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A PRELIMINARY ASSESSMENT OF THE STATUS OF WESTERN NORTH ATLANTIC BILLFISH STOCKS

by

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SUMMARY

The status of marlin and sailfish stocks in the western North Atlantic Ocean was investigated using a statistical data base consisting of data from U.S. recreational fisheries surveys, published ICCAT and FAO statistics, and annual reports of effort and catch statistics in the Japanese tuna longline fishery (1956-1974). The last source was extensively analyzed. Indices of abundance using a time-area strata from the Japanese data were used to calculate "relative effort" following Gulland (1974). Total catch and relative effort were then used to calculate maximum sustainable yield (MSY) by application of the Schaefer model. MSYs were caluculated under several assumptions regarding recreational catch.

It does not appear that any of these stocks are currently being fished at levels beyond MSY. However, harvests from some stocks have exceeded calculated MSYs in some years. Large increases in the annual harvest from any of these stocks are not to be expected.

RESUME

L'état des stocks de marlins et voiliers dans l'Atlantique Nord-Ouest a été étudié au moyen d'une base de données statistiques formée à partir d'enquêtes sur la pêche américaine de plaisance, de statistiques publiées par l'ICCAT et la FAO, et de rapports annuels sur les statistiques de prise et effort de la pêcherie palangrière japonaise (1956-74). Cette dernière source a été analysée de façon approfondie. Des indices d'abondance, utilisant les strates spatio-temporelles des données japonaises, ont été employés pour calculer l'"effort relatif", selon Gulland (1974). La prise totale et l'effort relatif ont alors été utilisés pour calculer la production maximale équilibrée, en appliquant le modèle de Schaefer. La production maximale équilibrée a été calculée selon plusieurs hypothèses concernant la pêche sportive.

Il ne semble pas qu'aucun de ces stocks soit actuellement exploité au-delà du niveau de production maximale équilibrée. Certaines années, cependant, l'exploitation de quelques stocks a dépassé les calculs. Il ne faut attendre d'accroissement important de la production annuelle d'aucun de ces stocks.

RESUMEN

Se investigó sobre la situación de los stocks de pez aguja y pez vela en el Atlántico Noroeste empleando una base de datos compuesta por resultados de encuestas sobre pesquerías deportivas en Estados Unidos, estadísticas publicadas por ICCAT y FAO e informes anuales sobre estadísticas de captura y esfuerzo de la pesquería palangrera de túnidos japonesa (1956-74). Esta última fuente de datos fue ampliamente analizada. Se emplearon índices de abundancia con estratos espacio/temporales de los datos japoneses para calcular el "esfuerzo relativo" según Gulland (1974). El cálculo del rendimiento máximo sostenible (RMS) se hizo con la captura total y el esfuerzo relativo aplicando el modelo Schaefer. Los cálculos de las RMS consideraban varias hipótesis respecto a la captura deportiva.

No es aparente que ninguno de estos stocks esté siendo explotado en la actualidad por encima del nivel del RMS. Sin embargo, algunos años y en algunos stocks se ha sobrepasado el nivel calculado. No es de esperar que se produzcan grandes aumentos en la captura anual de ninguno de estos stocks.

INTRODUCTION

In April 1977, a group of scientists met at the La Jolla Laboratory, Southwest Fisheries Center, National Marine Fisheries Service, NOAA, to evaluate available data on Atlantic billfishes and sharks and to provide preliminary assessments for stocks in the northwest Atlantic Ocean. This report summarizes the La Jolla work as it pertains to sailfish (*Istiophorus platypterus*), blue marlin (*Makaira nigricans*), and white marlin (*Tetrapturus albidus*).

The major fisheries for marlins and sailfish in the western North Atlantic are the U.S. recreational fishery, which dates back to the early 1900's, and the high seas longline fishery, which began around the middle 1950's. Major participants in the longline fishery are Japan, Republic of Korea, and China (Taiwan). Although the longline fishery is primarily directed at tunas, billfishes are commonly taken and in some areas make up a substantial part of the catch.

