	7.2	1.5	0.8	0.4	0.2	0.1	+	+	73.2	14,568	15,106	.964
1963	-	5.7	24.3	46.8	43.0	13.6	2.0	0.5	0.2	0.1	+	+	-	136.2	24,308	26,189	.928
1964	-	26.2	39.4	106.3	82.4	26.1	4.5	1.8	0.5	0.4	0.2	+	-	287.8	47,911	49,493	.968
1965	-	22.7	66.8	253.2	160.5	31.2	8.4	3.8	1.3	0.4	0.1	+	+	548.4	92,208	95,227	.968
1966	-	8.6	216.8	332.1	192.4	61.0	19.8	8.6	3.5	0.9	0.1	+	+	843.8	137,416	141,433	.972
1967	-	13.6	27.5	118.4	106.6	22.2	4.5	1.7	0.7	0.2	+	+	+	295.4	50,935	52,485	.970
1968	-	9.6	23.2	96.1	64.8	20.3	8.8	3.9	1.2	0.6	0.1	+	+	228.6	40,272	43,546	.925
1969	-	1.5	20.4	120.5	108.5	40.1	10.2	9.1	3.5	1.6	0.1	0.1	-	315.6	66,929	77,721	.861
1970	-	31.8	11.0	10.3	22.5	18.3	5.3	4.3	2.4	0.9	0.2	+	0.1	107.1	19,226	19,940	.964
1971	-	7.5	35.0	50.5	26.6	8.0	3.7	5.9	5.4	2.8	1.0	0.3	+	146.7	28,542	28,968	.985
1972	0.1	52.5	82.4	41.8	13.1	1.7	0.5	0.4	0.1	+	+	-	-	192.6	35,815	40,237	.890
1973	0.1	64.3	173.8	75.5	24.6	3.7	0.9	0.5	0.1	+	-	-	-	343.5	65,961	69,672	.947
1974	+	18.2	136.7	78.0	32.2	3.0	1.4	1.3	0.3	0.3	+	-	-	271.4	59,503	59,840	.994
1975	-	4.6	39.0	90.3	34.4	10.5	1.6	0.1	-	-	-	-	-	180.5	41,911	42,348	.990
1976	0.2	7.6	75.7	38.4	14.1	3.4	0.6	0.1	-	-	-	-	-	140.1	27,661	27,985	.988
1977	-	2.6	21.6	41.5	17.2	5.2	1.7	0.9	+	-	-	-	-	90.7	27,880	25,491	1.014
1978	-	1.3	31.2	21.0	21.4	7.1	2.1	0.8	+	+	-	-	-	84.8	26,169	26,111	1.002
1979	-	10.7	28.2	15.3	6.7	7.2	2.2	0.6	0.1	-	-	-	-	71.0	19,862	19,915	.977
1980	-	14.0	26.1	18.1	9.2	2.7	1.7	1.1	0.3	0.1	-	-	-	73.3	16,844	15,456	.918

[1]Using mean wts at age from Table 25 .

Table 25. Mean weights (kg) at age of silver hake catches from the Southern New England - Middle Atlantic Stock.

	Age												
Year	0	1	2	3	4	5	6	7	8	9	10	11	12+
1955	.003	.044	.101	.162	.222	.307	.422	.508	.662	.762	1.396	-	.783
1956	-	.034	.074	.154	.223	.316	.438	.496	.664	.777	1.232	1.396	.782
1957	-	.062	.085	.157	.224	.326	.465	.512	.683	.782	1.152	1.553	.781
1958	-	.060	.088	.152	.215	.310	.409	.490	.682	.818	1.254	1.369	.782
1959	-	.035	.105	.156	.227	.333	.439	.485	.629	.658	-	-	.782
1960	-	.047	.074	.159	.216	.317	.445	.547	.702	.904	1.098	1.383	.787
1961	-	.077	.106	.166	.219	.335	.498	.586	.832	.920	1.177	-	.786
1962	-	.067	.107	.157	.215	.305	.444	.605	.822	1.007	1.468	1.374	.783
1963	-	.076	.101	.171	.228	.312	.407	.485	.645	.622	1.211	1.388	.790
1964	-	.056	.107	.149	.204	.287	.387	.500	.796	1.007	1.141	1.369	.781
1965	-	.060	.103	.152	.199	.304	.440	.537	.672	.845	1.259	1.377	.784
1966	-	.058	.087	.141	.207	.313	.446	.523	.628	.765	1.111	1.397	.793
1967	-	.035	.098	.151	.200	.300	.423	.531	.694	.820	1.406	1.633	.787
1968	-	.045	.097	.138	.193	.315	.459	.556	.788	.865	1.029	1.480	1.252
1969	-	.070	.112	.191	.246	.313	.405	.527	.697	.915	1.095	1.335	-
1970	-	.042	.079	.166	.213	.270	.348	.448	.607	.832	.958	1.157	1.240
1971	-	.053	.093	.148	.195	.271	.327	.450	.596	.741	1.024	1.013	1.249
1972	.022	.100	.215	.269	.344	.481	.643	.647	1.201	.889	1.359	-	-
1973	.018	.091	.179	.272	.390	.459	.584	.485	1.119	.548	1.595	-	-
1974	.020	.076	.178	.241	.362	.460	.599	.638	1.144	.929	1.297	-	-
1975	-	.114	.150	.207	.336	.458	.534	.593	-	-	-	-	-
1976	.012	.064	.169	.218	.306	.479	.511	.823	-	-	-	-	-
1977	-	.126	.177	.265	.346	.513	.671	.648	1.491	-	-	-	-
1978	-	.115	.207	.286	.392	.422	.655	.974	.702	1.885	-	-	-
1979	-	.139	.218	.291	.349	.527	.532	.666	1.253	1.620	-	-	-
1980	-	.109	.205	.262	.323	.342	.417	.417	.378	.496	-	-	-

Table 26. Stratified mean catch (kg, linear) per tow of silver hake from the Southern New England-Middle Atlantic stock from USA bottom trawl surveys in the spring and autumn (strata 1-12) with accompanying estimates of precision.

Year	Mean	Variance	Standard deviation	2 S.D.	S.D./Mean	Mean ± 2 S.D.	No. of Tows
			Spring				
1968	17.37[1]	74.49	8.63	17.26	.50	.11-34.63	53
1969	9.02[1]	4.30	2.07	4.15	.23	4.87-13.17	58
1970	3.97[1]	.40	.63	1.26	.16	2.71-5.23	70
1971	8.81[1]	3.07	1.75	3.50	.20	5.31-12.31	64
1972	5.46[1]	.90	.95	1.90	.17	3.56-7.36	66
1973	7.21	.82	.91	1.81	.13	5.40-9.02	90
1974	10.35	4.33	2.08	4.16	.20	6.19-14.51	55
1975	19.08	12.93	3.60	4.19	.19	11.89-26.27	60
1976	12.17	17.15	4.14	8.28	.34	3.89-20.45	61
1977	7.18	1.02	1.01	2.02	.14	5.16-9.20	59
1978	11.31	9.67	3.11	6.22	.27	5.09-17.53	62
1979	4.59	1.70	1.30	2.60	.28	1.98-7.20	72
1980	3.92	.85	.92	1.84	.24	2.08-5.76	113
1981	6.35	1.06	1.03	2.06	.16	4.29-8.41	54
			Autumn				
1963	5.22	2.67	1.63	3.27	.31	1.95-8.49	45
1964	5.66	.73	.85	1.71	.15	3.95-7.37	49
1965	7.61	1.17	1.08	2.16	.14	5.45-9.77	50
1966	3.59	.40	.63	1.26	.18	2.33-4.85	52
1967	4.42	1.51	1.23	2.46	.28	1.96-6.88	65
1968	4.76	.62	.79	1.57	.17	3.19-6.33	62
1969	2.30	.13	.36	.72	.16	1.58-3.02	66
1970	2.59	.12	.35	.69	.13	1.90-3.28	63
1971	4.60	.74	.86	1.72	.19	2.88-6.32	71
1972	3.99	1.84	1.36	2.71	.34	1.28-6.70	64
1973	3.20	.47	.69	1.37	.21	1.83-4.57	59
1974	1.36	.07	.26	.53	.19	.83-1.89	58
1975	2.77	.21	.46	.92	.17	1.85-3.69	60
1976	3.92	.31	.56	1.11	.14	2.81-5.03	61
1977	3.10	.52	.72	1.44	.23	1.66-4.54	57
1978	4.63	.84	.92	1.83	.20	2.80-6.46	85
1979	3.44	.15	.39	.77	.11	2.67-4.21	89
1980	3.07	.64	.80	1.60	.26	1.47-4.67	56

[1]Adjusted from No. 36 "Yankee" trawl catches to equivalent No. 41 "Yankee" trawl catches using a 1.61.1 ratio (Sissenwine and Bowman, 1978).

Table 27. Stratified mean catch (numbers, linear) per tow of silver hake from the Southern New England - Middle Atlantic stock from USA bottom trawl surveys in the spring and autumn (strata 1-12) with accompanying estimates of precision.

Year	Mean	Variance	Standard deviation	2 S.D.	S.D./Mean	Mean ± 2 S.D.
			Spring			
1968	136.71[1]	6486.11	88.58	167.17	.61	30.66 - 303.88
1969	53.76[1]	197.53	14.05	28.11	.26	25.65 - 81.87
1970	55.34[1]	129.32	11.37	22.74	.21	32.60 - 78.08
1971	71.37[1]	415.58	20.39	40.77	.29	30.60 - 112.14
1972	27.29[1]	30.44	5.52	11.03	.20	16.26 - 38.32
1973	65.54	88.43	9.40	18.81	.14	46.64 - 84.26
1974	169.09	1494.18	38.65	77.31	.23	91.78 - 246.40
1975	170.98	1516.91	38.95	77.90	.23	93.08 - 248.88
1976	83.93	885.55	28.91	57.81	.34	26.12 - 141.74
1977	35.95	35.54	5.96	11.92	.17	24.03 - 47.87
1978	44.47	92.10	9.60	19.19	.22	25.28 - 63.66
1979	41.71	86.04	9.28	18.55	.22	23.16 - 60.26
1980	32.80	65.57	8.10	16.20	.25	16.60 - 49.00
1981	40.68	44.44	6.67	13.33	.15	31.11 - 57.77
			Autumn			
1963	42.76	94.91	9.74	19.48	.23	23.28 - 62.24
1964	45.17	33.02	5.75	11.49	.13	33.68 - 56.66
1965	96.14	182.97	13.53	27.05	.14	69.09 - 123.19
1966	190.26	5482.68	74.05	148.09	.39	42.17 - 338.35
1967	28.95	19.48	4.41	8.83	.15	20.12 - 37.78
1968	131.38	1979.70	44.49	88.99	.34	42.39 - 220.37
1969	37.83	67.10	8.19	16.38	.22	21.45 - 54.21
1970	56.58	166.55	12.91	25.81	.23	30.77 - 82.39
1971	98.52	4708.54	68.62	137.24	.70	38.72 - 235.76
1972	107.90	1913.30	43.74	87.48	.41	20.42 - 195.38
1973	36.15	89.68	9.47	18.94	.26	17.21 - 55.09
1974	117.04	1941.38	44.06	88.12	.38	28.92 - 205.16
1975	70.96	727.27	26.97	53.94	.38	17.02 - 124.90
1976	168.82	4386.71	66.23	132.46	.39	36.36 - 301.28
1977	106.50	1214.80	34.85	69.71	.33	36.79 - 176.21
1978	104.38	500.39	22.37	44.74	.21	59.64 - 149.12
1979	40.37	61.76	7.86	15.72	.19	24.65 - 56.09
1980	53.23	201.45	14.19	28.39	.27	24.84 - 81.62

[1]Adjusted from No. 36 "Yankee" trawl catches to equivalent No. 41 "Yankee" trawl catches using a 2.36:1 ratio (Sissenwine and Bowman 1978).

