International Commission for the Northwest Atlantic Fisheries

Serial No. 3544
(D.c.3)

ICNAF Res.Doc. 75/62
(Revised)

ANNUAL MEETING - JUNE 1975

Assessment of the ICNAF Division 5Y silver hake stock

by

E.D. Anderson
National Marine Fisheries Service
Northeast Fisheries Center
Woods Hole, Massachusetts 02543, USA

Abstract

Landings and commercial catch per effort have declined steadily in recent years in the US Div. 5Y silver hake fishery. Estimates of silver hake caught and discarded by the redfish, shrimp, and silver hake fisheries have been substantial since 1970. Age composition of both landings and discards was presented, with the latter comprised mainly of age 0 and 1 fish. US survey results indicate a decline in stock abundance in recent years in spite of a strong 1971 year-class and above-average year-classes in 1972-1973. Mean selection age was determined to be about 1.75 years with F_{max} = 0.6. Virtual population analysis was performed to estimate fishing mortality and stock size. A catch in 1975 equal to the TAC of 15,000 MT would require F = 0.52, a decrease from F = 1.1 in 1974, but would consist primarily of non-marketable age 1 fish. A 1976 catch of 22,500-25,100 MT would be taken if F = 0.52-0.6. Continued high levels of catch of age 0 and 1 fish may prevent the rebuilding of the stock.

Commercial fishery

The Gulf of Maine (ICNAF Div. 5Y) fishery for silver hake has been conducted exclusively by the US with only incidental catches by the USSR, FRG, GDR, and Bulgaria in recent years. The US fishery is conducted from May-December mainly by otter trawlers fishing on concentrations of silver hake that have moved inshore to spawn following overwintering in deep, offshore waters. Vessel trips generally last only a day. The fish are landed fresh and either processed at the respective port for human consumption or transported to New York or other large cities for sale as fresh fish. If any of the landed catch is too small or otherwise undesirable for processing as a food product, it undergoes reduction to meal and oil.

Landings

Commercial landings averaged 28,500 MT from 1955 through 1966 varying from 21,448 MT in 1956 to 36,980 MT in 1957 (Table 1, Figure 1). Landings dropped from 21,495 MT in 1966 to 14,653 MT in 1967, increased to 24,706 MT in 1968, but declined steadily to 6,651 MT in 1972. Following an increase to 8,896 MT in 1973, landings decreased to 5,208 MT in 1974, which includes 4,633 MT by the US and 575 MT by the USSR.

The 1974 monthly landings pattern differed markedly from past years (Table 2). Fishermen reported that fishable concentrations did not appear in traditional grounds in June-August as in previous years, but rather in October-November. The November landings in 1974 were higher than in any other month and were higher than November landings in any other year since 1964, except 1971. Only in 1974 were the monthly landings greatest in November. This pattern also prevailed in 1972 when peak landings occurred in October instead of in July or August with a similar amount taken in November.

Catch per effort

Landings per day of US vessels have declined markedly since 1957 (Table 1, Figure 1) and have closely paralleled the pattern of landings. Landings per day averaged 16.7 MT during 1957-1964, decreased first to an average of 11.3 MT in 1965-66 and then to 5.8 MT in 1967. Following a sharp rise to 14.7 MT in 1968 which

accompanied a large increase in landings that year, landings per day then dropped sharply to 1.99 MT in 1971. In 1972 and 1973, landings per day increased to 4.4 and 4.9 MT, respectively. However, the 1974 value declined to 0.92 MT. Even during October-December, when landings increased as fish moved inshore in large concentrations, landings per day were substantially less than in previous years.

Discard

Silver hake caught incidentally in fishing operations directed towards other species, and undersized and unmarketable silver hake caught in the silver hake fishery, are routinely discarded at sea. The amount of fish discarded has been generally unknown except for estimates obtained from interviews with a limited number of vessel captains. Discard information concerning silver hake was available only for 1972-1974 and was limited to certain areas, months, and fishing ports. Analysis of interview data indicated that estimates of silver hake discard were available from the redfish, shrimp, and silver hake fisheries. Although silver hake discarding occurs in nearly all months of the year, the major amount occurs during the summer and fall. The weight of discard from a particular vessel trip was expressed as a percentage of the landed weight of the main species. Percentages were averaged for each month and over all statistical areas in Div. 5Y. The US silver hake fishery in Subdiv. 5Ze is conducted in a similar manner to that in Div. 5Y, including the practice of discard. Therefore, discard estimates from Subdiv. 5Ze were applied to Div. 5Y when the latter were not available.

Discard information from the US redfish fishery was available only in 1972. Silver hake discard was estimated to be 24% of the redfish landed weight in July-November. In order to determine comparable estimates for other years, it was assumed that the percentage of discard was roughly proportional to stock abundance as measured by US fall survey pounds/tow (discussed later--see Table 8). Results given in Table 3 indicate that estimated discard from the redfish fishery varied from 52 MT in 1968 to 886 MT in 1972.

Discard information from the US otter trawl shrimp fishery was available only in 1974. The shrimp fishery began to develop rapidly in the late 1960's; landings peaked in 1969. As this fishery intensified, shrimp catches which previously had been limited to December-April were taken additionally throughout the summer and fall. This new summer and fall fishery produced considerable amounts of silver hake discard. Discard in 1974 was estimated to be 163% of the May-November landed weight of shrimp, or 4,526 MT. The shrimp fishery utilizes small mesh nets (approximately 45 mm codends). Although length frequencies of discarded silver hake are not available, reports indicate that most of the discard is small fish (ages 0 and 1). To determine the estimated discard for other years, it was assumed that the percentage of discard relative to shrimp landings was proportional to the abundance of ages 0 and 1 fish as measured by US fall surveys. Abundance of ages 0 and 1 fish in a given year was determined as the mean of the age 0 index in that year and the previous year. Results (Table 3) indicate an increase in estimated discard from 1 MT in 1967 to 4,816 MT in 1972.