Previous studies of Atlantic longline fisheries harvesting billfishes included: Fox's (1971) study of spatial relationships among tunas and billfishes; portions of Ueyanagi's (1974) general review of world commercial fisheries for billfishes; Wise and Davis's (1973) description of spatial and temporal trends in apparent abundance of tunas and billfishes; Kikawa, Honma, and Nishikawa's (1974) study of the "fishing intensity" of the Japanese Atlantic longline fishery for billfishes; and Kikawa and Honma's (1975) report on catches and fishing intensity in the Atlantic. Only the last of these included assessment data; Kikawa and Honma's report indicated that on a whole Atlantic basis, blue marlin were being fished at or near Maximum Sustainable Yield (MSY) and that the status of white marlin stocks was uncertain. Worldwide recreational fisheries for billfishes were reviewed by de Sylva (1974). Beardsley, et al (1974), 1975, 1976, 1977) and Nakamura and Rivas (1974) provide a review of catch and effort trends in Western Central Atlantic fishing tournaments and sport fish landings at selected U.S. ports.

The most extensive and detailed data available for analysis of the status of Atlantic billfish stocks are published by the Fisheries Agency of Japan as the *Annual Report of Effort and Catch Statistics by Area on the Japanese Longline Fishery*. This publication provides a monthly summary of effort in number of hooks set and catch in numbers by species for tunas and billfishes for each 5° square in which fishing occurred. These data are available for the Japanese longline fleet since the inception of the fishery in the Atlantic in 1956. A similar set of data, compiled from various (mostly unpublished) sources for the Taiwanese longline fleet, is available on a computer data base at the Southwest Fisheries Center. Additional commercial fishery data is available from the International Commission for the Conservation of Atlantic Tunas (ICCAT) Statistical Bulletins, the ICCAT Data Record, and the FAO Yearbook of Fishery Statistics. Lenarz and Nakamura's (1974) formulas were used to convert average lengths in the sport catch to weights. Kikawa (1975) and ICCAT (1977) were used as sources for the annual average size of marlins in the Japanese catch. Recreational statistics for the United States were taken from Clark (1962), Deuel and Clark (1968), Deuel and Clark (1968), Deuel (1973), and NMFS (1975), as well as from unpublished NMFS data. For recreational statistics, both interpolation and extrapolation of catches were necessary because complete statistics are not available. In addition, inaccuracies in the survey measurements of catches of billfishes by the recreational fishery are thought to be extreme even in the years when they are available. For these reasons, MSY estimates for billfishes were computed using "high," "low," and zero figures for the sport fish catch.

GENERAL METHODOLOGY

Japanese longline data are the longest, largest, and best documented data source available for Atlantic billfishes. These data were used as the basis for evaluating the status of marlin and sailfish stocks in the northwest Atlantic. This was done by graphically analyzing shifts in the spatial and temporal distribution of the fishery, changes in species composition of the catch, and trends in the nominal catch-per-unit-effort (CPUE) of various species. The purpose of these analyses was to define time-area categories through a partitioning of the data that would provide index values of CPUE. These values were chosen with the objective of providing indices that are relatively independent of shifts in the spatial and temporal distribution of the fishery, and that reflect changes in the overall abundance of the stock. Areas were chosen so as to be in the center of stock abundance and to provide the longest possible series of adequate effort for sampling purposes. Times were chosen to be in those quarters of the year when CPUE of the species in question was relatively high. CPUE indices were then used to compute the relative or "effective" effort in the total (all countries) fishery following Gulland (1974). Effective effort as used here should not be confused with "fishing intensity" of Honma (1974).

The assessment was confined to that area of the western North Atlantic north of the equator and west of 40° W longitude. This area is believed to encompass the range of stocks of white marlin, blue marlin, and sailfish that contribute to the U.S. recreational fishery (Mather, Jones, and Beardsley, 1972).

HISTORICAL TRENDS IN THE JAPANESE LONGLINE FISHERY

One of the most striking trends in the Japanese fishery in the North Atlantic is a shift in the distribution of effort from the tropics ($0-20^{\circ}$ N) to more northerly areas (Figure 1). This shift has been accompanied by a shift in species composition of the tuna catch (Figure 2). Whereas yellowfin tuna dominated the catch in the early years, bigeye and albacore became more important in the early 1960's, and bigeye alone have dominated the catch in recent years. It appears that the percentage of effort expended in the tropical North Atlantic shows two periods of decline. The first decline is associated with the shift in species composition from yellowfin to albacore and bigeye tunas (1960-1971).