Table 28. Stratified mean catch (numbers, linear) per tow at age for silver hake from the Southern New England-Middle Atlantic stock from USA bottom trawl surveys in the spring and autumn (Strata 1-12).

Year	Age											Total		
	0	I	II	III	IV	V	VI	VII	VIII	IX	X+	0+	I+	II+
							Spring							
1973	-	29.07	21.56	10.29	3.69	.57	.14	.13	.05	.04	-	65.54	65.54	36.47
1974	-	125.71	11.38	17.48	9.36	3.42	1.30	.37	-	.08	-	169.09	169.09	43.39
1975	-	81.67	24.75	47.91	12.38	3.55	.51	.21	-	-	-	170.98	170.98	89.31
1976	-	35.59	19.48	18.89	7.29	2.12	.36	.20	-	-	-	83.93	83.93	48.34
1977	-	9.92	5.29	11.87	5.67	1.75	.82	.53	.10	-	-	35.95	35.95	26.03
1978	-	6.46	13.74	7.87	9.85	4.69	1.60	.14	.12	-	-	44.47	44.47	38.01
1979	-	28.89	3.08	4.02	2.24	2.40	.88	.20	-	-	-	41.71	41.71	12.82
1980	-	18.49	6.43	3.51	1.86	.76	.91	.63	.15	.06	-	32.80	32.80	14.31
1981[1]	-	16.85										40.68	40.68	
							Autumn							
1973	19.95	5.86	6.33	2.87	.74	.37	.02	.01	-	-	-	36.15	16.20	10.34
1974	105.44	8.21	2.37	.81	.11	.02	.05	.03	-	-	-	117.04	11.60	3.39
1975	56.89	7.29	3.03	1.91	1.01	.54	.29	-	-	-	-	70.96	14.07	6.78
1976	152.78	2.44	6.09	4.25	2.35	.71	.17	.03	-	-	-	168.82	16.04	13.60
1977	93.98	5.46	2.38	3.46	.71	.35	-	.16	-	-	-	106.50	12.52	7.06
1978	77.89	12.98	6.91	3.33	2.20	1.05	.30	.19	-	-	-	104.85	26.96	13.98
1979	25.90	4.68	4.19	2.68	1.20	.88	.72	.09	.03	-	-	40.37	14.47	9.79
1980	39.70	6.03	2.56	2.35	1.63	.52	.21	.23	-	-	-	53.23	13.53	7.50

[1]Provisional estimate; survey age samples currently being analyzed.

Table 29. Estimation of F in 1980 for the Southern New England-Middle Atlantic silver hake fishery.

Year	Fishing effort[1]	Fishing mortality[2]
1964	6,944	.488
1965	16,234	.509
1966	29,823	.797
1967	9,739	.472
1968	7,671	.395
1969[5]	10,726	1.055
1970	2,510	.501
1971	5,885	1.074
1972	5,758	.626
1973	13,828	.745
1974	13,870	.771
1975[5]	7,963	1.084
1976	4,185	.477
1977	3,644	.503
1978	3,115	(.465)[3,4]
1979	2,603	(.449)[3,4]
1980	2,585	(.449)[3]

[1] Expressed as USA days fished.

[2] Weighted mean F for fully-recruited ages.

[3] Calculated from a power curve relationship of fishing effort on fishing mortality for 1964-1977:

$$Y = .102X^{.188}, \quad r = .589$$

[4] Values calculated from VPA were .609 and .421 respectively.

[5] Not used in calculation of power curve relationship because F values appeared excessively high for the amount of fishing effort in comparison to other years.

Table 30. Fishing mortality rates for the Southern New England-Middle Atlantic silver hake stock derived from virtual population analysis (M=.40).

	AGE													
YEAR	1	2	3	4	5	6	7	8	9	10	11	12+	100% RECRUITMENT MEAN F[2]	AGE
	FISHING MORTALITY													
1955	.061	.072	.282	.761	.910	.546	.742	.557	(.778)[1]	–	–	–	.778	4+
1956	.231	.278	.263	.445	.544	.384	.533	.533	(.465)[1]	–	–	–	.465	4+
1957	.011	.157	.404	.709	.785	.767	.888	(.737)[1]	(.737)[1]	–	–	–	.737	4+
1958	.088	.211	.328	.455	.460	.302	.618	(.447)[1]	–	–	–	–	.447	4+
1959	.033	.082	.626	.859	.671	.392	.305	.388	–	–	–	–	.745	4+
1960	.026	.073	.145	.451	.498	.294	.373	.309	(.435)[1]	–	–	–	.435	4+
1961	.001	.018	.171	.443	.521	.306	.333	.315	.315	–	–	–	.439	4+
1962	<.001	.012	.133	.325	.317	.315	.336	.269	(.322)[1]	(.322)[1]	–	–	.322	4+
1963	.003	.028	.144	.375	.340	.169	.204	.162	.123	–	–	–	.349	4+
1964	.017	.036	.207	.512	.528	.224	.282	.410	.724	(.488)[1]	–	–	.488	4+
1965	.021	.068	.431	.712	.475	.408	.378	.431	.903	(.509)[1]	–	–	.509	3+
1966	.012	.349	.711	.919	.881	.842	1.371	.966	(.797)[1]	(.797)[1]	–	–	.797	3+
1967	.032	.058	.415	.686	.307	.173	.190	.457	.154	–	–	–	.472	3+
1968	.052	.085	.365	.542	.333	.239	.280	.248	1.282	.132	–	–	.395	3+
1969	.008	.185	1.101	1.278	1.059	.351	.534	.559	.799	1.056	.236	–	1.055	3+
1970	.119	.087	.166	.830	1.067	.476	.308	.327	.341	.264	–	(.501)[1]	.501	3+
1971	.016	.232	.927	1.125	1.137	.864	2.906	(1.074)[1]	(1.074)[1]	(1.074)[1]	(1.074)[1]	–	1.074	3+
1972	.086	.300	.617	.896	.228	.227	.256	(.626)[1]	–	–	–	–	.626	3+
1973	.120	.578	.640	1.318	.942	.226	.474	.116	–	–	–	–	.745	3+
1974	.062	.511	.736	.837	.708	1.954	(.771)[1]	(.771)[1]	(.771)[1]	–	–	–	.771	3+
1975	.013	.227	1.039	1.222	1.005	1.595	(1.084)[1]	–	–	–	–	–	1.084	3+
1976	.054	.393	.463	.565	.449	.164	(.477)[1]	–	–	–	–	–	.477	3+
1977	.016	.268	.499	.500	.542	.548	(.503)[1]	–	–	–	–	–	.503	3+
1978	.009	.335	.581	.682	.510	.567	.712	–	–	–	–	–	.609	3+
1979	.054[3]	.324	.343	.471	.675	.369	.397	.219	–	–	–	–	.421	3+
1980	.080[3]	.220[3]	(.450)[4]	(.450)[4]	(.450)[4]	(.450)[4]	(.450)[4]	(.450)[4]	(.450)[4]	–	–	–	.450	3+

[1]Mean F for fully recruited ages in that year.
[2]Weighted by stock size at age (Table 31).
[3]Determined from assumed stock size and known catch.
[4]Estimated.

Table 31. Stock size estimates for the Southern New England-Middle Atlantic silver hake stock derived from VPA.

	AGE															
YEAR	1	2	3	4	5	6	7	8	9	10	11	12+	AGE 1+ TOTAL	AGE 1+ WGT[1]	AGE 2+ TOTAL	AGE 2+ WGT[1]
	STOCK SIZE (MILLIONS)															
1955	406.2	189.5	111.1	54.4	19.5	5.9	1.8	.8	.2	-	-	-	789.5	74.6	383.4	57.3
1956	400.2	256.2	118.2	56.2	17.0	5.3	2.3	.6	.3	-	-	-	856.3	72.0	456.1	58.5
1957	303.8	213.0	130.1	60.9	24.1	6.6	2.4	.9	.2	-	-	-	742.1	79.5	438.3	61.7
1958	336.1	201.4	122.0	58.2	20.1	7.4	2.1	.7	-	-	-	-	748.0	75.8	411.9	56.6
1959	511.9	206.2	109.3	59.0	24.8	8.5	3.7	.7	-	-	-	-	924.1	79.1	412.2	62.3
1960	652.8	332.0	127.4	39.2	16.7	8.5	3.9	1.8	.3	-	-	-	1182.6	92.9	529.7	63.4
1961	948.3	426.6	206.9	73.9	16.7	6.8	4.2	1.8	.9	-	-	-	1686.1	170.7	737.8	102.4
1962	1549.4	637.5	280.9	116.8	31.8	6.7	3.4	2.0	.9	.4	-	-	2629.8	248.5	1080.4	148.5
1963	2002.1	1051.6	422.4	164.8	56.6	15.5	3.3	1.6	1.0	-	-	-	3718.9	366.9	1716.8	225.7
1964	1874.9	1338.6	685.2	245.3	75.9	27.0	8.8	1.8	.9	.6	-	-	4259.0	424.5	2384.1	322.8
1965	1344.1	1235.0	865.3	373.4	98.5	30.0	14.5	4.4	.8	.3	-	-	3966.4	453.4	2622.3	375.3
1966	897.5	882.2	773.8	377.0	122.8	41.1	13.4	6.6	1.9	.2	-	-	3116.5	374.6	2219.1	324.0
1967	528.8	595.1	417.1	254.8	100.9	34.1	11.9	2.3	1.7	-	-	-	1946.5	237.4	1417.7	219.4
1968	229.0	343.4	376.5	184.6	86.0	49.7	19.2	6.6	1.0	1.0	-	-	1297.0	183.0	1068.0	173.5
1969	240.6	145.7	211.4	175.2	72.0	41.3	26.2	9.7	3.4	.2	.6	-	926.4	154.9	685.7	140.4
1970	341.6	160.0	81.2	47.1	32.7	16.7	19.5	10.3	3.7	1.0	-	.3	714.3	81.3	372.7	67.5
1971	578.7	203.2	98.4	46.1	13.8	7.5	7.0	9.6	5.0	1.8	.5	-	971.6	90.5	392.9	60.3
1972	766.6	382.0	108.0	26.1	10.0	3.0	2.1	.3	-	-	-	-	1298.0	182.4	531.5	114.2
1973	685.9	471.3	189.7	39.1	7.1	5.4	1.6	1.1	-	-	-	-	1401.2	209.2	715.3	150.1
1974	367.4	407.7	177.3	67.0	7.0	1.9	2.9	.7	.7	-	-	-	1032.5	173.3	665.0	145.6
1975	421.3	231.5	164.0	56.9	19.5	2.3	.2	-	-	-	-	-	895.6	144.6	474.3	97.1
1976	174.2	278.8	123.7	38.9	11.2	4.8	.3	-	-	-	-	-	632.0	104.0	457.8	92.9
1977	199.5	110.7	126.1	52.2	14.8	4.8	2.7	-	-	-	-	-	510.8	110.3	311.3	84.8
1978	184.4	131.6	56.8	51.4	21.2	5.8	1.9	-	-	-	-	-	452.9	99.6	268.6	78.3
1979	(250)[2]	122.4	63.1	21.3	17.4	8.5	2.2	.6	-	-	-	-	485.6	98.7	235.6	66.3
1980	(220)[2]	158.8	59.4	30.0	8.9	5.9	4.0	1.0	.3	-	-	-	488.3	82.1	268.3	60.1
1981	(220)[2]	136.1	85.4	25.4	12.8	3.8	2.5	1.7	.4	.1	-	-	488.2	82.9	268.2	60.9

[1]Adjusted using ratios of observed/calculated catch (in thousands of tons).
[2]Estimated.

Table 32. Catch per tow (numbers) of age 1 silver hake from the Southern New England - Middle Atlantic stock from USA spring bottom trawl surveys (strata 1-12) and year class size (millions of fish) at age 1 from VPA.