Estimates of discard from the silver hake fishery were obtained for 1972-1974 from interview data. These estimates indicated the discard to vary from 6% (502 MT) of the June-December silver hake landings in 1973 to 135% (6,846 MT) of the May-November landings in 1972. The 1974 estimate was 61% (2,400 MT) of the July-November landings. Since the discard from the silver hake fishery is small fish (primarily ages 0 and 1), estimates for 1965-1971 were therefore determined using the same procedure as described for the shrimp fishery. The percentage of discard relative to landings in 1972 was used as the base for determining the other years. Results showed a peak in discard in recent years of 8,417 MT in 1971 (Table 3).

Total discard from the redfish, shrimp, and silver hake fisheries varied from an estimated 437 MT in 1967 to a high of 12,548 MT in 1972, with the 1974 estimate being 7,181 MT.

Total catch

Estimated total catch (landings plus discard) from the Div. 5Y silver hake stock for 1965-1974 is given in Table 4. Catch varied from 26,376 MT in 1968 to 12,190 MT in 1973. Discard averaged less than 10% of the landings during 1965-1970. However, in 1971, 1972, and 1974 discard exceeded landings with the maximum being in 1972 when discard was nearly 190% of the landings. The total estimated catch in 1974 was 12,389 MT. Addition of the estimated discard to landings in 1973 and 1974 results in the catch exceeding the TAC of 10,000 MT set for those two years. However, those TACs were advised on the assumption that the catch included only landings, since the magnitude of the discard of small fish was unknown at that time.

Age composition of the landings

Length frequency samples from commercial landings were available for 1955-1974. Age-length data available from 1962-1963 and 1965-1967 were combined and applied along with the length frequencies to the total landings from 1955-1972 to estimate numbers of fish landed at age. Data for each sex were combined.

The 1962-1963 and 1965-1967 age data were determined by examining whole otoliths. A new method of ageing thin sections cut from otoliths (Anderson and Nichy, 1975) was used to age samples from the 1973 US spring and fall groundfish surveys. Age-length keys prepared from these data were applied to the 1973 and

1974 length frequencies of landings.

Numbers landed at age for 1955-1974 are presented in Table 5. Ages ranged from 0 to 12+. Most of the fish were ages 2-5, with ages 3-4 predominant in most years. Beginning in 1971, a definite shift occurred towards a greater proportion of younger fish in the landings. In 1971, age 3 was most prevalent, followed by age 2. In 1972, 1973, and 1974, age 2 fish were predominant. The 1973 and 1974 landings contained proportionatley fewer fish in the older age groups (4+) than previous years. This phenomenon may have been due, in part, to the new age-length data used.

Age composition of the discard

Length frequency samples were not available from silver hake discarded at sea. The only clues relating to the size and age composition of the discards were from reports and comments by NMFS fishery reporting specialists located in the various ports. Hence, the estimation of the age composition of the discard must be considered as tenuous.

Since the mesh used in the redfish fishery generally varies from 65 mm to 130 mm, larger than used in the silver hake fishery, the silver hake caught (and discarded) were assumed to be mainly larger fish similar in size to those landed in the silver hake fishery. Hence, the estimated weight of the discard was converted to numbers at age pro-rating on the basis of the numbers landed at age in Table 5.

Since the shrimp fishery utilizes codend mesh of 45 mm and reports indicate that the silver hake discarded by this fishery are quite small, it was assumed that the discard consisted entirely of ages 0 and 1 fish. Since the shrimp nets obviously catch silver hake of all sizes, the predominance of small fish in the discard suggests that the larger silver hake may be sorted out of the catch and landed. It was also assumed that the discard from the silver hake fishery consisted only of ages 0 and 1 fish because fish older than this would normally be marketable. In order to estimate the number of age 0 and 1 fish in the discard each year, it was assumed that they occurred in proportion to their relative abundance at age 0 as measured by the US fall surveys. In each year, age groups 0 and 1 were expressed as a percentage of the sum of the age 0 abundance indices of the two groups in the successive groundfish surveys. Mean weights of 0.012 and 0.053 kg were estimated from growth curve and length-weight data, for ages 0 and 1, respectively. Utilizing the estimated percentages for each age and the mean weights, numbers at age in the discard were determined (Table 6).

Mean weight at age

Mean weights at age of silver hake caught in 1970-1974 are given in Table 7. These weights were calculated by length-weight equations utilized in the procedure for determining numbers of fish landed at length and age.

Research vessel survey results

Relative abundance

US *Albatross IV* spring and fall survey stratified mean catch (pounds) per tow indices are given in Table 8 and in Figure 2. The fall index dropped sharply from 58.3 pounds per tow in 1963 to a low of 4.2 in 1968. It then improved to 14.3 pounds per tow in 1972, but declined to 9.2 in 1973 and 8.3 in 1974. The 1968-1974 spring index followed the same pattern as the fall index.

Recruitment index

Stratified mean number per tow of age 0 silver hake from fall surveys determined by length frequency analysis provided an estimate of the relative size of pre-recruit year-classes (Table 8). Results indicated poor year-classes in 1964-70 following a strong 1963 cohort. The 1971 year-class appeared to be strong, followed by 1972-73 year-classes which were less abundant than the 1971 but stronger than the 1964-70 year-class. The 1974 year-class appeared to be strong.