During the early 1960's, and perhaps associated with the trends noted in the preceding paragraph, billfishes became a more important component of the Japanese fishery in the North Atlantic (Figure 3). For example, billfishes constituted less than 5% of the longline catch before 1960 and about 10% of the catch for the years since 1962. The species composition of billfishes in the catch, however, has been far from constant (Figures 4 and 5). It appears that, as the fishery moved northward to more temperate areas, blue marlin became less and less important in the catch, and other species, notably white marlin, became more important.

Nominal CPUE expressed as the number of fish per 1,000 hooks for blue marlin, white marlin, and sailfish (including spearfish) are shown in Figures 6, 7, and 8 for the western North Atlantic. CPUE of blue marlin was relatively high in the period from 1961-1964. Aside from high catch rates in 1969, the apparent abundance of blue marlin has declined since the early 1960's. Catch rates of sailfish show a general increase up to about 1965 and remain at or near one fish per 1,000 hooks since then. Catch rates of sailfish also show large year to year variations throughout the history of the fishery.

A somewhat different impression of the relative abundance of blue marlin, white marlin, and sailfish is obtained from a plot of CPUE in weight per 10,000 hooks for the Caribbean index area (Figure 9). The index area is bounded by 50° W longitude, 20° N latitude and by South and Central America. The biomass of blue marlin apparently peaked in 1965 and 1969 in the index area and appears to be more nearly constant than in the whole western North Atlantic (Figure 6). In part, this difference is due to differing trends in the CPUE by numbers between the index area and the larger stock area which contains it and probably reflects spatial shifts in the western North Atlantic fishery. It is also true that during the 1961-1964 peak in CPUE, the average size of blue marlin taken by the Japanese Atlantic fleet was relatively small. Hence, the 1962 peak shown in Figure 6 tends to be modulated in Figure 9 by the fact that large numbers of small fish were being taken. The situation is similar with respect to white marlin CPUE between the stock area and the index area. The average size of white marlin, however, increased gradually up until 1965 and has been fairly constant since. The apparent abundance of sailfish (including spearfish) shows no general trend and no information is available on the average weight of sailfish in the Japanese fishery.

It is apparent that there have been significant changes in the spatial distribution of effort and in the species composition of the catch in the Japanese fishery. It also seems probable that there have been some changes in strategy, perhaps in the method of setting longlines, associated with the changing species composition in the fishery. Also, impressions of the relative abundance of marlins and sailfish are to some degree area dependent. Previous estimates of MSY were based on catch in numbers rather than weight and were possibly influenced by the use of nominal Japanese data without regard to changes in the fishery. At first, we also attempted to compute an MSY in numbers by using the index area to avoid biases due to shifts in the fishery and assuming a constant average weight in the fishery.

It soon became apparent, however, that fluctuations in weight needed to be considered. To this end we used the average weight of fish caught by the whole Atlantic fleet (marlins; Kikawa and Honma, 1975) to adjust the index CPUE. Previous estimates are also different in that only Japanese longline data were used and no allowance was made for the U.S. recreational fishery. In this study, we have used data from all countries reporting catches of billfishes to either ICCAT or FAO. We have made allowances for the recreational fishery by considering both a low and a high estimate of recreational catch for all species (Appendix).

Although the use of the index area was designed to obviate possible biases due to shifting areal distribution of the fishery relative to that of the stocks, the actual choice of the index area was somewhat arbitrary. The Caribbean index area was chosen because: it is a center of abundance for marlins and sailfish; there is a long, unbroken time series of data available for the area; and there has been sufficient effort in the area to adequately sample the year to year abundance of the stocks. However, the geographic limits of the area were arbitrarily defined and perhaps a "better" index area could be chosen.

BLUE MARLIN

The derivation of the index CPUE for blue marlins is shown in Table 1. Note that the index CPUE is the CPUE for quarters two through four and was obtained by summing the effort and catch for those quarters and calculating a combined CPUE. It is possible that some other time stratification would provide a better index and this should be investigated in the future. The index CPUE was multiplied by the average weight (Figure 10) in the Japanese catch to yield the index CPUE in weight (Table 2). It is noteworthy that there is agreement between the average weight of blue marlin taken in U.S. exploratory fishing and the Japanese longline data. Moreover, it appears that the average size of blue marlin before the inception of the Japanese fishery was similar to that of recent years. The derivation of estimated C[illegible]n and Venezuelan landings is shown in Table 3. The data shown in Table 2 and Figure 11 were used to calculate MSY values shown diagrammatically in Figures 12, 13, and 14 for the longline fishery alone and for the total fishery including low and high estimates of recreational catch (Appendix). The results of these calculations are summarized in Table 4. The range of catch in numbers in Table 4 is derived from the average sizes of blue marlin taken in recent years. Because the average size of recreationally caught marlin is generally greater than that of the longline catch, fewer fish would be available to the sport fishery. Hence the lower figure represents an approximate yield in numbers to the recreational fishery and the higher number represents yield in numbers to the longline fleet. As noted, there is some question as to whether the western North Atlantic blue marlin population can be considered to be in equilibrium (or even as a unit stock). That is, given the average rate of fishing during the early 1960's, for example, and population characteristics at that time, it seems probable that the population and its characteristics were unstable. More detailed studies of the dynamics of the mean size statistics for blue marlin are needed. Skillman and Yong's (1976) figures for blue marlin in the Pacific may be used to provide some information on what might possibly be expected in the Atlantic.