Year class	Spring survey Age 1	VPA Age 1
1973	125.71	367.4
1974	81.67	421.3
1975	35.59	174.2
1976	9.92	199.5
1977	6.46	184.4
1978	28.89	(248.8)[1]
1979	18.49	(221.6)[1]
1980	16.85	(216.3)[1]

[1] Calculated from power curve relationship between spring survey catch per tow (age 1) and VPA year class size for 1973-1977:

$$Y = 103.973\ X^{.259},\ r = .804$$

Table 33. Projected catch (age 1+) in 1982 from the Southern New England - Middle Atlantic silver hake stock with fishing mortality ranging from 0.05 to 1.00 under three options of catch in 1981. Resulting stock size (age 2+) in 1983 and the percentage change (by weight) from 1982 are also given.

	1981 Catch = 10,000 tons			1982 Catch = 15,000 tons			1981 Catch = 20,000 tons		
Fishing Mortality	1982 catch	1983 stock	% change in stock from 1982	1982 catch	1983 stock	% change in stock from 1982	1982 catch	1983 stock	% change in stock from 1982
.05	2.6	84.7	+14.0	2.4	80.9	+16.9	2.2	77.2	+20.4
.10	5.0	82.2	+10.6	4.7	78.7	+13.7	4.3	75.1	+17.2
.15	7.4	79.9	+7.5	6.9	76.5	+10.5	6.3	73.1	+14.0
.20	9.7	77.6	+4.4	9.0	74.4	+7.5	8.3	71.1	+10.9
.25	11.9	75.4	+1.5	11.0	72.3	+4.5	10.1	69.2	+8.0
.30	14.0	73.3	-1.3	13.0	70.4	+1.7	11.9	67.4	+5.1
.35	16.0	71.3	-4.0	14.9	68.5	-1.0	13.7	65.7	+2.5
.40	18.0	69.4	-6.6	16.7	66.7	-3.6	15.4	64.0	-0.2
.45	19.9	67.5	-9.2	18.4	64.9	-6.2	17.0	62.3	-2.8
.50	21.7	65.7	-11.6	20.1	63.3	-8.5	18.6	60.8	-5.1
*.55	23.5	64.0	-13.9	21.8	61.6	-11.0	20.1	59.3	-7.5
.60	25.2	62.3	-16.2	23.4	60.1	-13.2	21.6	57.8	-9.8
.65	26.8	60.7	-18.3	24.9	58.6	-15.3	23.0	56.4	-12.0
.70	28.4	59.2	-20.3	26.3	57.1	-17.5	24.3	55.1	-14.0
.75	29.9	57.7	-22.3	27.8	55.7	-19.5	25.7	53.7	-16.2
.80	31.4	56.3	-24.2	29.1	54.4	-21.4	26.9	52.5	-18.1
.85	32.8	54.9	-26.1	30.5	53.1	-23.3	28.2	51.3	-20.0
.90	34.2	53.5	-28.0	31.7	51.8	-25.1	29.3	50.1	-21.8
.95	35.5	52.3	-29.6	33.0	50.6	-26.9	30.5	48.9	-23.7
1.00	36.7	51.0	-31.4	34.2	49.4	-28.6	31.6	47.8	-25.4

*$F_{0.1}$

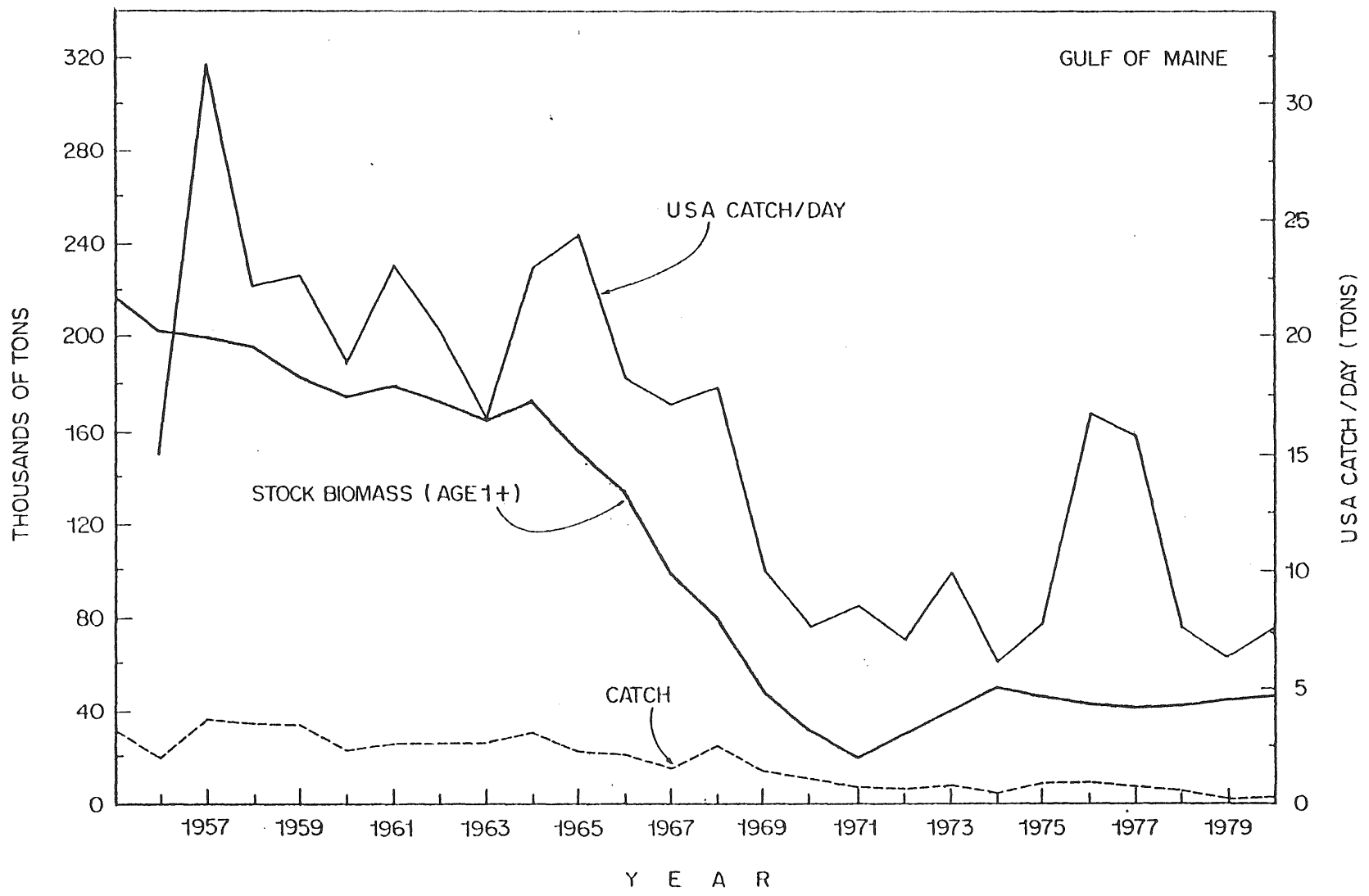

Figure 1. International catch, stock biomass (age 1+) from VPA and USA commercial catch-per-day from the Gulf of Maine silver hake stock.

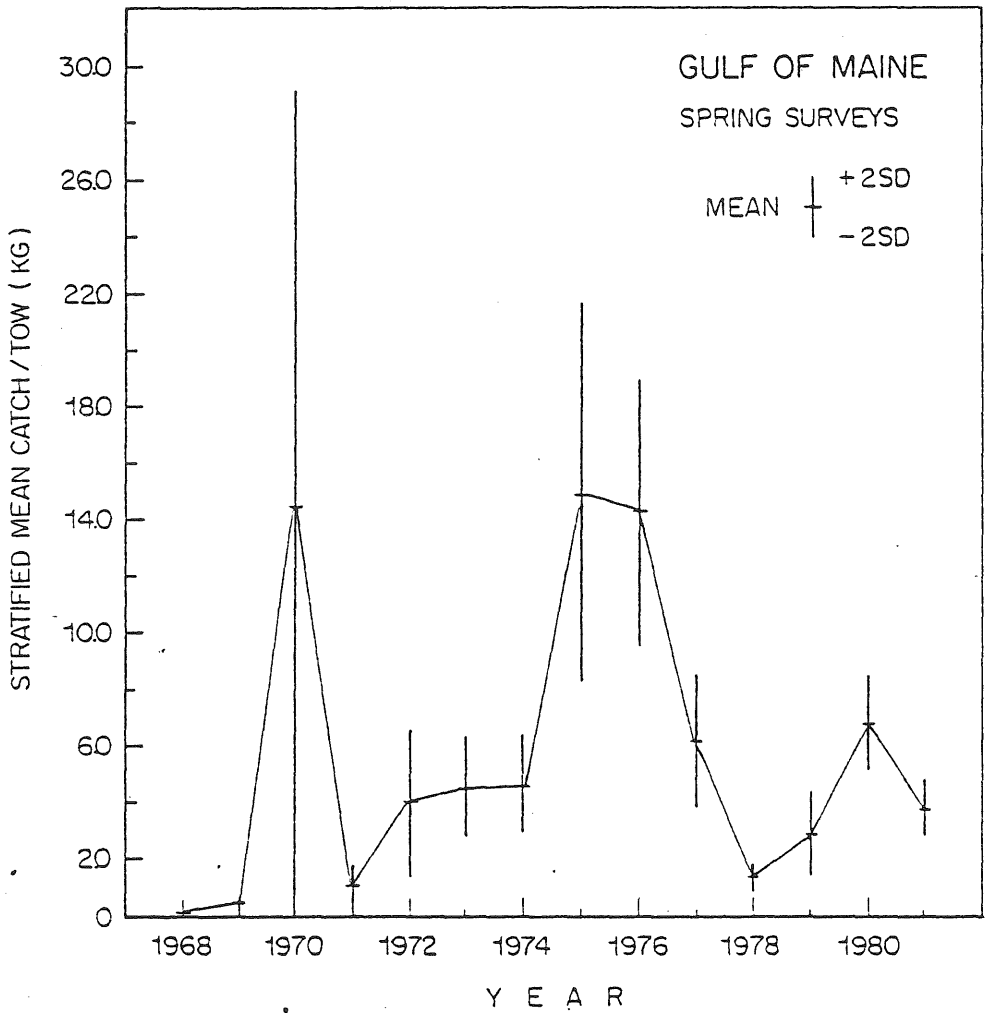

Figure 2. Stratified mean catch per tow (kg) of silver hake from the Gulf of Maine stock from USA spring bottom trawl surveys (1968-1981).

