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# Assessment of the ICNAF Subdivision 5Ze and Subdivision 5Zw - Statistical Area 6 silver hake stocks

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## Abstract

Commercial catches of silver hake in Subdivision 5Ze and Subdivision 5Zw-Statistical Area 6 during 1955-1974 were reviewed. Total international landings from the combined areas peaked at 328,400 MT in 1965, declined sharply in subsequent years, and recovered in the early 1970's to less than half of the earlier peak. US commercial catch per effort has decreased in both areas. Estimates were made of the amount of age 0 and 1 silver hake discarded by the US fishery in Subdivision 5Ze in 1964-1974. Age compositions of landings from both areas were presented indicating a general predominance of ages 3 and 4 but a shift to age 2 in 1973-1974. US survey catches declined in 1974 in both areas, but a much greater decrease has occurred in Subdivision 5Zw-Statistical Area 6. Mesh selection and yield per recruit studies suggest that $F_{max}$ = 0.45 for both stocks. Virtual population analysis was performed to estimate fishing mortality and stock size. Recruitment to both stocks was determined to be above average in the next several years. Stock size (age 0 and older) in Subdivision 5Ze improved from 208,300 MT in 1972 to 308,000 MT in 1975. A 1975 catch of 75,000 MT would require F = 0.858 and leave a 1976 stock size of 306,600 MT. A 1976 catch of 50,000 MT could be taken at $F_{max}$ = 0.45 and result in an increased 1977 stock size. The stock (age 1 and older) in Subdivision 5Zw-Statistical Area 6 decreased from 222,600 MT in 1973 to 123,700 MT in 1975. A 1975 catch of 70,000 MT would require F = 0.845 as compared to F = 0.684 in 1974 and leave a 1976 stock of 183,900 MT. A 1976 catch of 43,000 MT at $F_{max}$ = 0.45 would maintain the 1977 stock at the 1976 level.

## Introduction

The silver hake (*Merluccius bilinearis*) stocks in ICNAF Division 5Z and Statistical Area 6 have supported a US fishery dating back to the early 1930's (Fritz, 1962) which has experienced steadily declining landings since the early 1960's and a USSR fishery which began in 1962 and produced a peak catch of 299,200 MT in 1965. A sharp decline in catches occurred after the mid-1960's with some improvement in the early 1970's to less than half of the earlier peak. Seven other nations have taken incidental amounts of silver hake in recent years.

Total allowable catches (TAC's) of 80,000 MT each were set by ICNAF for the Subdivision 5Ze stock and the Subdivision 5Zw-Statistical Area 6 stock for 1973, 1974, and 1975 based on preliminary estimates of maximum sustainable yield. Silver hake catches rank in tonnage only behind mackerel and sea herring in SA 5 and 6, and silver hake constitute a significant portion of the total biomass in this area. This paper presents assessments of the two stocks used as a basis for recommendations for the 1976 TAC's.

## Commercial fishery

The USSR silver hake fishery in SA 5 and 6 is conducted throughout the year using otter trawlers. The US fishery, which employs small side otter trawlers, is a more seasonal fishery. The US fishery in Subdivision 5Ze is conducted in the Cultivator Shoals area of Georges Bank from June to September and along the eastern side of Cape Cod primarily from June to October. The fishing in both of these areas is on concentrations of silver hake that have moved to shoal areas following overwintering in deeper waters. US catches in Subdivision 5Zw are generally taken throughout the year although in most years the peak catches have occurred in May-July. The fishery in Statistical Area 6 (primarily Division 6A) is conducted mainly from November through May.

### Landings

Non-US landings prior to 1968 were not reported separately for Subdivision 5Ze and 5Zw. In order to obtain statistics prior to 1968 for use in assessing the stocks, non-US landings were partitioned into Subdivision 5Ze and 5Zw by assuming a direct relationship between the number of fishing vessels observed each month by US aerial surveillance and landings in each area.

Total international landings from Subdivision 5Ze (Table 1, Figure 1), after averaging only 19,000 MT during 1955-1961, increased sharply to a peak of 238,874 MT in 1965 as the result of an intensive USSR fishery, and then dropped abruptly to 18,353 MT in 1969. Landings increased to 77,512 MT in 1972 and then declined to 62,207 MT in 1973. The provisional catch for 1974 was 63,181 MT.

US landings from Subdivision 5Ze (1955-1974) peaked at 25,586 MT in 1957 and averaged 18,200 MT during 1955-1963. They dropped from 14,007 MT in 1963 to 5,522 MT in 1964, rose to 12,713 MT in 1966, and then decreased to a low in 1972 of 879 MT. US landings in 1973 of 5,698 MT were the highest since 1968, but the 1974 landings declined to 2,278 MT.

The USSR fishery for silver hake in Subdivision 5Ze began in 1962 when an estimated 41,900 MT were caught. The catch increased to 230,666 MT in 1965 but fell sharply to 16,144 MT in 1969. USSR catches increased to 73,882 MT in 1972 and were 55,042 and 60,745 MT in 1973 and 1974, respectively.

Other nations including Bulgaria, Cuba, FRG, GDR, Japan, Poland, and Romania have reported catches since 1967 ranging from 15 MT in that year to 2,751 MT in 1972.

Total international landings from Subdivision 5Zw-Statistical Area 6 (Table 2, Figure 2) averaged 12,400 MT from 1955 to 1962. Following the start of the USSR fishery in 1963, total landings increased to 136,051 MT in 1966 and then dropped to 39,143 MT in 1968. After jumping to 65,981 MT in 1969, landings dropped to 18,276 MT in 1970, and then improved steadily to 65,115 MT in 1973. The provisional 1974 catch was 62,391 MT.

US landings from Subdivision 5Zw-Statistical Area 6 averaged 13,700 MT during 1955-1959, dropped sharply to 8,151 MT in 1960, and then improved steadily to 25,008 MT in 1964. The abrupt drop from 20,998 MT in 1965 to 9,840 MT in 1966 resulted largely from a decline in demand for silver hake caused by the discontinuation of a major processing facility for fish meal and oil. US landings steadily decreased to a low of 4,989 MT in 1971, but have improved continually to 7,180 MT in 1974.

USSR landings increased from an estimated 4,191 MT in 1963 to 126,211 MT in 1966, dropped to 11,493 MT in 1970, and then increased steadily to 57,928 MT in 1973. The 1974 catch declined slightly to 52,175 MT.

Landings by other nations have ranged from 26 MT in 1967 to 3,036 MT in 1974.

### Catch per effort

The index of abundance based on US landings per day from Subdivision 5Ze has declined substantially since the late 1950's (Table 1, Figure 1) from a high of 33.7 MT in 1959 to only 0.9 MT in 1972. The index has been based, since the early 1960's, on a small portion of the total catch from the stock, but nevertheless indicates that stock abundance has been markedly reduced since the advent of the USSR fishery. Following the low point in 1972, the index rose to 16.2 MT in 1973 but dropped 50% to 8.2 MT in 1974.

The index of abundance based on US landings per day from Subdivision 5Zw-Statistical Area 6 does not encompass the period of low catch prior to 1964 (Table 2, Figure 2) but has rather consistently declined whenever total international catches increased. The index is limited in that it is based on only a small portion of the total catch from the stock. The index declined from 6.9 MT in 1964 to 4.6 MT in 1966 as catches peaked in 1966 and then increased steadily to 7.7 MT in 1970. After dropping to 4.8 MT in 1971 and recovering to 6.2 MT in 1972, catch per effort dropped in 1973 and again in 1974 to 4.3 MT, the lowest value in the data series (1964-1974).

Non-reported catch

It has been the practice of US fishermen to discard at sea small silver hake that are not marketable. Discarding is particularly evident in the Subdivision 5Ze fishery where the landed catch is intended primarily for human consumption. A similar situation exists in Division 5Y where silver hake discard has been estimated (Anderson, 1975). Many of the small silver hake caught by the US fishery in Subdivision 5Zw and in part of Statistical Area 6 are landed and processed as fish meal and oil and are accounted for in the length frequency samples. There undoubtedly is some discard of small fish in Subdivision 5Zw-Statistical Area 6 where the landed catch is processed for human consumption. However, estimates of discard are not available at the present time.