Yield per recruit

Mesh selection studies by Jensen and Hennemuth (1966) indicated the 50% selection factor for silver hake to average 4.2. Most of the silver hake are caught by commercial vessels with nets having a mesh of 46-51 mm in the codend. This would imply a 50% selection length (l_c) of 19.3-21.4 cm. Using von Bertalanffy growth parameters of L_∞ = 60 cm, K = 0.1916, and t_o = -0.51, the 50% selection age (t_c) was calculated as 1.5-1.8 years.

Silver hake are vulnerable to the fishing gears in the fall of their first year as age 0. Therefore, it was assumed that the 50% selection age as determined from the mesh selection data represented the mean selection age in the silver hake fishery.

Beverton and Holt (1957) model of yield per recruit for M = 0.4 (Fig. 3) indicates that F_{max} = 0.6 when t_c = 1.75 years.

Virtual population analysis

Virtual population analysis was performed on the 1958-1973 year-classes using the estimated numbers at age from landings and discard for 1965-1974 and with M = 0.4. In order to estimate the starting instantaneous fishing mortality (F) (at the oldest age) for each year-class, a catch curve ($\log_e$ of numbers caught versus age) was plotted for each year-class and a least squares line was calculated through the fully-recruited ages, the slope of which line was total instantaneous mortality (Z). The line was extrapolated beyond the oldest age to estimate hypothetical catches for several years hence for each year-class. The VPA was run using the observed and the hypothetical catches and assuming the starting F to be Z-M (0.4). The F calculated for the last year of observed catches was then used as the starting F in a second VPA. The starting F (1974) at age 1 for the 1973 year-class was assumed to be the same as the mean of the age 2+ fish (weighted by calculated stock size) in 1974.

The calculated F values and stock sizes are presented in Table 9. Examination of the F values by age and by year indicates a decrease in the age at full recruitment from age 4 in 1965-1970 to age 0 in 1971 and up to age 1 in 1972-1974. This change reflects the increase in the amount of discard estimated in 1971-1974 and the resulting high fishing mortality on small fish. Fishing mortality for ages 4 and older (weighted by stock size) increased from 0.76 in 1970 to 1.68 in 1972, decreased to 0.79 in 1973, and then increased to 0.94 in 1974. F for ages 1 and older increased from 0.42 in 1970 to 1.41 in 1972 and dropped slightly to 1.1 in 1973 and 1974. Stock size declined from about 47,000 MT in 1970 to 26,600 MT in 1973. The 1971 year-class at age 0 was 1.4 billion fish as compared to a mean of 0.22 billion for the weak 1965-1970 year-classes.

Stock and yield predictions

The relationship between the fall survey mean number of age 0 fish caught per tow (Table 8) and the VPA calculated stock size at age 0 (Table 9) was determined by least squares linear regression for 1965-1973 as: $Y = 128263 + 108763\ X$ ($r = 0.819$), where Y = stock size and X = survey index. The 1974 year-class at age 0 was estimated to contain 1.07 billion fish. The F at age 0 for the 1974 year-class necessary to produce the estimated catch of 165.7 million fish from the estimated stock of 1.07 billion fish was 0.207. The size of the 1975 and 1976 year-classes at age 0 was assumed to be equal to the mean of the 1969-1973 year-classes which was 448.8 million fish. The total stock size at the beginning of 1975 was calculated to be 1.08 billion fish or 48,000 MT.

The partial recruitment pattern assumed for 1975 and 1976 was determined from an examination of the 1972-1974 F's at age calculated by VPA. These data indicated 100% recruitment for ages 1 and older and a mean of 25% recruitment at age 0.

Mean weight at age for 1975 and 1976 was assumed the same as in 1974 (Table 7).

The catch in 1975 was assumed to be equal to the TAC of 15,000 MT. The F in 1975 needed to produce this catch would be 0.52. However, 74% of the weight of the estimated catch in 1975 was from the 1974 year-class at age 1. Therefore, the level of F is highly dependent on the estimated size of the 1974 year-class at age 0. If the estimate of 1.07 billion fish was greater than actual, then a higher F would be required to take the 1975 catch.

If, however, a catch of 15,000 MT in 1975 and an F of 0.52 are assumed, the total 1976 stock size (age 0+) will be 963.2 million fish or 70,000 MT. If F is maintained at 0.52 in 1976, the catch would be 22,500 MT and the 1977 stock size would be 917.9 million fish or 67,200 MT assuming the 1977 year-class at age 0 was the same as estimated for 1975 and 1976. If fishing mortality was at the level of F_{max} (0.60) in 1976, the catch would be 25,100 MT, and the 1977 stock size (age 0 and older) would be 63,300 MT or 896.9 million fish.

If it is assumed that F in 1975 will remain at the 1973-1974 level of 1.1, the catch will be 25,300 MT, leaving a stock size at the beginning of 1976 of 46,100 MT. Maintaining an F of 1.1 in 1976 would produce a catch of 24,300 MT but would result in a 1977 stock size of only 36,400 MT.