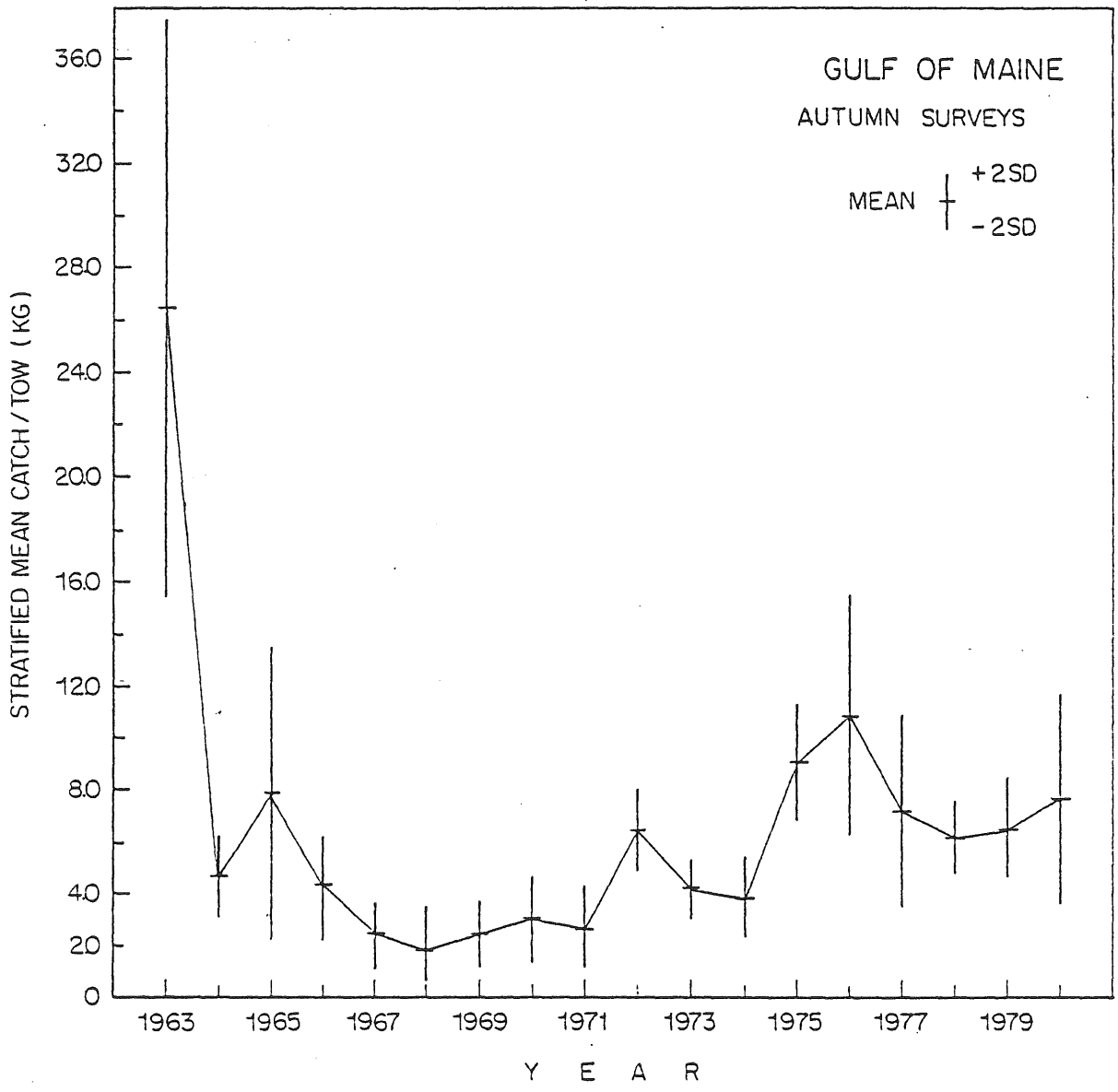

Figure 3. Stratified mean catch per tow (kg) of silver hake from the Gulf of Maine stock from USA autumn bottom trawl surveys (1963-1980).

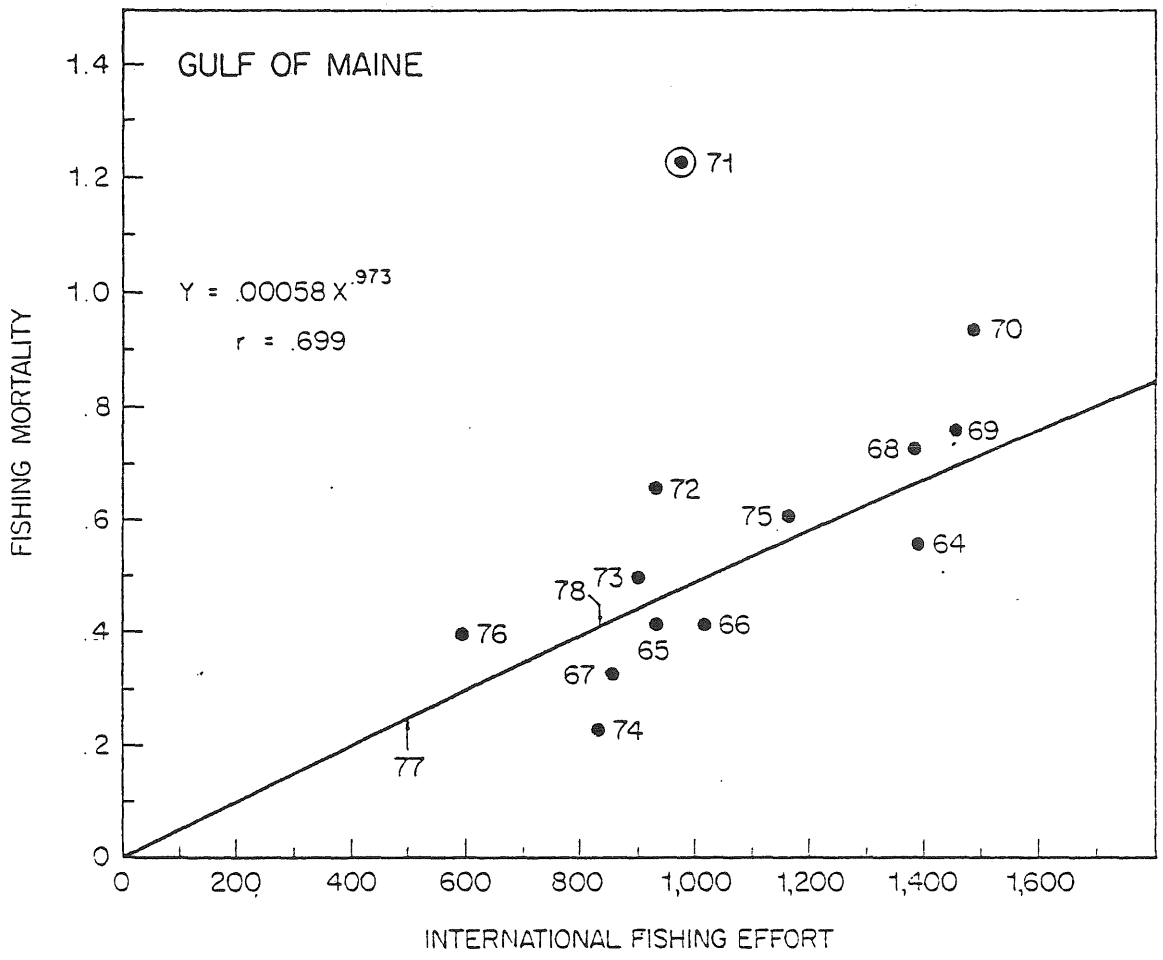

Figure 4. Relationship between fishing mortality from VPA and fishing effort expressed as USA days fished for the Gulf of Maine silver hake stock.

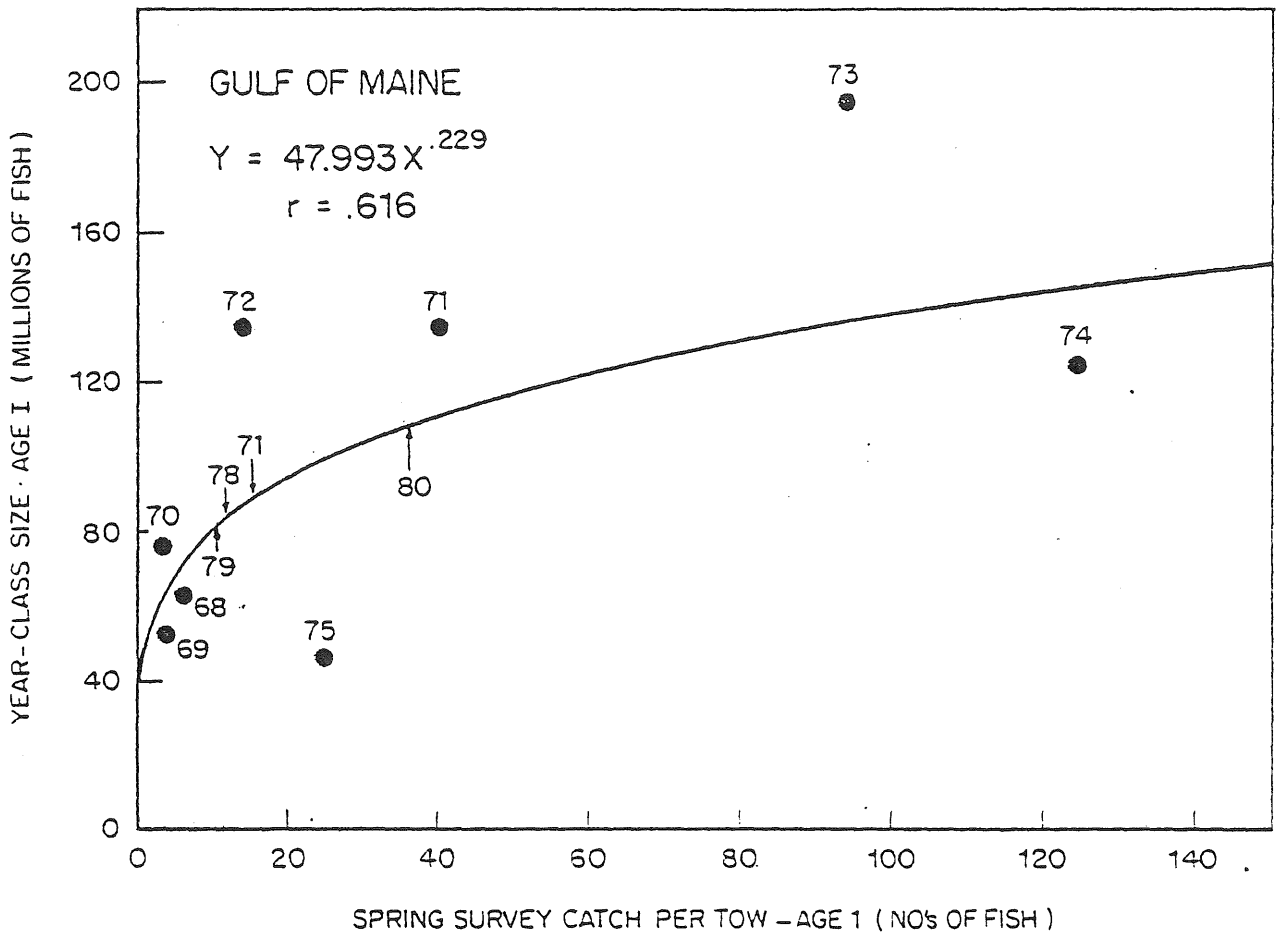

Figure 5. Relationship between year-class size from VPA and USA spring bottom trawl survey catch per tow at age 1 for the Gulf of Maine silver hake stock.