The weight of silver hake discarded during a fishing trip was determined by interviewing vessel captains and was expressed as a percentage of the landed weight of silver hake. The percentages were averaged for each month. Based on comments obtained from vessel captains during interviews, it was assumed that the discarded fish were only ages 0 and 1. Since data from interviews were available only for 1972-1974, the discard for 1964-1971 was estimated by assuming that the June-November mean percentage of discard relative to landings in 1972 was of the same proportion to the abundance of age 0 and 1 fish in 1964-1971 as it was in 1972. Abundance of age 0 and 1 fish in a given year was determined from US autumn groundfish surveys as the mean of the age 0 survey index in that year and the previous year.

The estimated discard ranged from 47 MT in 1965 to 3,418 MT in 1971, with the 1974 amount being 328 MT (Table 3). These estimates of discarded silver hake are minimal because they do not include the amount of small fish possibly discarded by US fisheries directed towards other species or non-US fisheries. Although USSR length frequencies do not indicate substantial numbers of age 0 and 1 silver hake in their catches, the use of 40 mm mesh codends by USSR trawlers (smaller than those used by US fishermen who do catch large numbers of age 0 and 1 fish) suggests that small fish are, in fact, caught and are probably reduced to meal and oil and may not be included in the reported length frequencies.

Age composition of the Subdivision 5Ze discard

Length frequency samples were not taken from silver hake discarded at sea. In order to assign discard to age groups in each year, age groups 0 and 1 were each expressed as a percentage of the sum of the abundance indices of the two groups as measured at age 0 (Table 7) in successive surveys. Numbers at age (Table 3) were determined by utilizing the estimated percentages for each age and the mean weights which were calculated from growth and length-weight data as 0.012 and 0.053 kg for ages 0 and 1, respectively.

Age composition of the catch

Length frequency samples from US landings and USSR catches were available throughout the period 1955-1974. US age-length data from 1962-1963 and 1965-1967 and USSR age-length data from 1963-1967 were combined to form age-length keys which were applied to the 1955-1967 length frequencies to estimate numbers landed at age for 1955-1967. USSR age-length keys for 1968-1972 were utilized to estimate numbers landed at age for those years. Age-length keys prepared from 1973 US spring and autumn groundfish survey samples were applied to the commercial length frequencies and landings for 1973-1974. These age data (1973) were obtained using a new technique of ageing thin sections cut from otoliths (Anderson and Nichy, 1975) which appeared to produce substantially different results than the previous method of examining whole otoliths. With the new method, fish of a given length were aged younger than before. The net effect was to indicate a catch of fish younger than in previous years.

Numbers at age in the 1964-1974 catch are given in Table 8 for Subdivision 5Ze (landings plus US discard estimates) and in Table 9 for Subdivision 5Zw-Statistical Area 6 (landings). Ages ranged from 0 to 12+. Age 3 and 4 fish were generally predominant with the bulk of the catch age 5 and younger. In 1973 and 1974, age 2 was predominant in both areas. In Subdivision 5Ze, age 0 was predominant in 1968 and 1971 due to the large amount of estimated discard in those years.

Mean weight at age

Mean weights at age of silver hake caught in 1970-1974 are given in Tables 4 and 5. These weights were calculated from length-weight equations derived from US commercial sample data which were employed in the computation of numbers landed at length and age.

## Research vessel survey catches

US *Albatross IV* spring and autumn groundfish survey stratified mean catch (pounds) per tow indices are presented in Table 6 and Figures 3 and 4. The autumn catch in Subdivision 5Ze dropped from 7.94 lb/tow in 1963 to 2.77 lb/tow in 1964 and averaged 2.93 lb/tow during 1964-1967. In 1968, the catch rose to 5.49 lb/tow but then declined steadily to 2.66 lb/tow in 1971. Following an increase to 3.85 lb/tow in 1973, the autumn catch dropped 38% to 2.40 lb/tow in 1974, the lowest point since 1967. The spring survey catch per tow index in Subdivision 5Ze has closely paralleled the fall index since 1970. This index declined from 1.80 lb/tow in 1973 to 0.74 lb/tow in 1974.

The autumn survey index in Subdivision 5Zw-Statistical Area 6 rose from 11.50 lb/tow in 1963 to a peak of 16.79 lb/tow in 1965 but then declined sharply to 7.92 in 1966. This was followed by an increase to 10.48 lb/tow in 1968 and a second decline even lower to 5.08 in 1969. The catch again recovered, rising to 10.14 lb/tow in 1971. However, since 1971 the autumn index has dropped continuously with the sharpest decline from 7.05 lb/tow in 1973 to 2.69 lb/tow in 1974, the lowest point during the period of the survey. The spring index followed the same pattern as the autumn index. The changes in abundance as measured by the autumn survey exhibited a very close inverse relationship to commercial catches. The declines in abundance after 1965, 1968, and 1971 all followed marked increases in commercial catches, and the increases in abundance after 1966 and 1969 occurred as catches decreased.

## Yield per recruit

The USSR fishery, which currently catches a high percentage of the total in both areas, employs nets with a codend mesh of 40 mm. Applying the 50% selection factor of 4.2 for silver hake, as determined by Jensen and Hennemuth (1966), results in a 50% selection length ($l_c$) of 16.8 cm. Using von Bertalanffy growth parameters calculated from age-length data presented by Nichy (1969) of $L_\infty$ = 60 cm, K = 0.1916, and $t_o$ = -0.51 gives a 50% selection age ($t_c$) of 1.2 years.

The Beverton and Holt (1957) yield per recruit model assuming M = 0.4 (Figure 5) indicates that $F_{max}$ = 0.45 when $t_c$ = 1.2 years.

## Virtual population analysis

Virtual population analysis was performed utilizing the catch in numbers at age during 1964-1974 from Subdivision 5Ze (1958-1973 year-classes) and from Subdivision 5Zw-Statistical Area 6 (1958-1972 year-classes). Instantaneous natural mortality (M) was assumed as 0.4 for all ages. The starting value for instantaneous fishing mortality (F) at the oldest age of each year-class was estimated using the following procedure. A catch curve (*i.e.* $\log_e$ of numbers caught versus age) was plotted for each year-class, and a least squares linear regression was calculated through the fully recruited ages to determine instantaneous total mortality (Z) (slope of regression line). The line was extrapolated beyond the oldest age to determine hypothetical catches for several additional years. The VPA was performed using the observed plus the hypothetical catches and assuming a starting F of Z - 0.4. The F calculated by the VPA for the last year of observed catches was taken as the starting F in a second VPA. This procedure of estimating the starting F was used because it provided a reasonable approximation of F whereas other methods of determining F from estimates of Z (*e.g.* $\log_e$ of ratio of year-class catch per effort in numbers, using US commercial C/E, in successive years) did not provide reasonable estimates.

### Subdivision 5Ze

The procedure described above for estimating starting F's was applied to the 1958-1969 year-classes for Subdivision 5Ze. The 1970-1971 year-classes each contained only two ages which appeared to be fully recruited. Since it was felt that total mortality (Z) would probably increase at succeeding ages, as was the case with other year-classes, the starting F at age 4 for the 1970 year-class was chosen as the approximate mean of the 1969 year-class F's at ages 3-5 (1.10) (Table 8). The starting F at age 3 for the 1971 year-class was taken as 0.88 assuming that total mortality determined between ages 3 and 4 would be the same as that shown by catch curve analysis for the 1970 year-class.

The starting F at age 2 for the 1972 year-class was selected as 0.40 which was 45% of the F at age 3 assumed for the 1971 year-class. This percentage was the approximate mean of the ratios of F at age 2 to age 3 for 1970-1973. The starting F at age 1 for the 1973 year-class was assumed to be 0.03. This value was the approximate mean of F's for other year-classes at age 1 having similar numbers caught.

The calculated F values and stock sizes are given in Table 8. The F values by age indicate that full recruitment generally occurred at age 3. Fishing mortality for ages 3 and older (weighted by stock size) increased from 0.18 in 1970 to 0.68 in 1971 to 2.01 in 1972, and then decreased to 0.93 in 1973 and 0.95 in 1974. The calculated stock size (age 0 and older) increased from 234,000 MT in 1970 to 245,000 MT in 1971, decreased to 208,300 MT in 1972, and then increased to 258,300 MT in 1973.