Discussion

The Div. 5Y silver hake fishery has been characterized by a steady decline in landings and catch per effort since the mid-1950's. The decline in stock abundance has been verified by US fall groundfish survey catch per tow indices. On the basis of survey age 0 indices and stock sizes calculated by virtual population analysis, the stock decline resulted from catches exceeding recruitment. Stock abundance, as measured by commercial catch per effort and survey catch (pounds) per tow data, showed an increase in 1972 following the recruitment of a strong 1971 year-class. Landings in 1973 underwent an increase from the previous year. The

strength of the 1972-1974 year-classes was also much greater than those produced between 1963 and 1971. However, the survey index decreased after 1972 and the commercial catch per effort index declined sharply after 1973. Considering the strong incoming year-classes in 1971 and in the years following, and the low level of landings compared to the 1950's and early-to-mid 1960's, it would appear that the stock should have begun to rebuild.

The fact that the stock does not appear to be gaining in size despite good recruitment can apparently be attributed to the massive amount of age 0 and 1 fish caught and discarded particularly by the shrimp and silver hake fisheries. The substantial fishing mortality on age 0 and 1 fish has apparently prevented the rebuilding of the adult stock. If large removals of small fish continue, it would appear that the silver hake stock will continue to remain at low levels of abundance.

Predictions of catch for 1975 and 1976 include both landings and discard. Since 77% or 11,600 of the 15,000 MT assumed to be caught in 1975 were estimated to be age 0 and 1 fish and hence would largely be included in the discarded portion of the catch, only a small part of the TAC would be landed as marketable fish. The present data indicate that the stock of age 2 and older fish is not large enough to produce the 1975 TAC. The estimated 1976 catch of 22,500 MT (F = 0.52) or 25,200 MT (F = 0.60) would consist of 16,900 to 18,900 MT, respectively, of age 2 and older fish.

Literature cited

Anderson, E.D., and F.E. Nichy. 1975. A comparison between US and USSR silver hake ageing. Int. Comm. Northw. Atlant. Fish., Res. Doc. 75/13.

Beverton, R.J.H., and S.J. Holt. 1957. On the dynamics of exploited fish populations. Min. Agric., Fish. and Food, Fish. Invest., Ser. 2, 19: 533 pp.

Jensen, A.C., and R.C. Hennemuth. 1966. Size selection and retainment of silver hake and red hake in nylon codends of trawl nets. Int. Comm. Northw. Atlant. Fish., Res. Bull. 3: 86-101.

Table 1. Silver hake landings statistics from the Div. 5Y stock.

Year	Landings (MT)						US landings/day (MT)	International effort as US days fished
	Bulgaria	FRG	GDR	USSR	US	Total		
1955	-	-	-	-	33,833	33,833	-	-
1956	-	-	-	-	21,448	21,448	9.22	2,326
1957	-	-	-	-	36,980	36,980	26.05	1,420
1958	-	-	-	-	35,522	35,522	16.30	2,179
1959	-	-	-	-	34,750	34,750	16.74	2,076
1960	-	-	-	-	23,628	23,628	13.01	1,816
1961	-	-	-	-	26,576	26,576	17.14	1,551
1962	-	-	-	-	26,253	26,253	14.35	1,829
1963	-	-	-	3,660	22,978	26,638	16.04	1,661
1964	-	-	-	-	31,722	31,722	13.79	2,300
1965	-	-	-	-	22,649	22,649	11.09	2,042
1966	-	-	-	-	21,495	21,495	11.50	1,869
1967	-	-	-	-	14,653	14,653	5.79	2,531
1968	-	-	-	-	24,706	24,706	14.71	1,680
1969	-	-	-	-	14,632	14,632	4.89	2,992
1970	-	-	-	-	11,384	11,384	2.97	3,833
1971	-	-	-	53	8,263	8,316	1.99	4,179
1972	-	131	93	857	5,570	6,651	4.40	1,512
1973	3	29	34	483	8,347	8,896	4.93	1,804
1974	-	-	-	575	4,633	5,208	0.92	5,661

Table 2. Monthly US landings of silver hake in Div. 5Y, 1964-1974.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total[1]
1964	1	-	-	-	341	3,635	11,599	7,547	3,965	2,302	1,192	97	30,680
1965	-	-	-	-	6	1,562	9,663	6,188	3,228	1,425	629	34	22,735
1966	-	-	-	-	1	1,432	7,143	8,122	2,542	1,598	458	27	21,322
1967	-	1	-	-	-	918	5,159	4,372	1,781	1,640	507	12	14,389
1968	-	-	-	-	274	2,262	7,931	7,846	4,242	1,989	137	6	24,687
1969	-	-	-	-	24	1,770	5,883	3,619	1,642	1,211	365	91	14,603
1970	5	4	21	21	285	1,640	4,556	2,667	712	835	548	84	11,379
1971	2	-	6	3	7	585	3,349	1,316	452	963	1,436	137	8,256
1972	10	1	1	3	224	214	866	1,042	655	1,067	1,010	464	5,556
1973	9	9	16	54	132	792	1,257	1,601	1,262	1,875	813	529	8,348
1974	18	2	3	8	140	223	465	1,071	624	660	1,130	291	4,634

[1]Total may not correspond to official ICNAF figures.

Table 3. Discard of silver hake by various US fisheries in Div. 5Y expressed as a percentage of the May-November (July-November in redfish fishery) landed weight of the main species and as the annual estimated weight, 1965-1974.

	Fishery						
	Redfish		Shrimp		Silver hake		
Year	%	MT	%	MT	%	MT	Total
1965	29	397	-	-	6	1,476	1,873
1966	16	258	-	-	6	1,299	1,557
1967	9	235	2	1	1	201	437
1968	7	52	7	38	6	1,580	1,670
1969	9	270	12	284	11	1,553	2,107
1970	11	374	9	200	8	900	1,474
1971	10	360	120	2,581	104	8,417	11,358
1972	24	886	155	4,816	135	6,846	12,548
1973	15	259	99	2,533	6	502	3,294
1974	14	255	163	4,526	61	2,400	7,181

Table 4. Estimated total catch from the Div. 5Y silver hake stock including landings and discard, 1965-1974.