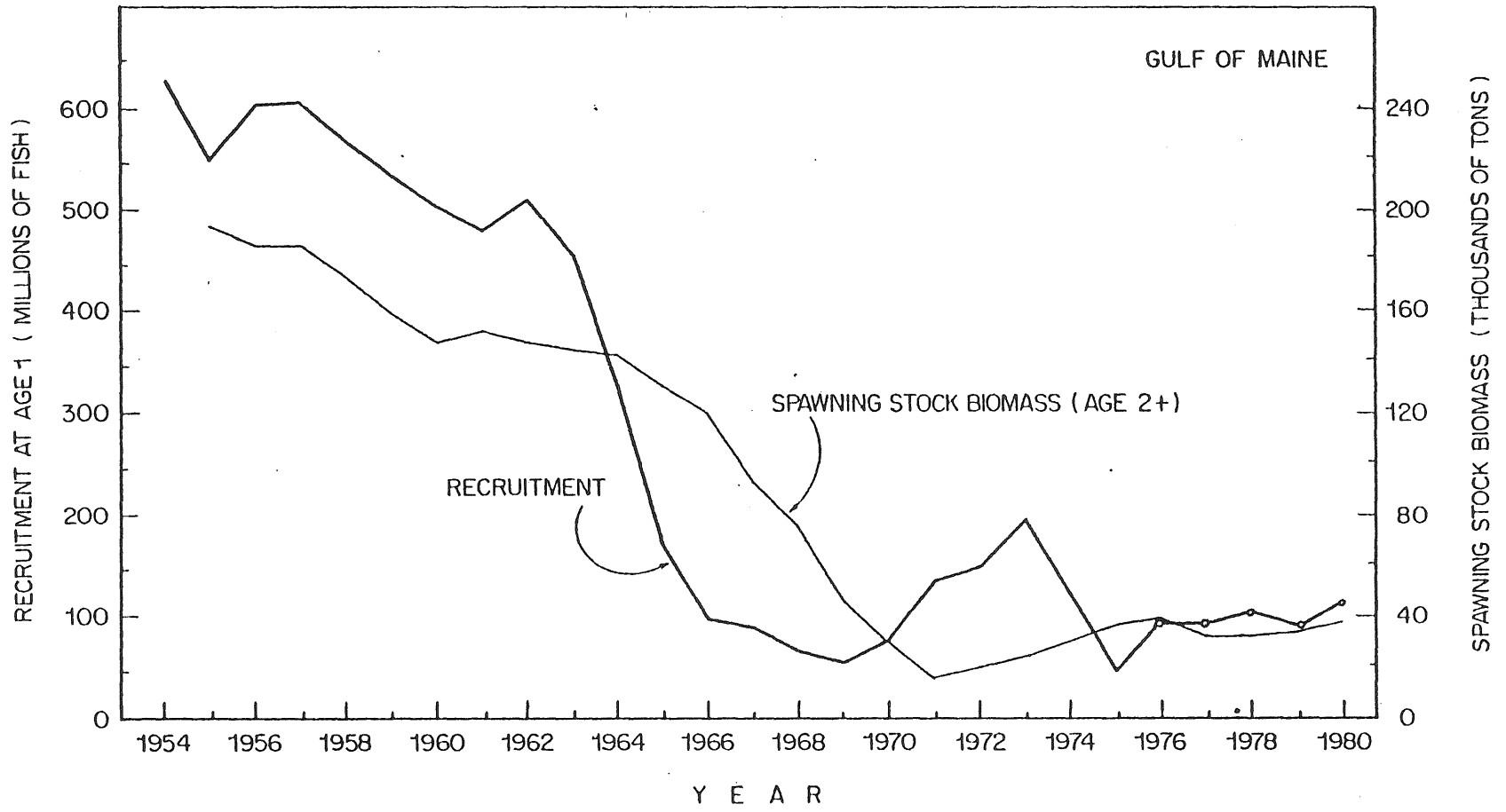

Figure 6. Gulf of Maine silver hake spawning stock biomass (age 2+) during 1955-1980 and abundance at age 1 of the 1954-1980 year classes.

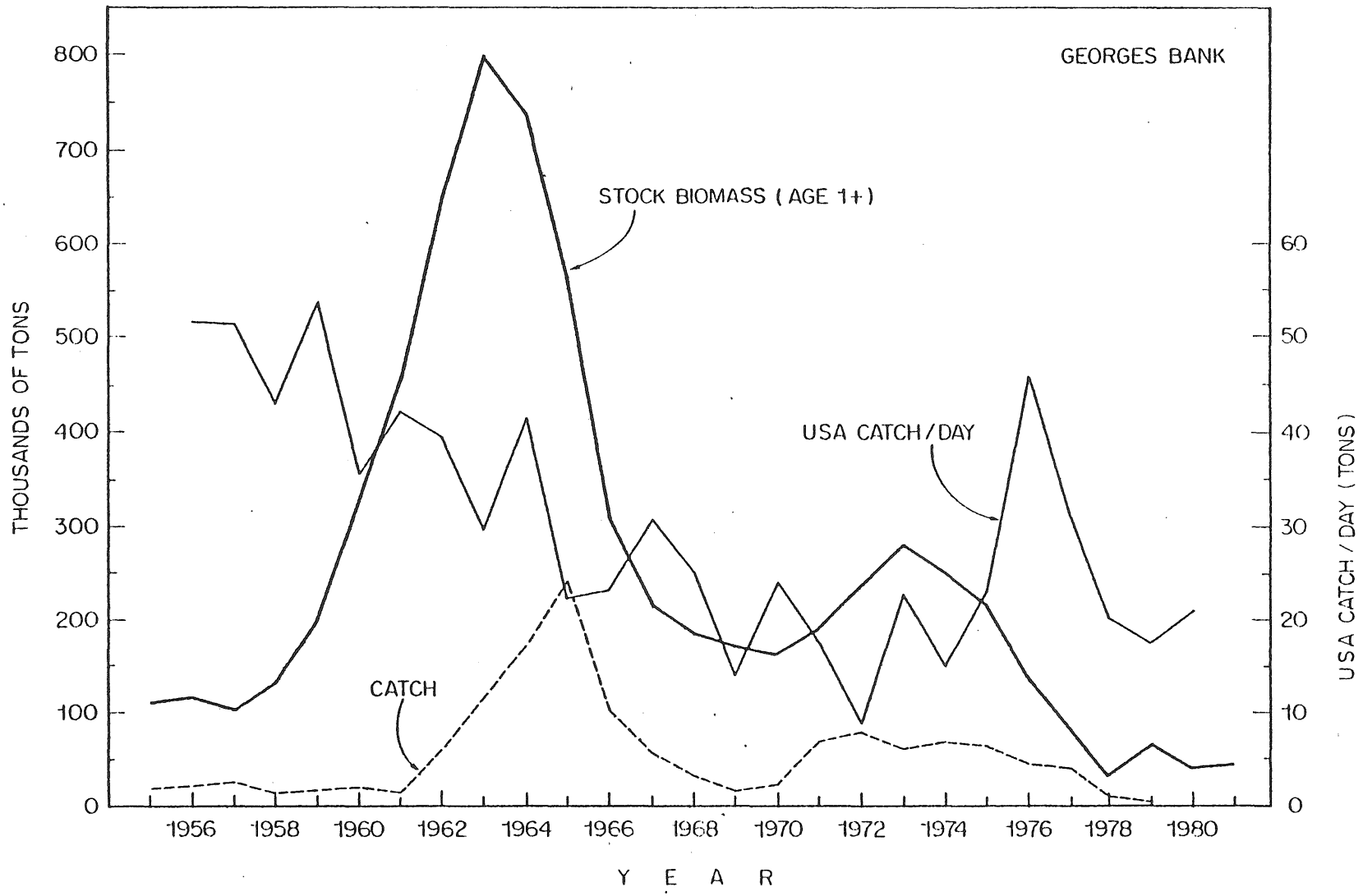

Figure 7. International catch, stock biomass (age 1+) from VPA and USA commercial catch-per-day from the Georges Bank silver hake stock.

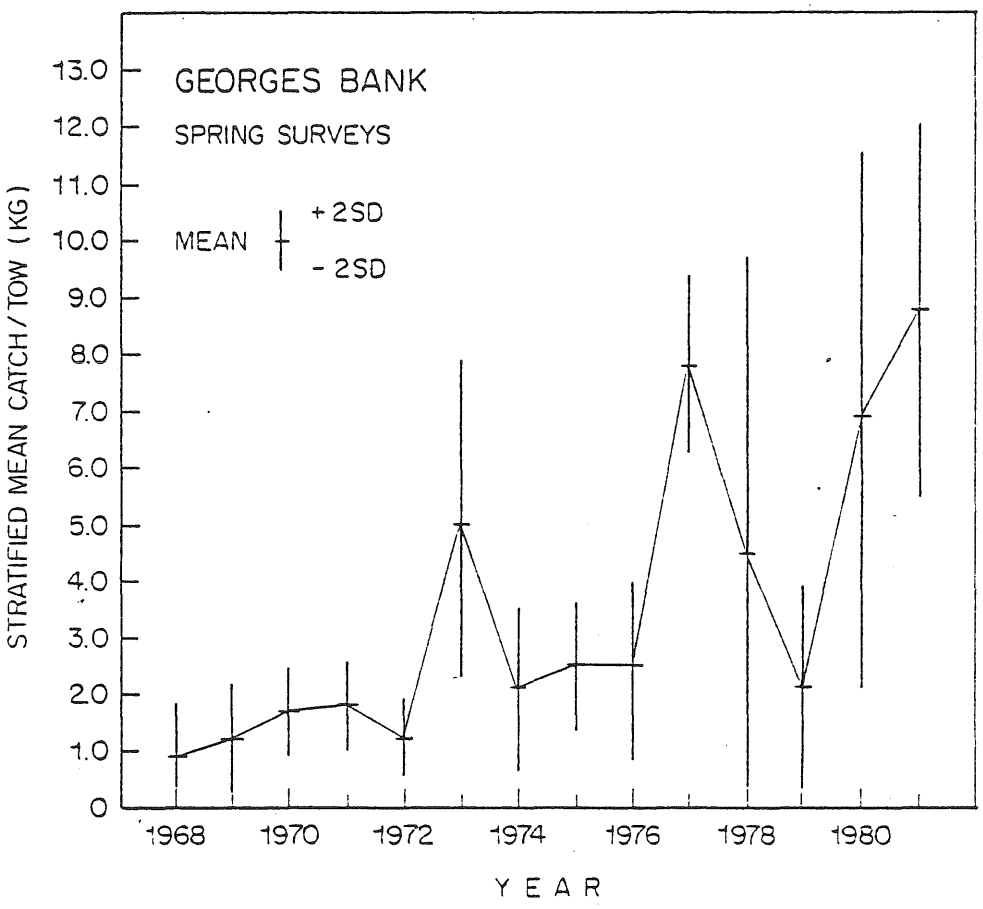

Figure 8. Stratified mean catch per tow (kg) of silver hake from the Georges Bank stock from USA spring bottom trawl surveys (1968-1981).

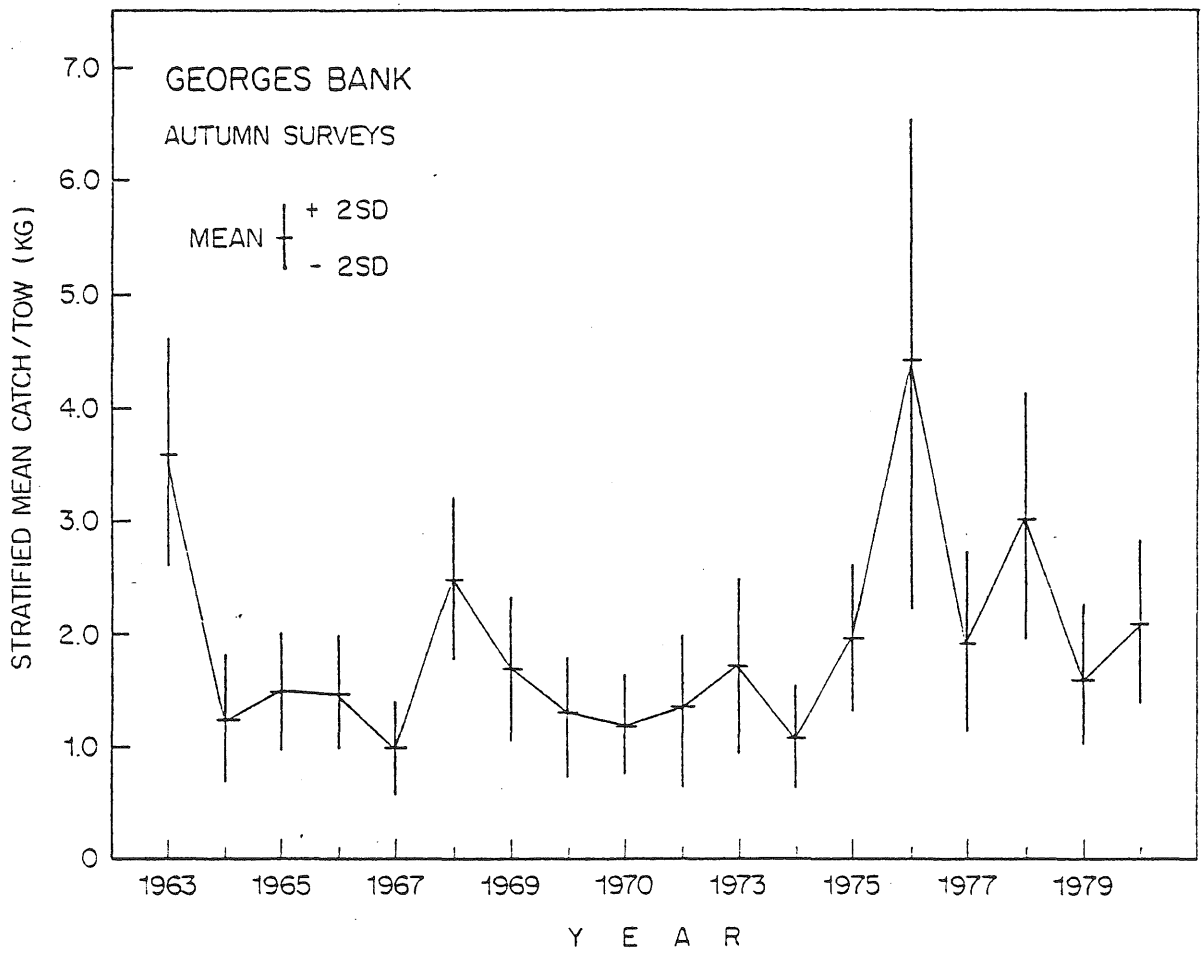

Figure 9. Stratified mean catch per tow (kg) of silver hake from the Georges Bank stock from USA autumn bottom trawl surveys (1963-1980).