Subdivision 5Zw-Statistical Area 6

Starting F's for the 1958-1969 year-classes were estimated by the catch curve extrapolation procedure described above. Catch curve analysis indicated F = 0.8 for the 1970 year-class between ages 3 and 4 based on only two years of catches from fully recruited ages. This was assumed to be an underestimate of F because the 1968 and 1969 year-classes at age 4 had much larger F's. Therefore, a value of 1.0 was taken as the starting F at age 4 for the 1970 year-class which was similar to the mean F at ages 3-5 for the 1969 year-class (Table 9). Catch curve analysis of the 1971 year-class (ages 2 and 3) indicated F = 0.4 for those ages. This was also assumed to be too low for age 3 in comparison to the F's at age 3 calculated for the 1969 and 1970 year-classes. An F of 0.6 was therefore assumed at age 3 for the 1971 year-class. The ratio of this value to the assumed F at age 4 in 1974 (1970 year-class) was similar to the ratio between F at age 3 and age 4 in 1973. The starting F for the 1972 year-class at age 2 was assumed equal to the F at age 2 for the 1971 year-class (0.525) since similar numbers of fish were caught from those two year-classes at that age.

Calculated F's and stock sizes are given in Table 9. Full recruitment to the fishery, as indicated by the F values, seemed to occur at age 3. Fishing mortality at age 3 and older (weighted by stock size) increased from 0.32 in 1970 to 0.54 in 1971 to 1.39 in 1972 and then declined to 1.01 in 1973 and to 0.68 in 1974. Stock size increased from 104,900 MT (age 1 and older) in 1970 to 222,600 MT in 1973.

Year-class strength

The stratified mean catch (numbers) per tow of age 0 silver hake during autumn surveys was determined from length frequency analysis (Table 7). The catch of age 0 fish may offer clues relative to year-class strength and be useful in predicting the size of recruitment to the commercial fishery. However, the reliability of the survey index of age 0 fish as a means of estimating recruitment can only be determined by a comparison of survey indices and year-class sizes as calculated by virtual population analysis.

Subdivision 5Ze

The survey catches of age 0 silver hake in Subdivision 5Ze were low during 1963-1967, averaging 1.4 per tow, suggesting weak year-classes during that period. Catches during 1968-1973, except 1970, were higher and averaged 15.8 fish per tow. The 1971 year-class (35.0/tow) appeared to be the strongest of all during 1963-1973. The 1974 catch per tow was 172.5 fish, much greater than in any previous year, suggesting that the 1974 year-class may be quite strong.

Virtual population analysis indicated that the 1971 year-class at age 0 was 1.88 billion fish, the strongest during 1964-1973 (average of 1.26 billion). The 1969 year-class (0.55 billion) and the 1970 year-class (0.70 billion) were considerably below average, while the 1973 (1.54 billion) and 1972 (1.35 billion) year-classes were both above average.

The relationship between the autumn groundfish survey mean catch (numbers) per tow of age 0 fish (Table 7) and the VPA calculated year-class size (numbers) at age 0 (Table 8) was examined to determine if the survey index could be used to predict the strength of year-classes recruiting to the fishery. Prior to 1968, survey indices showed no relationship to year-class size. The 1968-1973 values, however, appeared to offer some relationship, but a least squares linear regression indicated a nonsignificant coefficient of correlation (r = 0.746). It was concluded, therefore, that the survey index did not offer a significantly reliable prediction of year-class strength. Since the survey did suggest a strong 1974 year-class, the size of that year-class at age 0 was set equal to the mean of the strong 1971-1973 year-classes or 1.59 billion fish (Table 8). The F at age 0 for the 1974 year-class needed to generate the estimated catch of 22.2 million fish from 1.59 billion fish would be 0.017. The size of the 1975, 1976, and 1977 year-classes at age 0 was assumed equal to the mean of the 1969-1973 year-classes which was 1.21 billion fish.

Subdivision 5Zw-Statistical Area 6

Catch per tow of age 0 silver hake has been much higher in Subdivision 5Zw-Statistical Area 6 than in Subdivision 5Ze, with a peak of 161.2 in 1966. The survey data suggest that the 1966, 1968, 1971, and 1974 year-classes were above average. The 1973 year-class appeared to be poor, but catches of the 1974 year-class were the highest since 1966.

Virtual population analysis indicated that year-class strength at age 1 ranged from 1.84 billion fish (1963 year-class) to 0.31 billion (1967 year-class) and averaged 0.77 billion (1963-1972 year-classes). The 1966-1970 year-classes were all below average. The 1971 and 1972 year-classes contained 0.78 and 0.80 billion fish, respectively.

The autumn groundfish survey mean catch (numbers) per tow index of age 0 silver hake (Table 7) was compared with year-class size (numbers) at age 1 as calculated by virtual population analysis (Table 9) to determine if a significant linear relationship existed. No meaningful relationship was apparent for year-classes before 1969. A least squares linear regression was calculated for the 1969-1972 year-classes resulting in a highly significant coefficient of correlation ($r = 0.995$): $Y = 122302 + 8974X$, where Y = year-class size and X = survey index. Applying this relationship to the survey indices of the 1973 and 1974 year-classes resulted in estimates of those year-classes at age 1 of 0.30 and 1.00 billion fish, respectively (Table 9). The F at age 1 for the 1973 year-class in 1974 required to produce the observed landings of 46.9 million fish from a year-class size of 0.30 billion fish would be 0.208. The 1975 and 1976 year-classes at age 1 were assumed to be equal to the mean of the 1968-1972 year-classes which was 0.54 billion fish.

## Stock and yield predictions

Subdivision 5Ze

With the assumptions concerning the strength of recruiting year-classes given above, stock size of age 0 and older fish was calculated to be 279,400 MT in 1974 and 308,000 MT in 1975.

The partial recruitment pattern for 1975 and 1976 was assumed to be the same as that indicated by the F values which were determined for the VPA for 1974. Assuming 100% recruitment at age 3 (and older), the partial recruitment coefficients were 45% at age 2, 3% at age 1, and 2% at age 0. Mean weight at age for 1975 and 1976 was assumed to be the same as for 1974 (Table 4).

In spite of a TAC of 80,000 MT set for 1975, it was assumed that the catch would only be 75,000 MT, since the US would very likely not take its full allocation of 11,100 MT. An F of 0.858 would be needed to produce the expected 1975 catch (Table 10). The stock size (age 0 and older) in 1976 would then be 306,600 MT. If F was held at 0.858 in 1976, the catch would be 84,000 MT but stock size in 1977 would decline to 285,300 MT. In order to maintain the same stock size in 1977 as in 1976 (306,600 MT), the 1976 catch would be 63,500 MT with F = 0.596. If fishing mortality was reduced to $F_{max} = 0.45$ in 1976, the catch would be 50,300 MT and the 1977 stock size would be 320,300 MT, about a 5% increase over 1975-1976.

Subdivision 5Zw-Statistical Area 6

With the assumptions concerning year-class strength of recruits given above, calculated stock size of age 1 and older fish was determined to be 180,500 MT in 1974 and 123,700 MT in 1975.

The pattern of partial recruitment in 1974, as indicated by the F values used in the VPA, was assumed for 1975 and 1976. This pattern was 100% recruitment at ages 3 and older, 88% at age 2, and 35% at age 1. Mean weight at age for 1975 and 1976 was assumed to be the same as for 1974 (Table 5).

The 1975 catch was estimated to be 70,000 MT, assuming that the US takes only 8,900 MT of its 18,900 MT allocation and all other nations take their entire share of the TAC. This level of catch would require an F of 0.845 as compared to 0.684 in 1974 and leave a 1976 stock size of 183,900 MT (Table 10). If the F in 1976 was the same as in 1975, then a 1976 catch of 70,900 MT could be expected leaving a 1977 stock size of 153,500 MT. If the 1977 stock size is to be maintained at the 1976 level (183,900 MT) then a 1976 catch of 43,000 MT could be allowed which would require an F of 0.446. A 1976 catch of 43,400 MT could be taken at $F_{max} = 0.45$ with the 1977 stock size remaining nearly the same (183,600 MT) as in 1976 (183,900 MT).