Year	Landings (MT)	Discard (MT)	Total Catch (MT)
1965	22,649	1,873	24,522
1966	21,495	1,557	23,052
1967	14,653	437	15,090
1968	24,706	1,670	26,376
1969	14,632	2,107	16,739
1970	11,384	1,474	12,858
1971	8,316	11,358	19,674
1972	6,651	12,548	19,199
1973	8,896	3,294	12,190
1974	5,208	7,181	12,389

Table 5. Number of silver hake landed (thousands) at age in Div. 5Y during 1955-1974.

	Age														
Year	0	1	2	3	4	5	6	7	8	9	10	11	12+	Total	MT
1955	128	16,088	19,928	32,942	40,734	20,593	12,876	5,810 *	3,111	879	261	259	18	153,627	33,833
1956	138	16,404	11,062	21,159	27,643	13,165	8,587	3,442	1,563	563	128	113	8	103,975	21,448
1957	104	47,623	16,219	34,482	47,273	22,715	15,595	5,655	2,922	925	230	198	9	193,950	36,980
1958	11	20,068	17,910	30,181	43,871	20,311	16,595	5,154	2,718	879	203	157	10	158,068	35,522
1959	10	7,911	27,156	40,830	39,950	19,610	12,043	5,561	2,957	790	236	232	8	157,294	34,750
1960	-	2,740	30,161	37,809	26,131	10,529	6,028	3,123	1,578	512	163	137	26	118,937	23,628
1961	-	702	21,879	39,071	35,372	14,763	7,284	3,546	1,624	546	167	134	29	125,117	26,576
1962	-	955	18,262	37,657	35,077	14,953	7,569	3,533	1,713	595	204	139	34	120,691	26,253
1963	-	502	15,492	37,255	34,934	13,764	8,041	3,237	1,662	592	191	158	54	115,882	26,638
1964	15	1,106	21,518	34,640	38,443	18,170	9,425	4,752	2,707	889	342	360	114	132,481	31,722
1965	-	180	16,578	28,785	27,108	12,547	6,584	3,541	2,029	777	226	242	73	98,670	22,649
1966	-	15	9,479	30,526	33,123	14,044	5,375	2,539	1,255	453	162	149	66	97,186	21,495
1967	-	227	3,689	16,364	24,837	11,891	4,797	1,974	689	261	60	38	6	64,833	14,653
1968	-	570	2,728	14,912	35,707	21,262	11,968	4,648	1,849	820	143	98	36	94,741	24,706
1969	-	2,976	2,518	6,603	17,288	11,380	7,633	3,420	1,654	675	152	56	36	54,391	14,632
1970	-	664	5,727	9,966	11,016	5,938	4,908	2,531	1,641	457	241	124	2	43,215	11,384
1971	-	1,812	11,682	13,617	10,399	4,036	1,942	991	426	138	44	56	-	45,143	8,316
1972	-	1,840	11,237	6,521	6,052	2,653	2,476	1,136	500	215	76	65	16	32,787	6,651
1973	96	9,914	26,384	8,720	803	554	438	101	97	57	56	23	-	47,243	8,896
1974	32	5,696	12,174	6,230	766	493	304	30	22	26	32	3	-	25,808	5,208

Table 6. Estimated number of silver hake (thousands) at age in the 1965-1974 discard in Div. 5Y.

Year	Age 0	1	2	3	4	5	6	7	8	9	10	11	12+	Total	MT
1965	51,349	16,218	290	504	475	220	115	62	36	14	4	4	1	69,292	1,873
1966	5,459	23,273	114	366	397	168	64	30	15	5	2	2	1	29,896	1,557
1967	646	3,667	59	263	399	191	77	32	11	4	1	-	-	5,350	437
1968	118,563	3,668	6	31	75	45	25	10	4	2	-	-	-	122,429	1,670
1969	21,566	29,836	46	122	319	210	141	63	30	12	3	1	1	52,350	2,107
1970	13,372	17,747	188	328	362	195	161	83	54	15	8	4	-	32,517	1,474
1971	806,339	25,016	506	590	450	175	84	43	18	6	2	2	-	833,233	11,358
1972	71,611	204,059	1,498	869	807	354	330	151	67	29	10	9	2	279,796	12,548
1973	64,137	43,045	768	254	23	16	13	3	3	2	2	1	-	108,267	3,294
1974	165,641	93,450	594	304	37	24	15	1	1	1	2	-	-	260,070	7,181

Table 7. Mean weight (Kg) at age of Div. 5Y silver hake caught in 1970-1974.

Age	1970	1971	1972	1973	1974
0	0.012	0.012	0.012	0.012	0.012
1	0.053	0.054	0.053	0.070	0.056
2	0.159	0.132	0.102	0.197	0.192
3	0.217	0.191	0.188	0.272	0.260
4	0.315	0.252	0.287	0.459	0.366
5	0.375	0.290	0.353	0.585	0.409
6	0.437	0.396	0.454	0.491	0.384
7	0.512	0.465	0.628	0.943	0.797
8	0.536	0.549	0.666	1.026	0.922
9	0.565	0.505	0.694	1.119	1.119
10	0.808	0.589	0.908	1.182	1.220
11	0.589	0.653	0.906	1.375	1.057
12+	1.522	-	1.298	-	-

Table 8. Stratified mean catch (pounds) per tow of silver hake from US *Albatross IV* spring and fall groundfish surveys and stratified mean catch (numbers) per tow of age 0 silver hake from fall surveys.