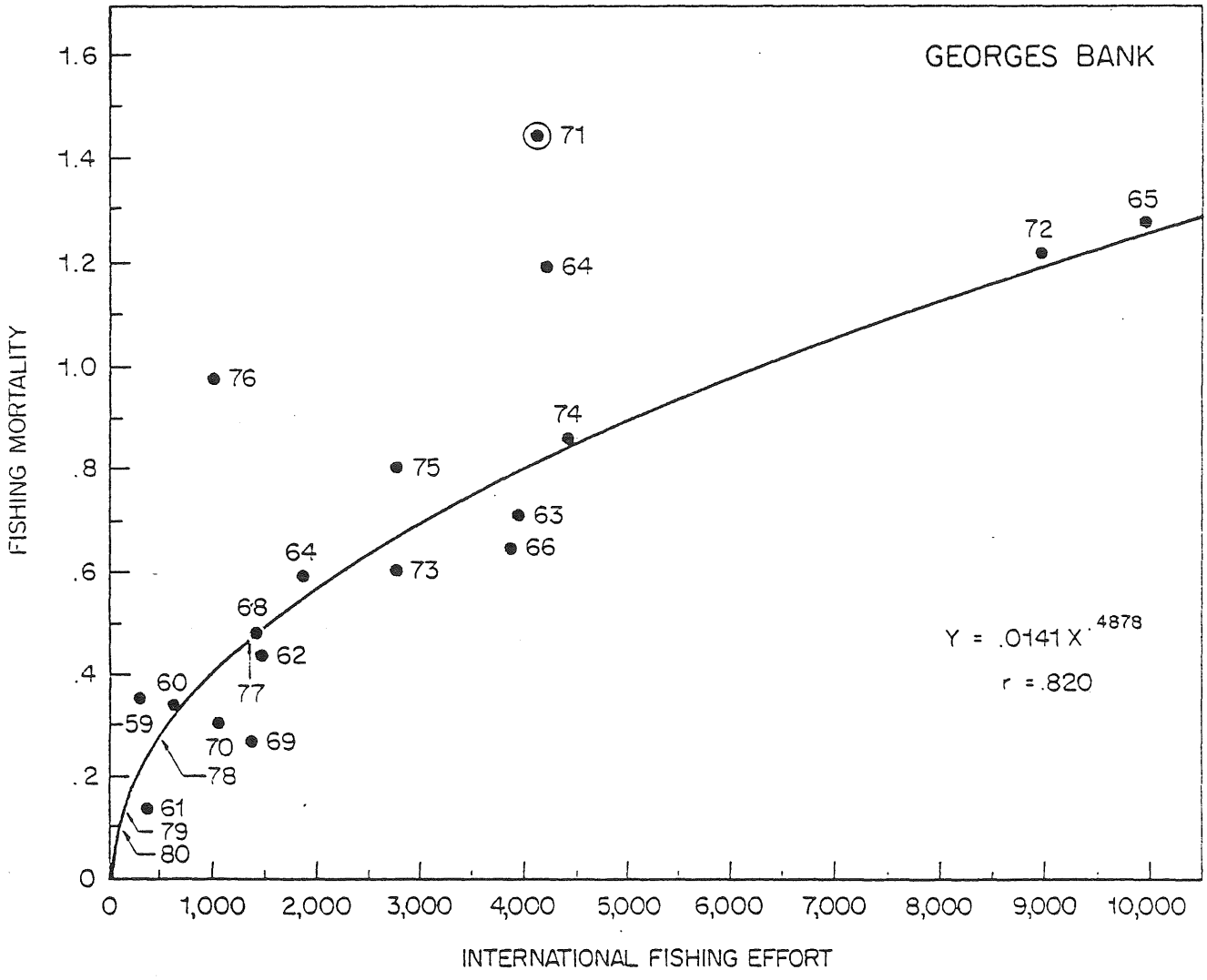

Figure 10. Relationship between fishing mortality from VPA and fishing effort expressed as USA days fished for the Georges Bank silver hake stock.

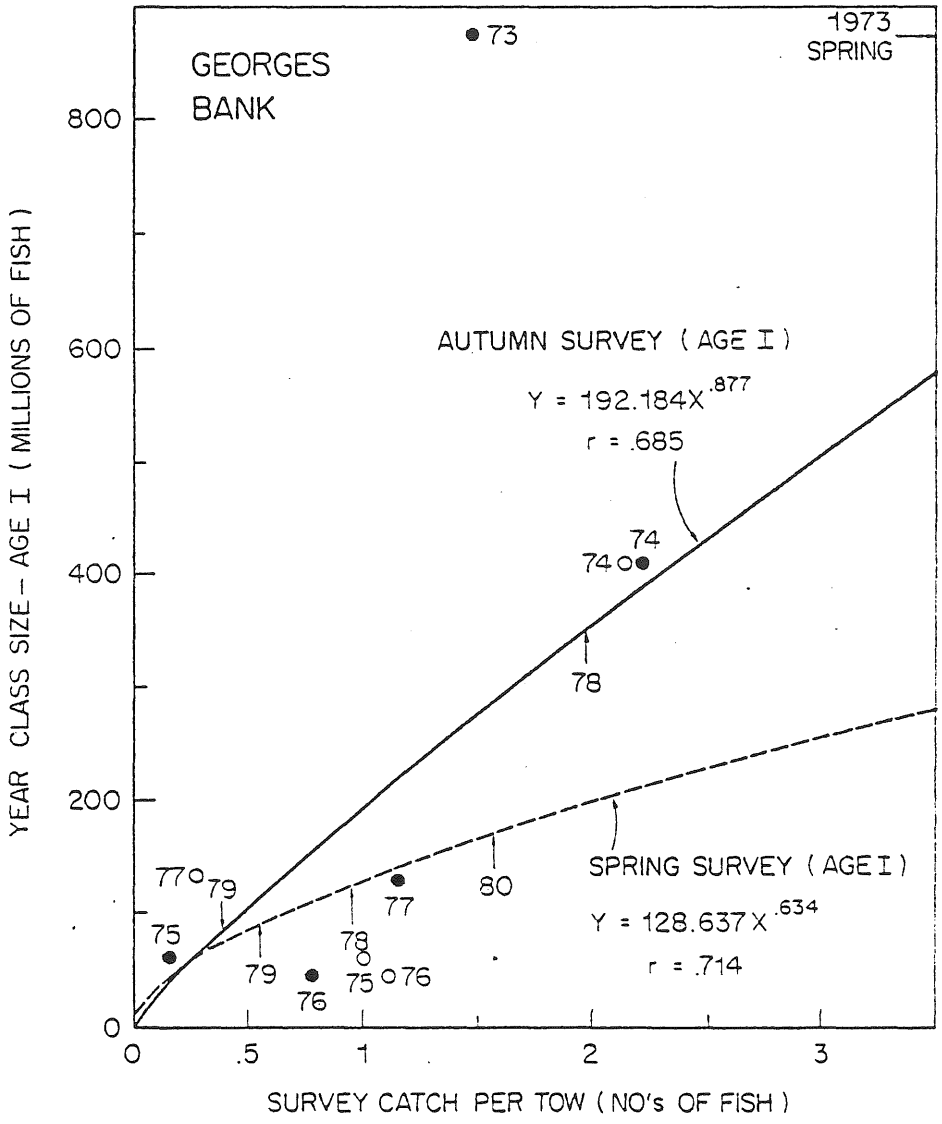

Figure 11. Relationship between year class size from VPA and spring (open circles) and autumn (closed circles) USA bottom trawl survey catch per tow at age 1 for the Georges Bank silver hake stock.

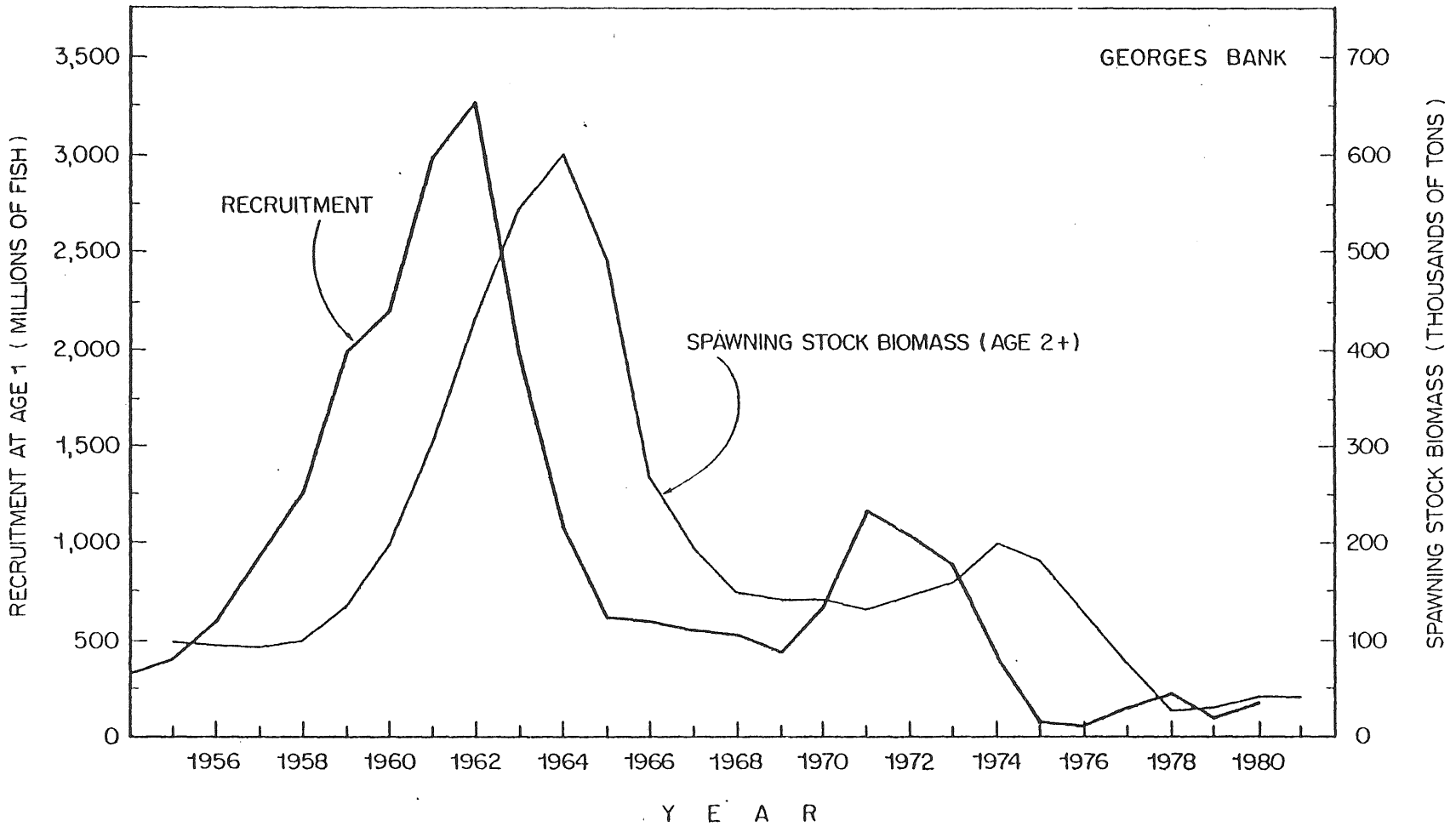

Figure 12. Georges Bank silver hake spawning stock biomass (age 2+) during 1955-1981 and abundance at age 1 of the 1954-1980 year classes.