## Discussion

The silver hake stocks in Subdivision 5Ze and in Subdivision 5Zw-Statistical Area 6 have undergone similar changes since the early 1960's. Both were apparently lightly exploited by US fishermen prior to the arrival of the USSR fleets. The intensive USSR fishery harvested large amounts of silver hake within a few years time with the result that stock biomass declined sharply. This decline was documented by both US commercial C/E and survey abundance indices. Subsequent catches declined because of low biomass and the shift of USSR fishing effort onto sea herring. As the stocks began to rebuild in response to improved recruitment, catches in the early 1970's increased, but to levels less than half of that in the mid-1960's. ICNAF total allowable catch regulations, which have been in effect since 1973, have limited the catches since then.

Virtual population analysis indicated that the Subdivision 5Ze stock biomass (age 0 and older) increased from 208,300 MT in 1972 to 308,000 MT in 1975 as a result of recent strong year-classes (1971-1974). Mesh selection and yield per recruit studies indicated that fishing mortality in 1973-1974 was about twice that of $F_{max} = 0.45$. From the standpoint of rational conservation management objectives, it would appear wise to reduce fishing mortality to the level of $F_{max}$. Such an approach would indicate a 1976 TAC of 50,000 MT which would produce a 5% increase in stock size in 1977 and achieve a 16% improvement in catch in 1977 assuming $F_{max}$ is maintained and recruitment materializes as estimated.

The Subdivision 5Zw-Statistical Area 6 stock underwent a sharp decline from 222,600 MT in 1973 to 123,700 MT in 1975. Fishing mortality on this stock also exceeded $F_{max} = 0.45$ in recent years. The prospect of a strong 1974 year-class would increase the stock size to 183,900 MT in 1976. In order to prevent the continued decline of this stock, a decrease in fishing mortality to the level of $F_{max}$, which would reduce the 1976 catch to 43,000 MT, would prevent the stock from being reduced below the 1976 level.

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Table 1. Silver hake landings statistics from the Subdivision 5Ze stock.

| Year | Landings (MT) | | | | | | | | | | | US landings/day (MT) | International effort as US days fished |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bulgaria | Cuba | FRG | GDR | Japan | Poland | Romania | USSR | US | Other | Total | | |
| 1955 | - | - | - | - | - | - | - | - | 19,595 | - | 19,595 | | |
| 1956 | - | - | - | - | - | - | - | - | 20,729 | - | 20,729 | 32.23 | 643 |
| 1957 | - | - | - | - | - | - | - | - | 25,856 | - | 25,856 | 32.16 | 804 |
| 1958 | - | - | - | - | - | - | - | - | 14,498 | - | 14,498 | 25.97 | 558 |
| 1959 | - | - | - | - | - | - | - | - | 15,899 | - | 15,899 | 33.67 | 472 |
| 1960 | - | - | - | - | - | - | - | - | 22,070 | - | 22,070 | 21.05 | 1,048 |
| 1961 | - | - | - | - | - | - | - | - | 14,468 | - | 14,468 | 25.58 | 566 |
| 1962 | - | - | - | - | - | - | - | 41,900 | 16,339 | - | 58,239 | 23.61 | 2,467 |
| 1963 | - | - | - | - | - | - | - | 103,697 | 14,007 | - | 117,704 | 20.34 | 5,787 |
| 1964 | - | - | - | - | - | - | - | 164,763 | 5,522 | - | 170,285 | 19.02 | 8,953 |
| 1965 | - | - | - | - | - | - | - | 230,666 | 8,208 | - | 238,874 | 11.59 | 20,610 |
| 1966 | - | - | - | - | - | - | - | 88,086 | 12,713 | - | 100,799 | 14.56 | 6,923 |
| 1967 | - | - | - | 3 | 12 | - | - | 47,348 | 12,300 | - | 59,663 | 16.18 | 3,687 |
| 1968 | - | - | - | - | 35 | 887 | - | 28,013 | 6,451 | 14 | 35,406 | 11.64 | 3,042 |
| 1969 | - | - | - | 42 | 95 | 292 | 7 | 16,144 | 1,654 | 119 | 18,353 | 5.20 | 3,529 |
| 1970 | - | - | - | - | 31 | 15 | 73 | 20,548 | 4,238 | - | 24,905 | 9.92 | 2,511 |
| 1971 | 1,393 | 265 | - | - | 82 | 124 | - | 66,809 | 3,069 | - | 71,742 | 10.67 | 6,724 |
| 1972 | 1,914 | 354 | 226 | 111 | 104 | - | 42 | 73,882 | 879 | - | 77,512 | 0.89 | 87,092 |
| 1973 | 879 | - | - | 145 | 188 | 251 | 4 | 55,042 | 5,698 | - | 62,207 | 16.22 | 3,835 |
| 1974 | - | - | 46 | 36 | - | 70 | 5 | 60,745 | 2,278 | 1 | 63,181 | 8.17 | 7,733 |

Table 2. Silver hake landings statistics from the Subdivision 5Zw and SA 6 stock.

| Year | Landings (MT) | | | | | | | | | | US landings/day (MT) | International effort as US days fished |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bulgaria | Cuba | FRG | GDR | Japan | Poland | Romania | USSR | US | Total | | |
| 1955 | - | - | - | - | - | - | - | - | 12,412 | 12,412 | - | - |
| 1956 | - | - | - | - | - | - | - | - | 13,390 | 13,390 | - | - |
| 1957 | - | - | - | - | - | - | - | - | 15,390 | 15,390 | - | - |
| 1958 | - | - | - | - | - | - | - | - | 12,039 | 12,039 | - | - |
| 1959 | - | - | - | - | - | - | - | - | 15,398 | 15,398 | - | - |
| 1960 | - | - | - | - | - | - | - | - | 8,151 | 8,151 | - | - |
| 1961 | - | - | - | - | - | - | - | - | 10,562 | 10,562 | - | - |
| 1962 | - | - | - | - | - | - | - | - | 11,932 | 11,932 | - | - |
| 1963 | - | - | - | - | - | - | - | 4,191 | 17,666 | 21,857 | - | - |
| 1964 | - | - | - | - | - | - | - | 19,434 | 25,008 | 44,442 | 6.90 | 6,441 |
| 1965 | - | - | - | - | - | - | - | 68,493 | 20,998 | 89,491 | 5.68 | 15,755 |
| 1966 | - | - | - | - | - | - | - | 126,211 | 9,840 | 136,051 | 4.60 | 29,576 |
| 1967 | - | - | - | - | 26 | - | - | 41,242 | 8,493 | 49,761 | 5.23 | 9,515 |
| 1968 | - | - | - | - | 47 | 121 | - | 30,812 | 8,163 | 39,143 | 5.25 | 7,456 |
| 1969 | 746 | - | - | 2 | 178 | - | - | 57,820 | 7,235 | 65,981 | 6.24 | 10,574 |
| 1970 | 439 | - | - | - | 299 | - | 40 | 11,493 | 6,005 | 18,276 | 7.66 | 2,386 |
| 1971 | 621 | - | - | - | 70 | 24 | 432 | 21,714 | 4,989 | 27,850 | 4.85 | 5,742 |
| 1972 | 1,629 | 474 | - | 16 | 101 | - | 127 | 27,146 | 5,552 | 35,045 | 6.22 | 5,634 |
| 1973 | 668 | - | 1 | 15 | 268 | 92 | 45 | 57,928 | 6,098 | 65,115 | 4.77 | 13,651 |
| 1974 | 2,532 | - | - | 2 | 107 | 70 | 325 | 52,175 | 7,180 | 62,391 | 4.29 | 14,543 |

Table 3. Estimated number of silver hake (thousands) at age discarded by the US silver hake fishery in Subdiv. 5Ze, 1964-1974.