Year	Pounds per tow: Spring (Strata 21-30,36-40)	Pounds per tow: Fall (Strata 24, 26-30,36-40)	Numbers per tow at age 0
1963	-	58.31	11.77
1964	-	10.25	0.15
1965	-	17.39	0.47
1966	-	9.44	0.11
1967	-	5.33	0.02
1968	0.06	4.15	0.59
1969	0.40	5.39	0.43
1970	0.68	6.63	0.33
1971	0.78	6.05	9.56
1972	3.81	14.32	3.28
1973	1.55[1]	9.20	4.88
1974	1.60[1]	8.32	8.62

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

Table 9. Catch of silver hake in numbers (thousands) in Div. 5Y in 1965-1974 and fishing mortalities (F) and stock sizes 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	Weighted F Age 1+	Weighted F Age 4+
F																				
1965	.723	.473	.411	.372	.180	.069	.056	.174												
1966	.813	.426	.391	.424	.406	.215	.052	.138	.036											
1967	.501	.245	.306	.316	.314	.343	.147	.036	.039	.005										
1968	.734	.653	.670	.740	.775	.713	.693	.247	.043	.052	.577									
1969	1.017	.304	.748	.887	.709	.830	.661	.664	.174	.050	.392	.220								
1970	.100	.570	.912	.907	1.327	1.036	.931	.673	.639	.358	.139	.375	.122						.420	.758
1971			.735	.248	.448	.628	.639	.641	.680	1.085	.746	.590	.484	1.116					.627	.865
1972			.700	1.070	.692	1.216	1.265	1.736	2.519	1.600	1.514	1.246	.579	1.485	.462				1.406	1.683
1973					.540	1.763	.518	.814	1.069	2.069	.601	.549	1.608	1.136	1.010	.261			1.087	.786
1974						.490	.860	.710	1.000	1.290	1.130	1.110	.790	1.400	.990	1.100	(.207)		1.100	.938
Stock size (000's)																			Total	MT
1965	8293	21217	45313	106483	214846	307767	363629	387065												
1966	2697	8858	20131	49219	120339	192618	230472	217933	189629											
1967	802	3877	9128	21595	53767	104166	146701	127235	122712	151386										
1968	326	2035	4504	10553	26318	49532	84884	82248	79098	100942	321895									
1969	105	710	1545	3376	8131	16274	28452	43080	50811	64233	121158	131315								
1970	25	351	490	932	2683	4755	9848	14866	28622	40976	54874	70612	140659						369,693	46,981
1971			132	252	477	1131	2602	5086	10124	19194	31996	32544	83460	1403430					1,590,428	43,848
1972			42	132	204	405	920	1796	3437	4347	10172	12093	34472	308127	231474				607,621	33,293
1973					69	80	174	212	186	588	1500	2331	12945	46774	97802	336880			499,541	26,637
1974						9	70	63	43	50	551	903	1738	10064	23873	174031	(1065800)[1]		1,277,195	31,186
1975						4	20	21	11	9	119	199	529	1664	5946	38832	(580843)	(448752)[2]	1,076,949	47,982
Catch (000's)																			Total	MT
1965	3603	6699	12767	27583	29289	16868	16398	51349												
1966	1270	2569	5439	14212	33520	30892	9593	23288	5459											
1967	265	700	2006	4874	12082	25236	16627	3748	3894	646										
1968	143	822	1853	4658	11993	21307	35782	14943	2734	4238	118563									
1969	57	155	687	1684	3483	7774	11590	17607	6725	2564	32812	21566								
1970	2	128	249	472	1695	2614	5069	6133	11378	10294	5915	18411	13372						75,732	12,858
1971			58	46	144	444	1034	2026	4211	10849	14207	12188	26828	806339					878,374	19,674
1972			18	74	86	244	567	1287	2806	3007	6859	7390	12735	205899	71611				312,583	19,199
1973					24	58	59	100	104	451	570	826	8974	27152	52959	64233			155,510	12,191
1974						3	34	27	23	31	319	517	803	6534	12768	99146	165673		285,878	12,389

[1]Determined from linear relationship between mean number of age 0 fish caught in the fall survey and calculated stock size at age 0 for 1965-1973.

[2]Mean of 1969-1973 year-classes at age 0.