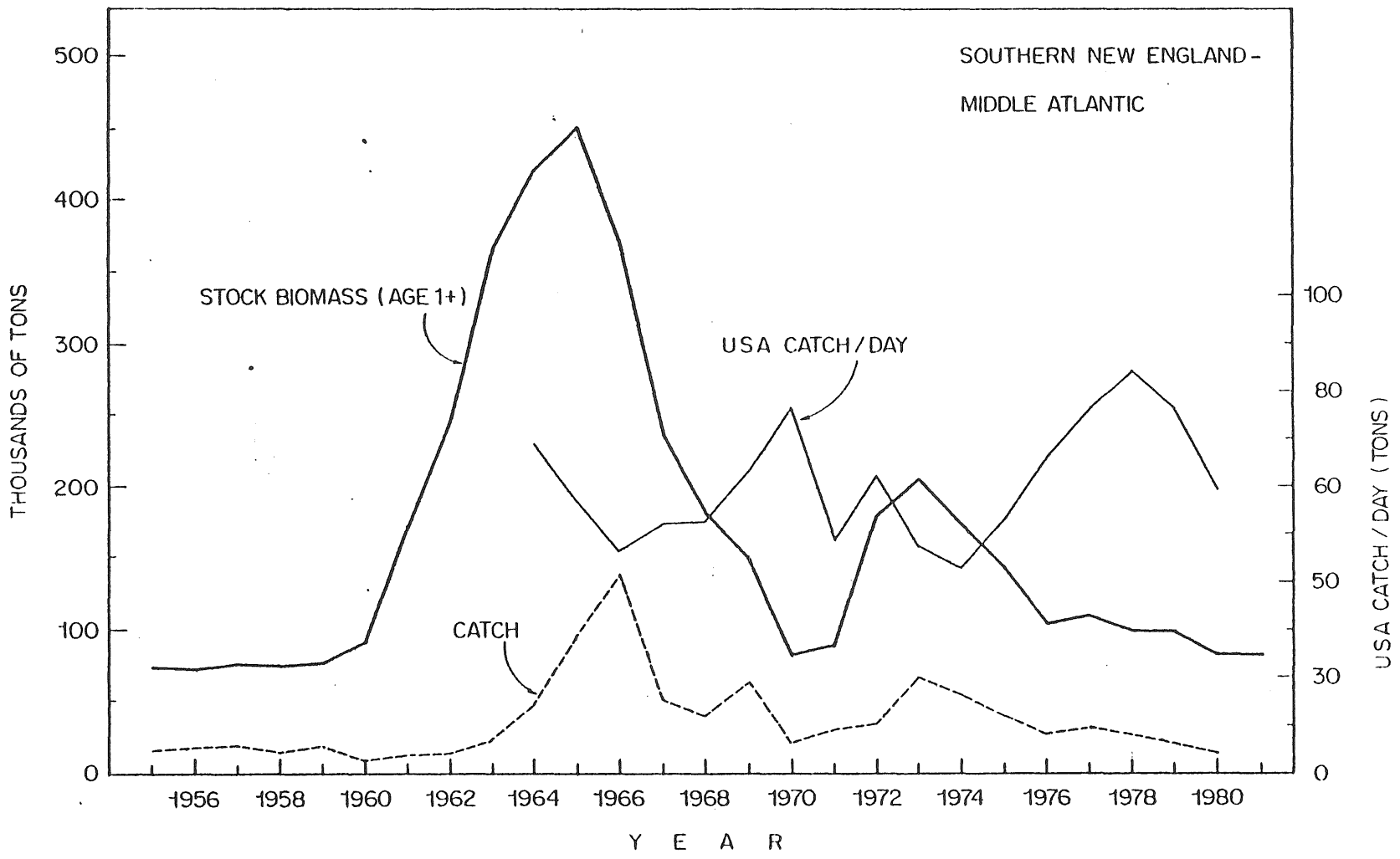

Figure 13. International catch, stock biomass (age 1+) from VPA and USA commercial catch-per-day from the Southern New England-Middle Atlantic silver hake stock.

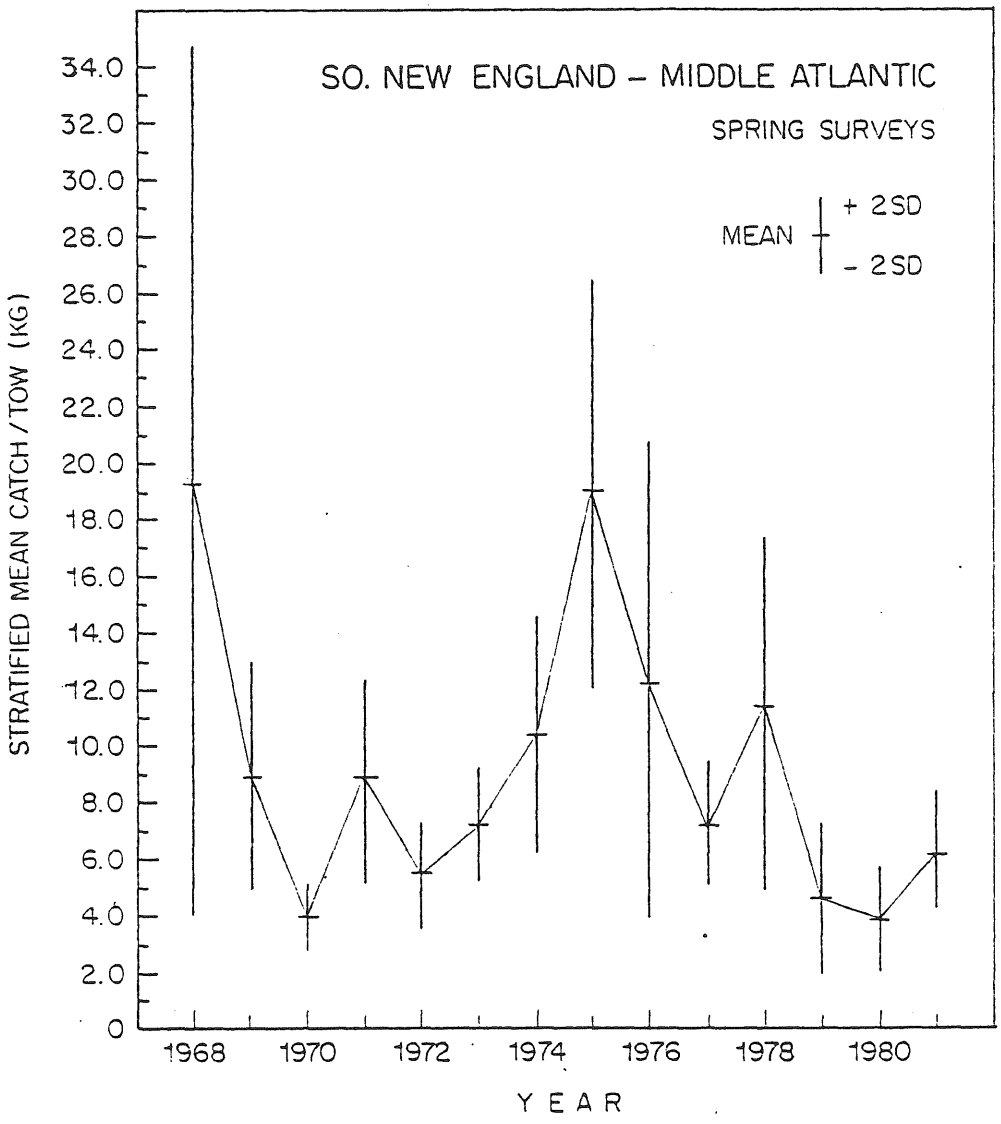

Figure 14. Stratified mean catch per tow (kg) of silver hake from the Southern New England-Middle Atlantic stock from USA spring bottom trawl surveys (1968-1981).

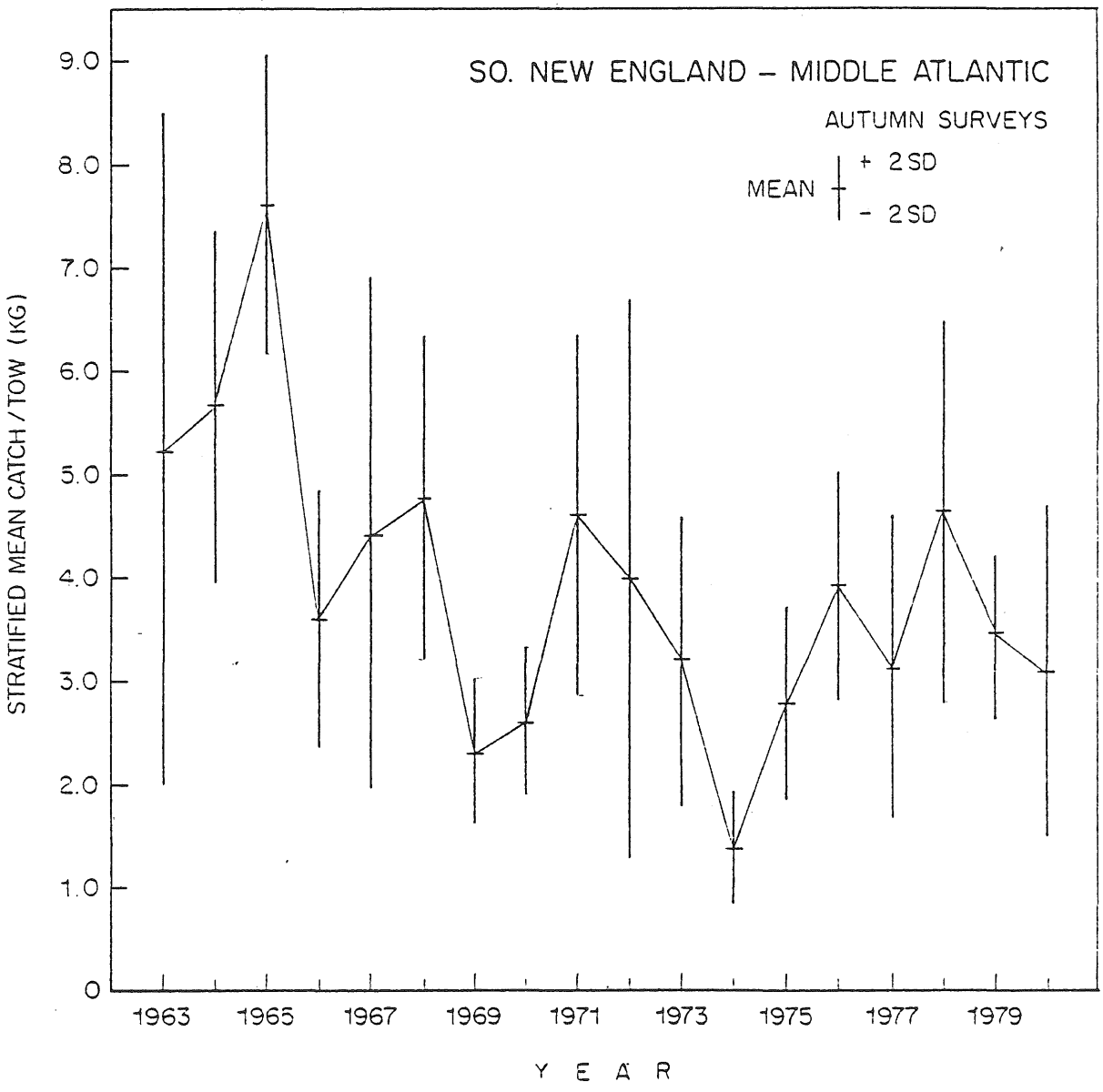

Figure 15. Stratified mean catch per tow (kg) of silver hake from the Southern New England-Middle Atlantic stock from USA autumn bottom trawl surveys (1963-1980).