| | Age | | | |
|---|---|---|---|---|
| Year | 0 | 1 | Total | MT |
| 1964 | 105 | 10,386 | 10,491 | 552 |
| 1965 | 2,260 | 377 | 2,637 | 47 |
| 1966 | 48,055 | 4,522 | 52,577 | 816 |
| 1967 | 22,321 | 22,410 | 44,731 | 1,456 |
| 1968 | 150,420 | 21,882 | 172,302 | 2,965 |
| 1969 | 11,312 | 16,278 | 27,590 | 998 |
| 1970 | 667 | 21,581 | 22,248 | 1,152 |
| 1971 | 275,053 | 2,218 | 277,271 | 3,418 |
| 1972 | 8,324 | 23,208 | 31,532 | 1,330 |
| 1973 | 3,493 | 4,784 | 8,277 | 296 |
| 1974 | 22,158 | 1,166 | 23,324 | 328 |

Table 4. Mean weight (kg) at age of Subdivision 5Ze silver hake caught in 1970-1974.

| Age | 1970 | 1971 | 1972 | 1973 | 1974 |
|---|---|---|---|---|---|
| 0 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 |
| 1 | 0.059 | 0.073 | 0.066 | 0.106 | 0.087 |
| 2 | 0.101 | 0.112 | 0.102 | 0.157 | 0.175 |
| 3 | 0.162 | 0.159 | 0.156 | 0.215 | 0.239 |
| 4 | 0.198 | 0.206 | 0.221 | 0.334 | 0.299 |
| 5 | 0.262 | 0.275 | 0.283 | 0.447 | 0.386 |
| 6 | 0.322 | 0.342 | 0.370 | 0.492 | 0.324 |
| 7 | 0.388 | 0.425 | 0.459 | 0.643 | 0.461 |
| 8 | 0.490 | 0.557 | 0.620 | 0.939 | 0.953 |
| 9 | 0.771 | 0.792 | 0.797 | 1.096 | 1.090 |
| 10 | 1.259 | 0.977 | 0.942 | 1.073 | 1.187 |
| 11 | 1.151 | 1.154 | 1.087 | 0.808 | 1.299 |
| 12+ | 1.403 | - | 1.582 | 0.808 | 0.789 |

Table 5. Mean weight (kg) at age of Subdivision 5Zw and SA 6 silver hake landed in 1970-1974.

| Age | 1970 | 1971 | 1972 | 1973 | 1974 |
|---|---|---|---|---|---|
| 0 | - | - | - | 0.018 | 0.020 |
| 1 | 0.042 | 0.053 | 0.069 | 0.091 | 0.099 |
| 2 | 0.079 | 0.093 | 0.121 | 0.179 | 0.179 |
| 3 | 0.166 | 0.148 | 0.181 | 0.272 | 0.229 |
| 4 | 0.213 | 0.195 | 0.230 | 0.390 | 0.336 |
| 5 | 0.270 | 0.271 | 0.298 | 0.459 | 0.433 |
| 6 | 0.348 | 0.327 | 0.352 | 0.584 | 0.589 |
| 7 | 0.448 | 0.450 | 0.506 | 0.485 | 0.621 |
| 8 | 0.607 | 0.596 | 0.719 | 1.119 | 1.155 |
| 9 | 0.832 | 0.741 | 0.909 | 0.548 | 0.888 |
| 10 | 0.958 | 1.024 | 0.998 | 1.595 | 1.315 |
| 11 | 1.157 | 1.013 | 1.414 | - | - |
| 12+ | 1.240 | 1.249 | - | - | - |

Table 6. Stratified mean catch (pounds) per tow of silver hake from US ALBATROSS IV spring and fall groundfish surveys.

| | 5Zw + 6 | | 5Ze | |
|---|---|---|---|---|
| | Spring | Fall | Spring | Fall |
| Year | (Strata 1-12) | (Strata 1-12) | (Strata 13-20) | (Strata 13-23,25) |
| 1963 | - | 11.50 | - | 7.94 |
| 1964 | - | 12.48 | - | 2.77 |
| 1965 | - | 16.79 | - | 3.33 |
| 1966 | - | 7.92 | - | 3.27 |
| 1967 | - | 9.75 | - | 2.34 |
| 1968 | 16.23 | 10.48 | 0.81 | 5.49 |
| 1969 | 8.43 | 5.08 | 1.16 | 3.73 |
| 1970 | 3.71 | 5.71 | 1.63 | 2.85 |
| 1971 | 8.23 | 10.14 | 1.68 | 2.66 |
| 1972 | 5.10 | 8.79 | 1.14 | 2.95 |
| 1973 | 2.56[1] | 7.05 | 1.80[1] | 3.85 |
| 1974 | 3.68[1] | 2.69 | 0.74[1] | 2.40 |

[1]Adjusted from No. 41 trawl catches to equivalent No. 36 trawl catches using 6.20:1 ratio.

Table 7. Stratified mean catch (number) per tow of age 0 silver hake from US ALBATROSS IV fall groundfish surveys.

| | 5Zw + 6 | 5Ze |
|---|---|---|
| Year | Strata 1-12 | Strata 13-23,25 |
| 1963 | 12.66 | 3.09 |
| 1964 | 4.77 | 0.03 |
| 1965 | 17.04 | 0.18 |
| 1966 | 161.16 | 1.92 |
| 1967 | 1.24 | 1.91 |
| 1968 | 85.82 | 13.10 |
| 1969 | 26.13 | 9.10 |
| 1970 | 28.65 | 0.28 |
| 1971 | 69.90 | 34.99 |
| 1972 | 78.20 | 12.52 |
| 1973 | 19.96 | 9.15 |
| 1974 | 97.31 | 172.53 |

Table 8. Catch of silver hake in numbers (thousands) from Subdiv. 5Ze and fishing mortalities (F) and stock sizes in numbers (thousands) calculated by virtual population analysis.