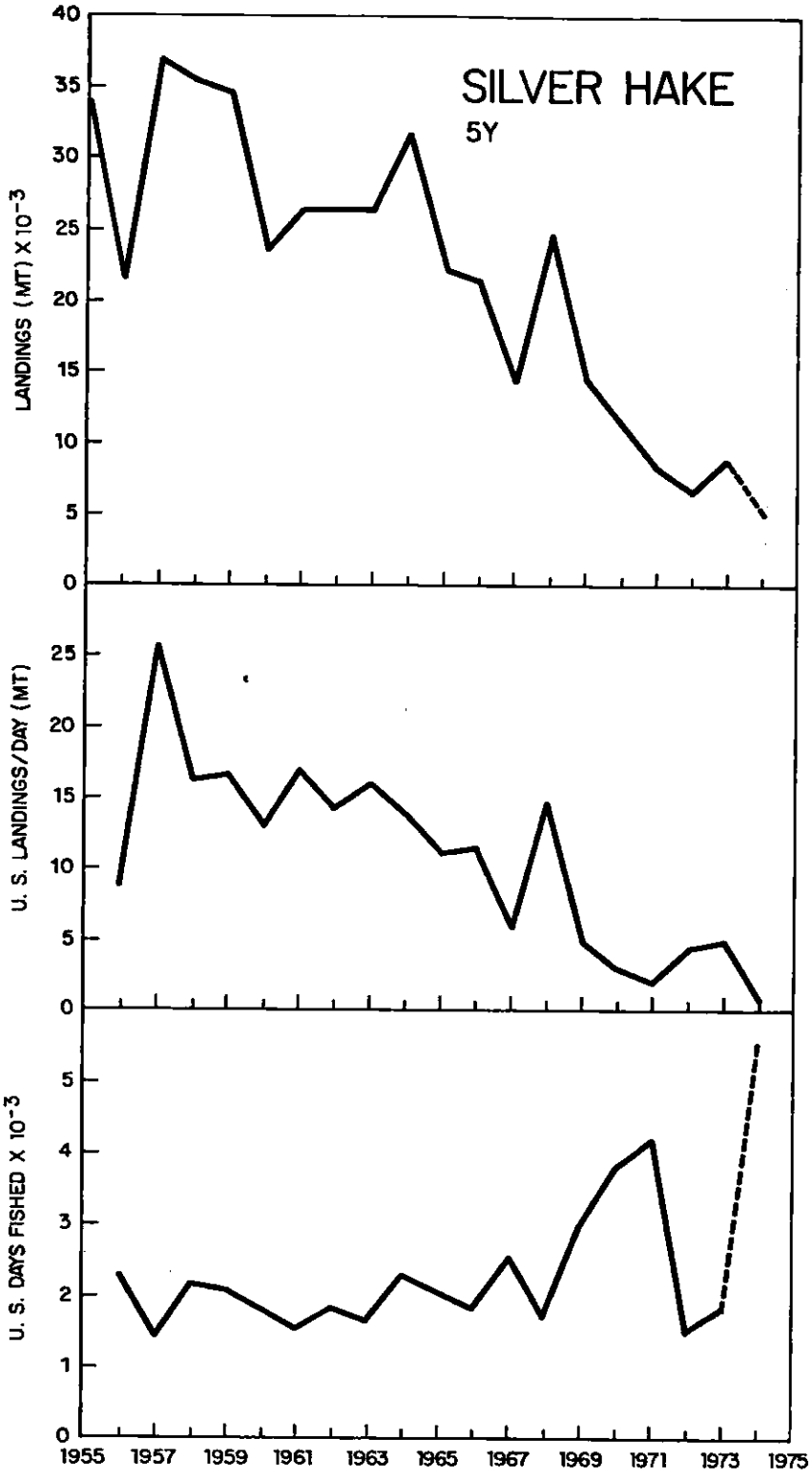

Fig. 1. International landings, US catch per effort, and international effort expressed as US days fished for silver hake in Div. 5Y.