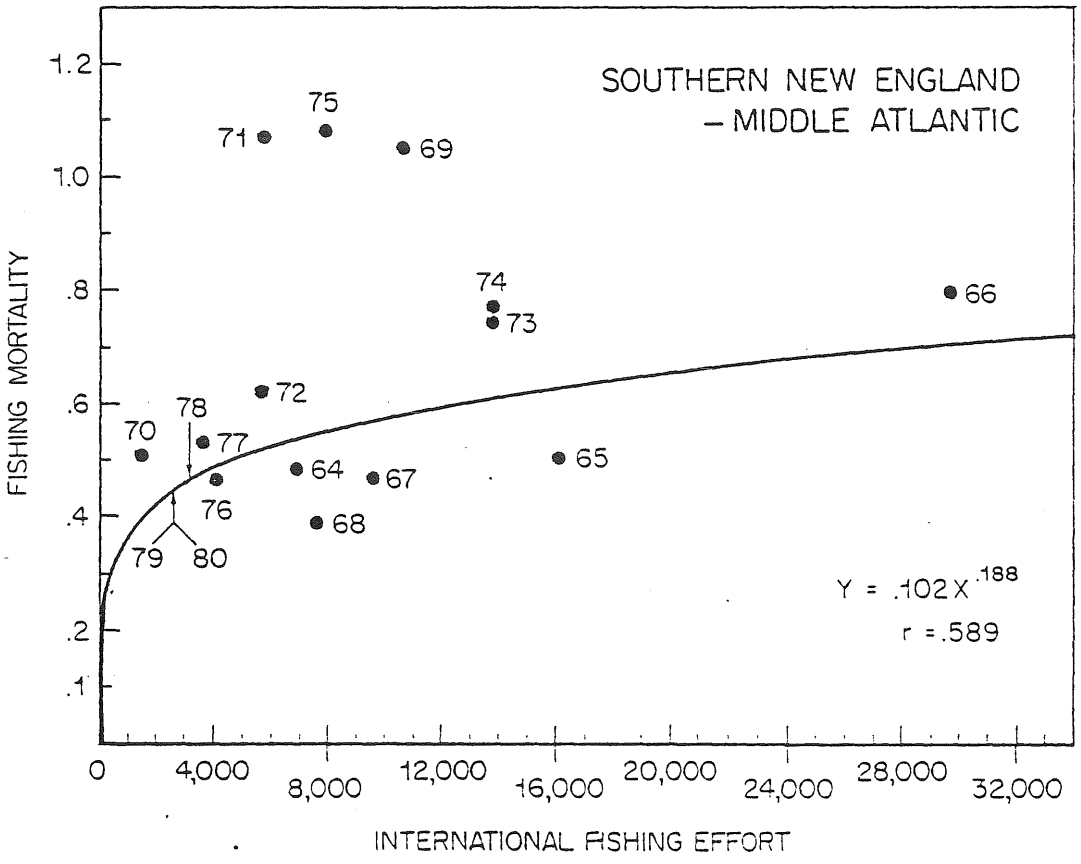

Figure 16. Relationship between fishing mortality from VPA and fishing effort expressed as USA days fished for the Southern New England-Middle Atlantic silver hake stock.

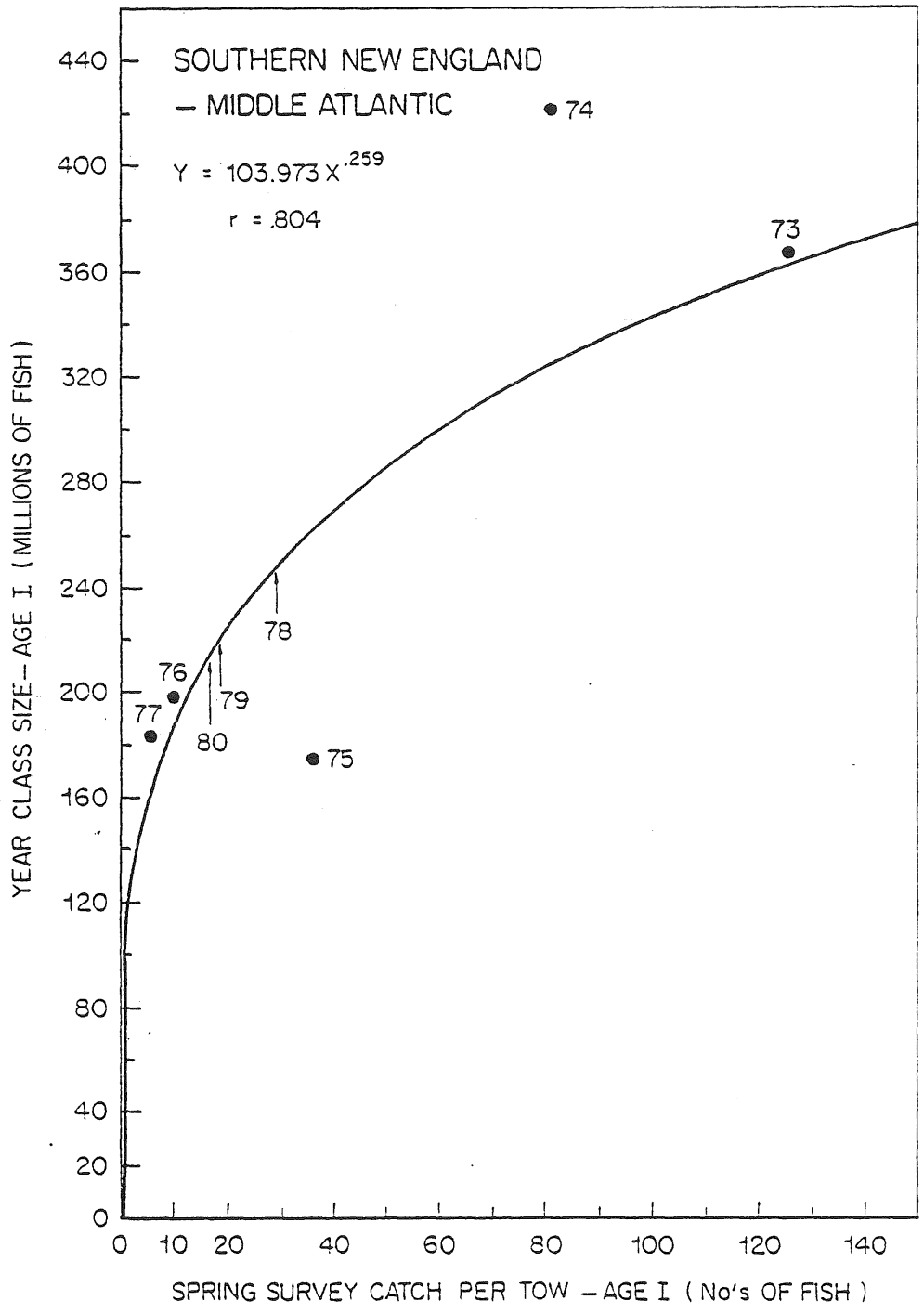

Figure 17. Relationship between year class size at age 1 from VPA and USA spring bottom trawl survey catch per tow at age 1 for the Southern New England-Middle Atlantic silver hake stock.

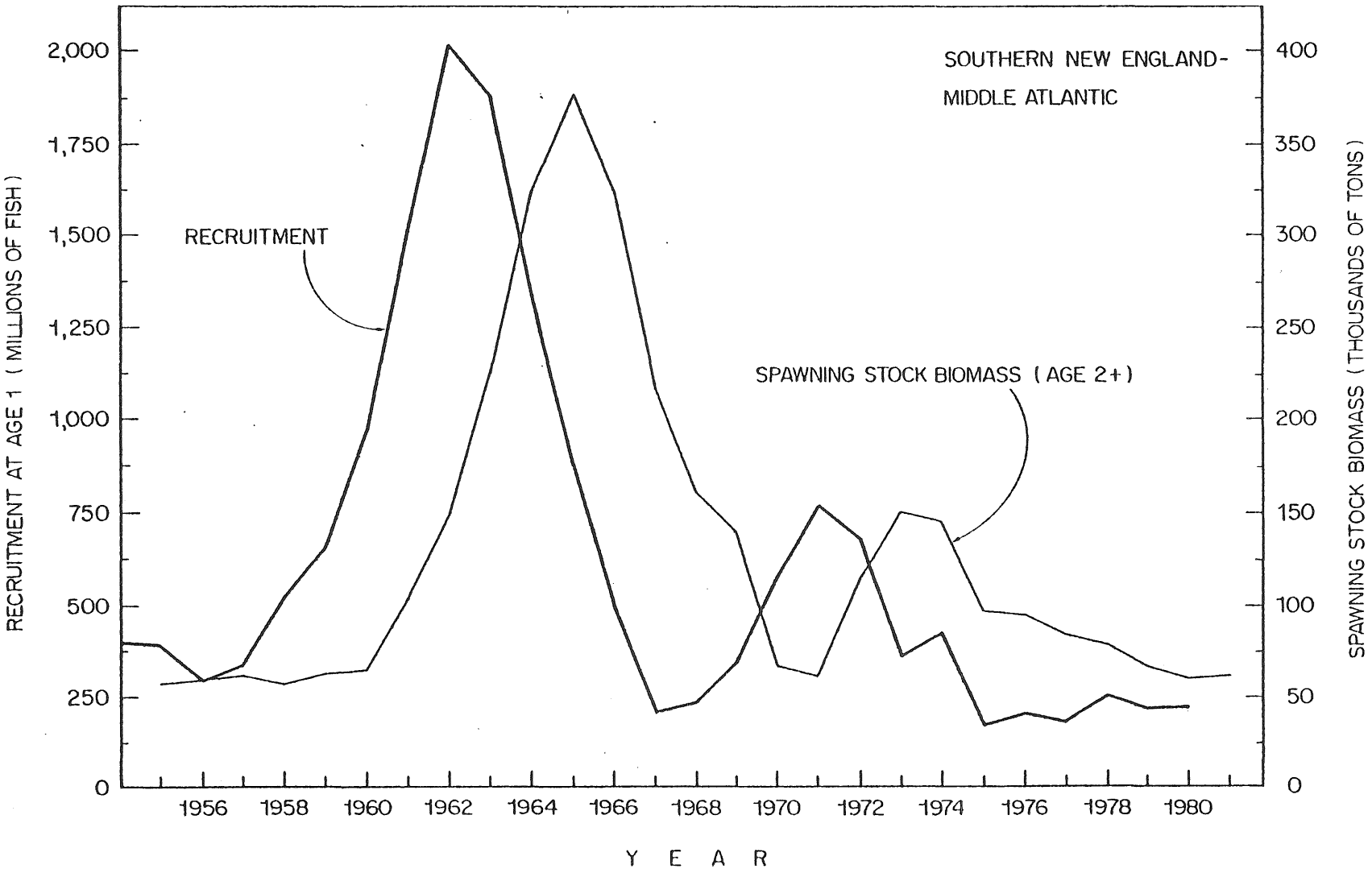

Figure 18. Southern New England-Middle Atlantic silver hake spawning stock biomass (age 2+) during 1955-1981 and abundance at age 1 of the 1954-1980 year classes.