| Year | Year-class 1958 | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | F | | | | | | | | | | | Weighted F | |
| | | | | | | | | | | | | | | | | | | | Age 3+ | |
| 1964 | 1.140 | 1.426 | 1.114 | .332 | .045 | .007 | <.001 | | | | | | | | | | | | | |
| 1965 | .711 | .735 | 1.015 | 1.743 | 1.030 | .152 | .033 | .003 | | | | | | | | | | | | |
| 1966 | 1.503 | .984 | .538 | .622 | .826 | .512 | .316 | .037 | .051 | | | | | | | | | | | |
| 1967 | .616 | .874 | .293 | .242 | .470 | .721 | .414 | .031 | .044 | .022 | | | | | | | | | | |
| 1968 | .589 | 1.148 | .298 | .207 | .232 | .516 | .484 | .317 | .011 | .034 | .130 | | | | | | | | | |
| 1969 | .795 | 1.101 | .811 | .331 | .329 | .183 | .277 | .143 | .090 | .030 | .024 | .025 | | | | | | | | |
| 1970 | .920 | .900 | .040 | .095 | .160 | .188 | .155 | .232 | .268 | .122 | .059 | .221 | .001 | | | | | | .180 | |
| 1971 | | | 1.183 | .429 | 1.341 | 1.259 | .750 | .837 | 1.059 | .823 | .452 | .146 | .014 | .194 | | | | | .685 | |
| 1972 | | | 1.050 | 2.567 | 2.346 | 2.005 | 1.573 | 1.787 | 2.218 | 2.347 | 2.455 | 1.215 | .337 | .139 | .007 | | | | 2.009 | |
| 1973 | | | | .180 | .154 | .319 | .182 | .302 | .958 | .642 | .431 | 1.013 | .962 | .636 | .035 | .003 | | | .926 | |
| 1974 | | | | | .670 | .460 | .400 | .300 | 1.620 | 3.500 | 2.010 | 1.140 | 1.100 | .880 | .400 | .030 | (.017) | | .946 | |
| | | | | | | | | Stock size (000's) | | | | | | | | | | | Total | MT |
| 1964 | 54796 | 150176 | 468385 | 1333231 | 2193488 | 2051770 | 1607680 | | | | | | | | | | | | | |
| 1965 | 11743 | 24182 | 103058 | 641417 | 1405593 | 1366562 | 1187397 | 1064092 | | | | | | | | | | | | |
| 1966 | 3867 | 7772 | 24299 | 75252 | 336332 | 786584 | 770382 | 711652 | 1166853 | | | | | | | | | | | |
| 1967 | 576 | 1947 | 9508 | 27077 | 98680 | 315904 | 376633 | 459589 | 743176 | 1257831 | | | | | | | | | | |
| 1968 | 209 | 545 | 4756 | 14250 | 41323 | 102987 | 166702 | 298789 | 476595 | 825333 | 1492173 | | | | | | | | | |
| 1969 | 78 | 116 | 2366 | 7768 | 21966 | 41204 | 68900 | 145864 | 316176 | 534867 | 878444 | 553890 | | | | | | | | |
| 1970 | 24 | 26 | 682 | 3742 | 10599 | 23001 | 35016 | 84772 | 193689 | 348016 | 574402 | 362105 | 704091 | | | | | | 2,340,165 | 233,968 |
| 1971 | | | 439 | 2282 | 6016 | 12776 | 20111 | 45075 | 99265 | 206514 | 363032 | 194644 | 471695 | 1881480 | | | | | 3,303,329 | 244,953 |
| 1972 | | | 90 | 996 | 1054 | 2433 | 6402 | 13083 | 23070 | 60763 | 154899 | 112713 | 311698 | 1038985 | 1353116 | | | | 3,079,302 | 208,283 |
| 1973 | | | | 51 | 68 | 220 | 891 | 1469 | 1683 | 3897 | 8913 | 22426 | 149176 | 606246 | 899650 | 1541894 | | | 3,236,584 | 258,281 |
| 1974 | | | | | 39 | 107 | 498 | 728 | 432 | 1375 | 3882 | 5461 | 38224 | 215246 | 582523 | 1029033 | (1592163)[1] | | 3,469,711 | 279,412 |
| 1975 | | | | | 13 | 45 | 224 | 362 | 57 | 28 | 349 | 1171 | 8529 | 59846 | 261744 | 669395 | (1049269) | (1206894)[2] | 3,257,913 | 308,042 |
| | | | | | | | | Catch (000's) | | | | | | | | | | | Total | MT |
| 1964 | 31873 | 98398 | 268809 | 313616 | 80086 | 11278 | 106 | | | | | | | | | | | | | |
| 1965 | 5040 | 10627 | 56955 | 460480 | 770193 | 160038 | 31623 | 2260 | | | | | | | | | | | | |
| 1966 | 2599 | 4142 | 8486 | 29324 | 160130 | 264300 | 173671 | 21581 | 48055 | | | | | | | | | | | |
| 1967 | 223 | 962 | 2008 | 4834 | 31001 | 136934 | 106911 | 11475 | 26617 | 22321 | | | | | | | | | | |
| 1968 | 78 | 318 | 1021 | 2209 | 7105 | 34805 | 53525 | 67620 | 4361 | 22686 | 150420 | | | | | | | | | |
| 1969 | 36 | 66 | 1142 | 1822 | 5128 | 5715 | 13860 | 16071 | 22508 | 13046 | 17530 | 11312 | | | | | | | | |
| 1970 | 12 | 13 | 22 | 279 | 1346 | 3269 | 4155 | 14558 | 37924 | 33049 | 27083 | 59561 | 667 | | | | | | 181,938 | 26,057 |
| 1971 | | | 261 | 666 | 3822 | 7849 | 8918 | 21647 | 55310 | 98098 | 110386 | 21946 | 5534 | 275053 | | | | | 609,490 | 75,150 |
| 1972 | | | 50 | 817 | 843 | 1845 | 4394 | 9490 | 18119 | 48584 | 125534 | 67920 | 74306 | 111446 | 8324 | | | | 471,672 | 78,842 |
| 1973 | | | | 7 | 8 | 50 | 123 | 319 | 882 | 1554 | 2610 | 12161 | 78362 | 239967 | 25332 | 3541 | | | 364,916 | 62,503 |
| 1974 | | | | | 16 | 33 | 137 | 157 | 301 | 1209 | 2947 | 3176 | 21775 | 106843 | 160386 | 25091 | 22175 | | 374,246 | 64,265[3] |

[1]Mean of the 1971-1973 year-classes at age 0.
[2]Mean of the 1969-1973 year-classes at age 0.
[3]Estimated.

Table 9. Landings of silver hake in numbers (thousands) from Subdiv. 5Zw + SA6 and fishing mortalities (F) and stock sizes in numbers (thousands) calculated by virtual population analysis.

| Year | Year-class 1958 | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | F | | | | | | | | | Weighted F | |
| | | | | | | | | | | | | | | | | | | Age 3+ | |
| 1964 | .218 | .488 | .486 | .198 | .035 | .016 | | | | | | | | | | | | | |
| 1965 | .375 | .382 | .463 | .709 | .433 | .067 | .020 | | | | | | | | | | | | |
| 1966 | 1.015 | 1.226 | .827 | .901 | .958 | .715 | .344 | .011 | | | | | | | | | | | |
| 1967 | .198 | .339 | .185 | .177 | .327 | .681 | .400 | .055 | .027 | | | | | | | | | | |
| 1968 | .186 | .724 | .243 | .288 | .260 | .328 | .507 | .345 | .071 | .016 | | | | | | | | | |
| 1969 | .434 | .500 | .769 | .588 | .610 | .349 | .942 | 1.158 | .839 | .125 | .005 | | | | | | | | |
| 1970 | .450 | .257 | .246 | .344 | .384 | .292 | .362 | .770 | .442 | .102 | .052 | .114 | | | | | | | |
| 1971 | | .820 | .710 | 1.624 | 1.651 | 1.000 | 1.292 | .456 | .362 | .543 | .463 | .227 | .023 | | | | | .321 | |
| 1972 | | | | .260 | .260 | .460 | 2.065 | 2.409 | 2.140 | 1.896 | 2.026 | .723 | .140 | .038 | | | | .537 | |
| 1973 | | | | | | | 1.078 | .036 | .716 | .452 | 1.262 | 1.600 | .876 | .525 | .101 | | | 1.386 | |
| 1974 | | | | | | | .840 | 2.370 | .690 | 1.190 | 1.820 | .910 | 1.000 | .600 | .525 | (.208) | | 1.009 | |
| | | | | | | | | | | | | | | | | | | .684 | |
| | | | | | | | | | Stock sizes (000's) | | | | | | | | | Total | MT |
| 1964 | 25923 | 74943 | 237049 | 661288 | 1291431 | 1844207 | | | | | | | | | | | | | |
| 1965 | 13973 | 30836 | 97729 | 363599 | 836036 | 1216472 | 1346055 | | | | | | | | | | | | |
| 1966 | 6435 | 14111 | 41213 | 119901 | 363467 | 762991 | 884684 | 913480 | | | | | | | | | | | |
| 1967 | 1564 | 2776 | 12086 | 32653 | 93437 | 250190 | 420417 | 605048 | 605886 | | | | | | | | | | |
| 1968 | 860 | 1325 | 6730 | 18329 | 45153 | 84918 | 188976 | 383775 | 395267 | 312487 | | | | | | | | | |
| 1969 | 479 | 431 | 3537 | 9216 | 23340 | 41020 | 76279 | 182180 | 246709 | 206240 | 373689 | | | | | | | | |
| 1970 | 208 | 175 | 1099 | 3431 | 8501 | 19405 | 19940 | 38345 | 71441 | 121968 | 249603 | 338361 | | | | | | | |
| 1971 | | 91 | 576 | 1630 | 3880 | 9711 | 9303 | 11903 | 30780 | 73803 | 158827 | 202323 | 394224 | | | | | 872,477 | 104,907 |
| 1972 | | | | 215 | 499 | 2395 | 1713 | 5055 | 14370 | 28738 | 66981 | 108047 | 258408 | 776624 | | | | 897,051 | 105,057 |
| 1973 | | | | | | | 146 | 305 | 1133 | 2893 | 5920 | 35141 | 150596 | 501193 | 800575 | | | 1,263,045 | 140,207 |
| 1974 | | | | | | | 33 | 197 | 371 | 1234 | 1124 | 4757 | 42050 | 198823 | 485234 | (301416)[1] | | 1,497,902 | 222,611 |
| 1975 | | | | | | | 10 | 12 | 125 | 252 | 122 | 1284 | 10369 | 73143 | 192411 | (164102) | (995528)[1] | 1,035,239 | 180,491 |
| | | | | | | | | | | | | | | | | | | 1,437,031 | 123,676 |
| | | | | | | | | | Landings (000's) | | | | | | | | | Total | MT |
| 1964 | 4216 | 24241 | 76428 | 98631 | 36580 | 24274 | | | | | | | | | | | | | |
| 1965 | 3649 | 8167 | 30334 | 155831 | 245653 | 64714 | 21939 | | | | | | | | | | | | |
| 1966 | 3494 | 8547 | 19630 | 60418 | 190517 | 328842 | 214659 | 8530 | | | | | | | | | | | |
| 1967 | 233 | 666 | 1696 | 4402 | 21728 | 104092 | 115672 | 26873 | 13261 | | | | | | | | | | |
| 1968 | 121 | 576 | 1208 | 3812 | 8592 | 19768 | 63009 | 93367 | 22506 | 4009 | | | | | | | | | |
| 1969 | 141 | 142 | 1604 | 3443 | 8962 | 10064 | 39543 | 106916 | 118702 | 20111 | 1472 | | | | | | | | |
| 1970 | 63 | 33 | 199 | 833 | 2265 | 4094 | 5056 | 17401 | 21344 | 9814 | 10454 | 30246 | | | | | | | |
| 1971 | | 43 | 247 | 1135 | 2721 | 5225 | 5796 | 3649 | 7792 | 25953 | 49294 | 34162 | 7279 | | | | | 101,802 | 18,276 |
| 1972 | | | | 41 | 95 | 739 | 1313 | 4074 | 11152 | 21342 | 50994 | 46942 | 27948 | 23885 | | | | 143,296 | 27,850 |
| 1973 | | | | | | | 82 | 9 | 489 | 881 | 3642 | 24306 | 74512 | 171559 | 63433 | 110 | | 188,525 | 35,045 |
| 1974 | | | | | | | 16 | 158 | 156 | 735 | 821 | 2413 | 22628 | 75408 | 166197 | 46875 | 10 | 339,023 | 65,115 |
| | | | | | | | | | | | | | | | | | | 315,417 | 61,277[2] |