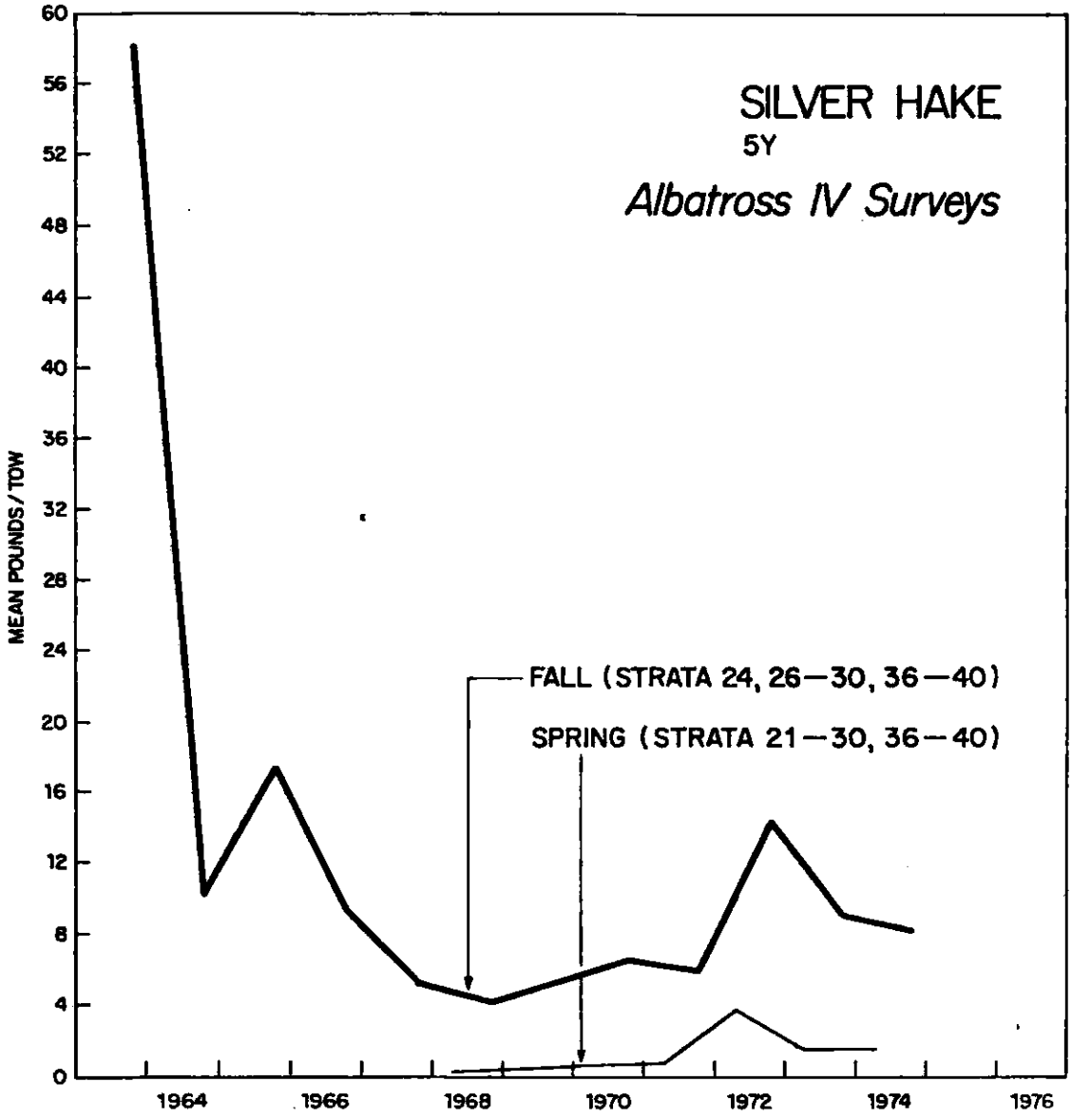

Fig. 2. Stratified mean catch (pounds) per tow of silver hake from US fall and spring groundfish surveys in Div. 5Y.

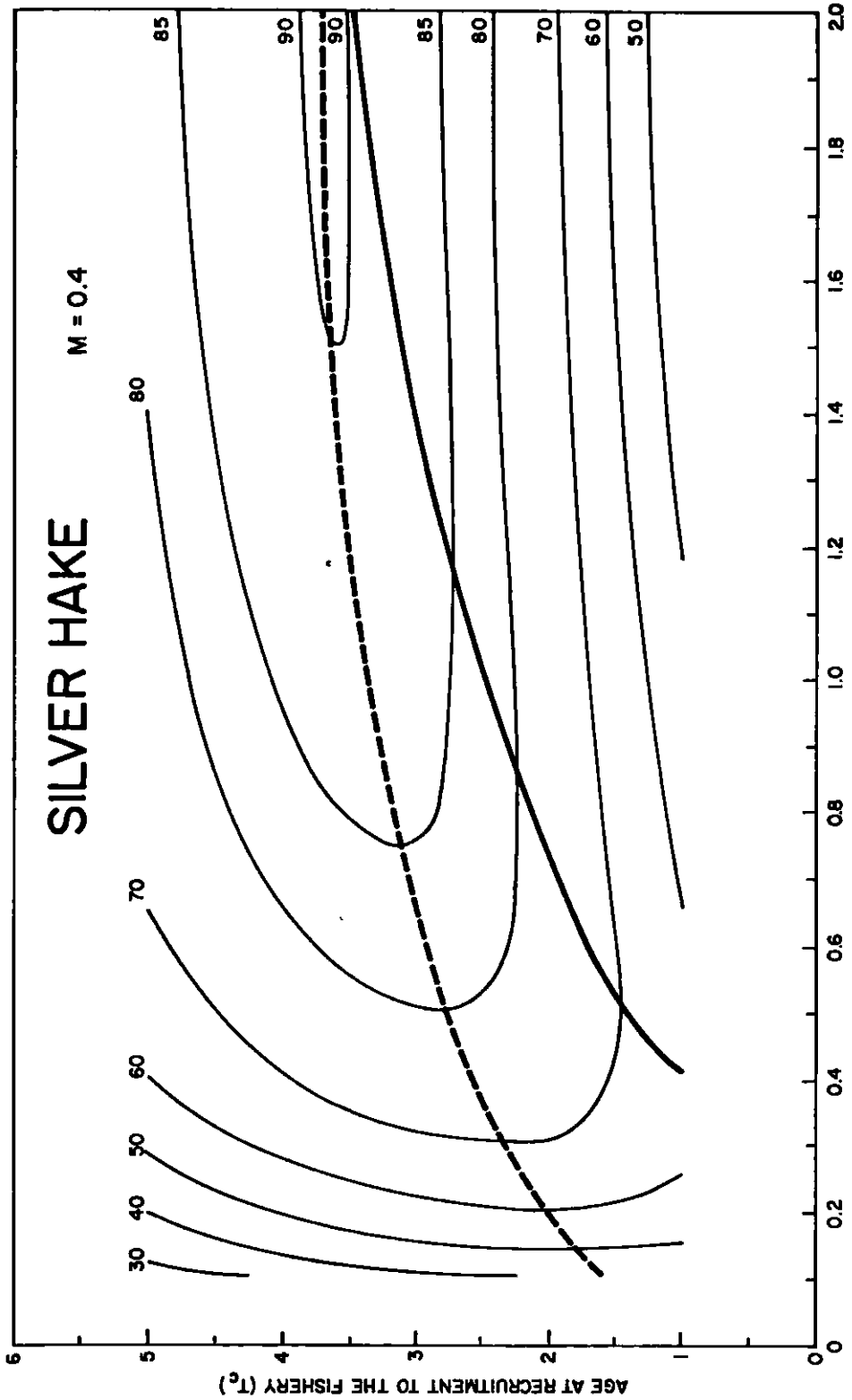

Fig. 3. Yield per recruit isopleth for silver hake for M = 0.4. The heavy solid line indicates F_{max} at t_c and the dashed line indicates t_c giving the maximum yield per recruit at a given F.