[1]Determined from linear relationship between mean number of age 0 silver hake caught in the fall survey and calculated stock size at age 1 for 1969-1972.
[2]Estimated

Table 10. Catch in 1974 (preliminary), estimated catches in 1975-1976, and stock sizes in 1974-1977 (age 0 and older in Subdiv. 5Ze and age 1 and older in Subdiv. 5Zw and SA 6) of silver hake given various levels of fishing mortality (F) on fully-recruited age-groups (3 and older).

| Fishing mortality (F) | | | Catch (MT) | | | Stock size (MT) | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1974 | 1975 | 1976 | 1974 | 1975 | 1976 | 1974 | 1975 | 1976 | 1977 |
| | | | | Subdiv. 5Ze | | | | | |
| 0.946 | 0.858 | 0.858 | 64,265 | 75,000 | 84,000 | 279,400 | 308,000 | 306,600 | 285,300 |
| 0.946 | 0.858 | 0.596 | 64,265 | 75,000 | 63,500 | 279,400 | 308,000 | 306,600 | 306,600 |
| 0.946 | 0.858 | 0.450 | 64,265 | 75,000 | 50,300 | 279,400 | 308,000 | 306,600 | 320,300 |
| | | | | Subdiv. 5Zw and Stat. Area 6 | | | | | |
| 0.684 | 0.845 | 0.845 | 61,277 | 70,000 | 70,900 | 180,500 | 123,700 | 183,900 | 153,500 |
| 0.684 | 0.845 | 0.450 | 61,277 | 70,000 | 43,400 | 180,500 | 123,700 | 183,900 | 183,600 |
| 0.684 | 0.845 | 0.446 | 61,277 | 70,000 | 43,000 | 180,500 | 123,700 | 183,900 | 183,900 |

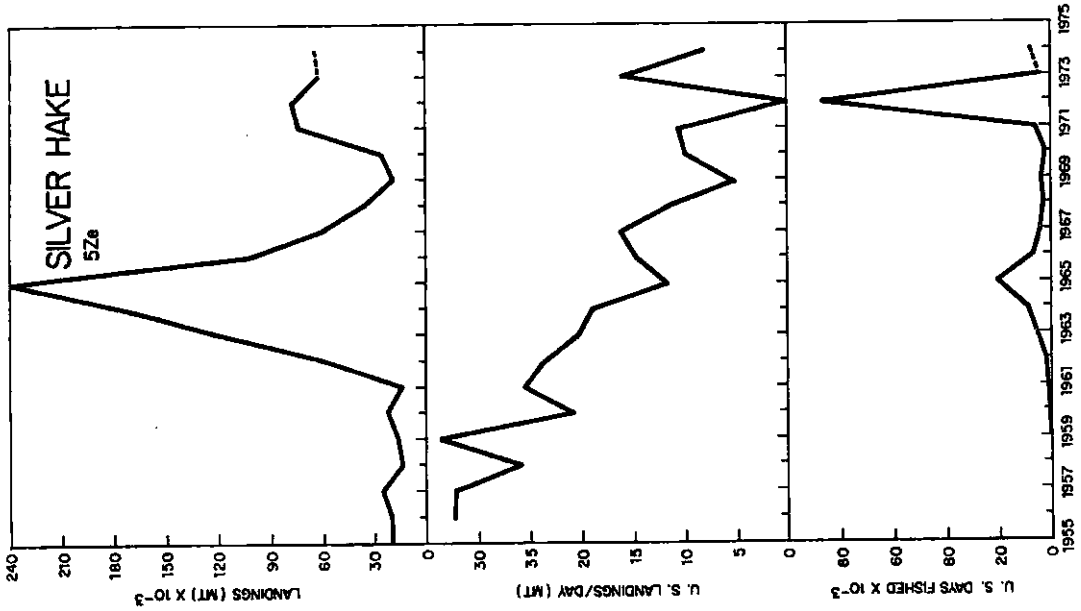


Fig. 1. International landings, US catch per effort, and international effort expressed as US days fished for silver hake in Subdiv. 5Ze.

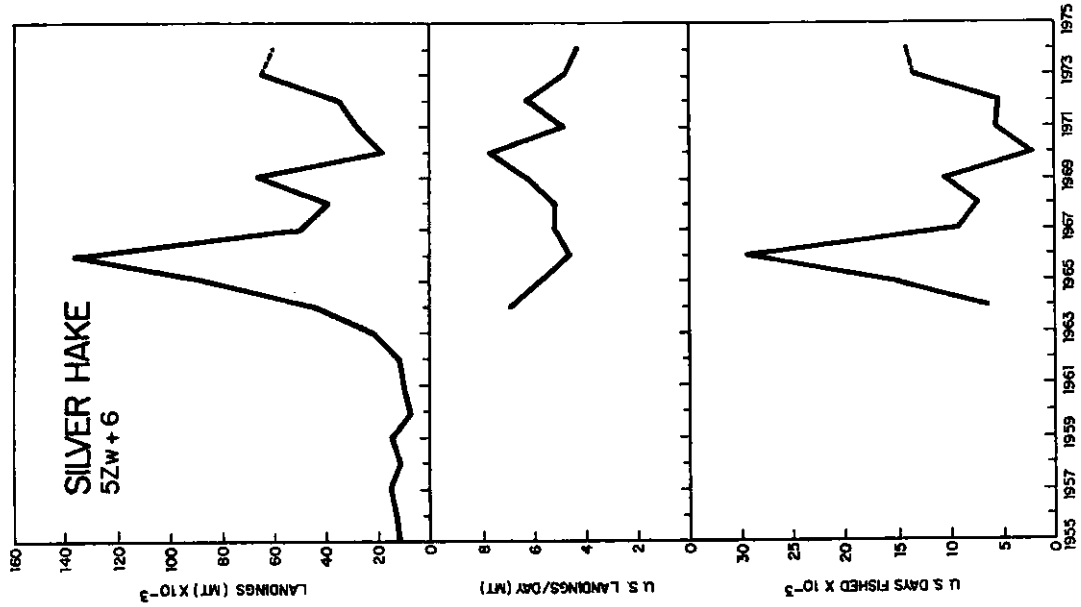


Fig. 2. International landings, US catch per effort, and international effort expressed as US days fished for silver hake in Subdiv. 5Zw and SA 6.

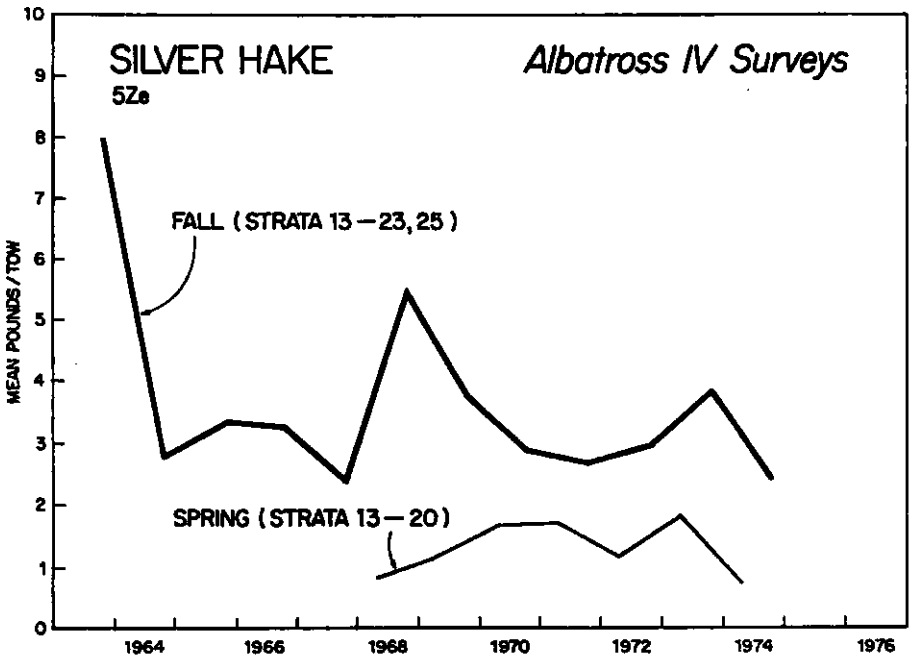


Fig. 3. Stratified mean catch (pounds) per tow of silver hake from US autumn and spring groundfish surveys in Subdiv. 5Ze.

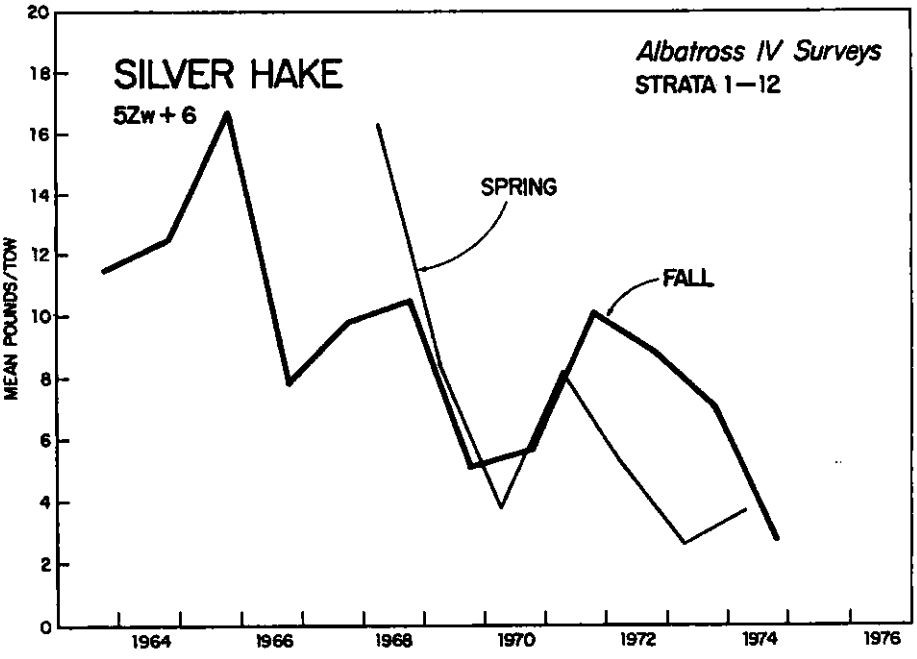


Fig. 4. Stratified mean catch (pounds) per tow of silver hake from US autumn and spring groundfish surveys in Subdiv. 5Zw and SA 6.

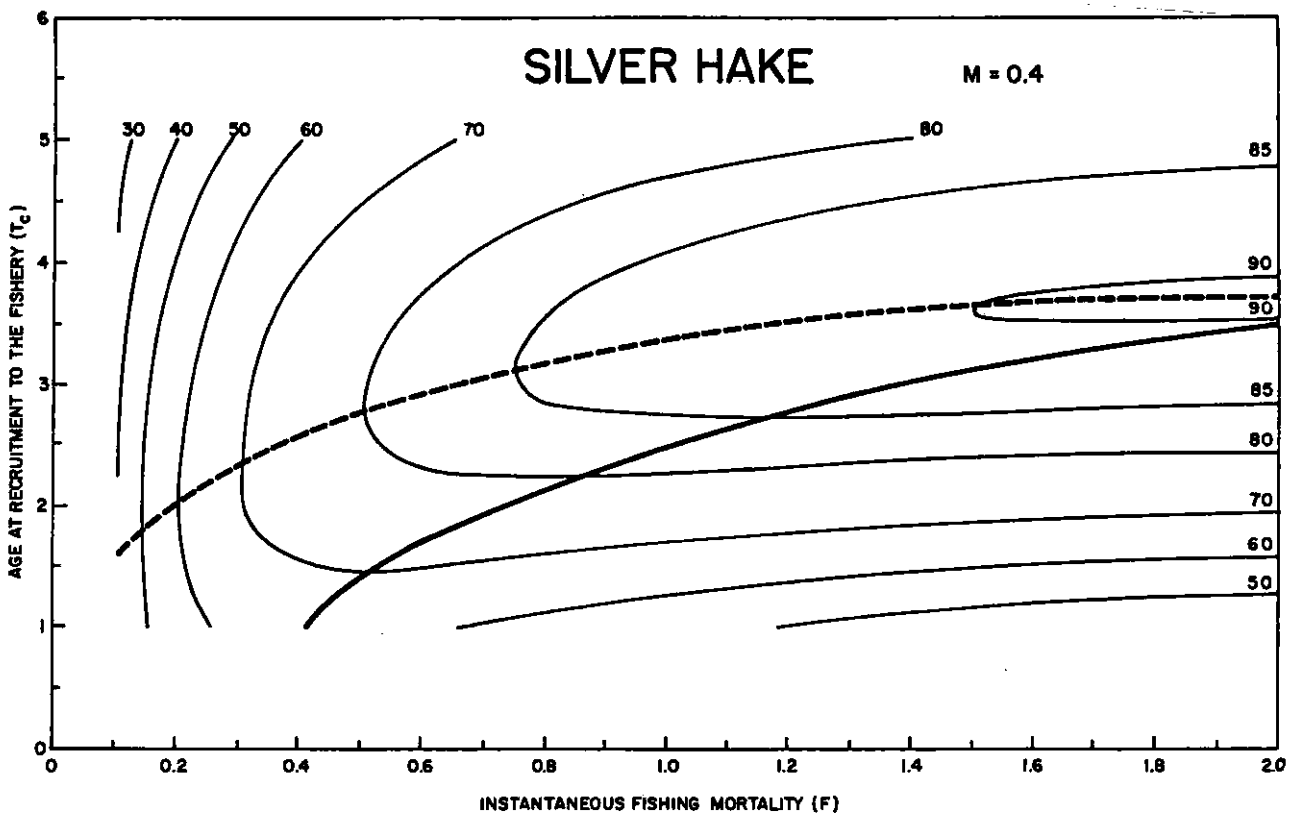


Fig. 5. Yield per recruit isopleth for silver hake for M = 0.4. The heavy solid line indicates $F_{max}$ at $t_c$ and the dashed line indicates $t_c$ giving the maximum yield per recruit at a given F.