Using the methodology outlined above, it appears that blue marlin populations have been fished at or near MSY in the past but are currently being fished at a level below MSY.

WHITE MARLIN

The derivation of the CPUE index for white marlin is shown in Table 5 along with catch and CPUE by quarter for comparison. The CPUE was multiplied by the average weight (Figure 15) in the Japanese Atlantic fishery to convert the CPUE into weight. The assumption that the Japanese data is representative of the western North Atlantic is corroborated by rough agreement, at least, with U.S. exploratory fishing data from the area. The derivation of high and low estimates of recreational catch is shown in the Appendix. The calculation of MSY values is shown diagrammatically in Figures 17, 18 and 19 for the total longline fishery alone, total fishery with low estimated recreational catch, and total fishery with high estimated recreational catch, respectively. MSY calculations are summarized in Table 7. The range of catch in numbers was derived in the same way as it was for blue marlin.

It appears that white marlin stocks are being fished at or near MSY. This conclusion could be an artifact of the method if, for example, catch rates during the mid-1960's in the index area are high relative to the actual abundance of the stock. However, catch and average size have been fairly stable over a wide range of relative effort. If relative effort is not well correlated with fishing mortality then stability in catch and average size could suggest that the stock is at some sort of equilibrium. Mather et al.'s (1972, 1974) tagging studies support a Northwest Atlantic stock; however, Robins' (1974) observations on white marlin in the eastern Atlantic indicate that eastern and western North Atlantic collections of white marlin are not meristically distinct and perhaps suggest that a North Atlantic stock hypothesis is tenable.

SAILFISH

The index CPUE for sailfish (Tables 8 and 9) was derived in the same way as for marlins, except that size was available only as average lengths from the recreational fishery (Beardsley, 1976). Lengths from the sport fishery were converted to weight (Figure 20) from the data given in Beardsley et al. (1976), Data from U.S. exploratory fishing tend to corroborate trends in average size from the sport fishery. The derivation of high and low estimates of recreational catch are shown in the Appendix. The calculation of MSY is shown diagrammatically in Figures 22, 23, and 24. MSY calculations are summarized in Table 10. The yield in numbers is derived from the average size of recreationally captured fish in recent years.

In general, it appears that sailfish have been fished at a level somewhat below MSY in recent years. It is difficult to evaluate the position of MSY given the widely divergent yields resulting from only narrow ranges of effort. There is nothing to suggest (here or elsewhere) that sailfish in the western central Atlantic have ever been overfished; however, there does not appear to be any room for large increases in catch either.

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Table 1. Derivation of Index Catch per unit of effort for blue marlin in the Caribbean Index Area. Effort (E) in thousands of hooks, catch (C) in numbers of fish, and catch-per-unit-effort (CPUE) in numbers of fish per 10,000 hooks.

YEAR	QUARTER (1) JANUARY-MARCH			(2) APRIL-JUNE			(3) JULY-SEPTEMBER			(4) OCTOBER-DECEMBER			INDEX CPUE QUARTERS 2,3,4
	E	C	CPUE	E	C	CPUE	E	C	CPUE	E	C	CPUE	
1956	0	0	-	2.2	2	8.93	0	0	-	0	0	-	8.93 1/
1957	0	0	-	0	0	-	10.4	8	7.73	0	0	-	7.73 1/
1958	0	0	-	273.63	294	10.74	449.82	592	13.16	589.55	411	6.97	9.53 1/
1959	176.28	148	8.40	433.57	594	13.7	206.95	113	5.46	864.68	919	10.63	[illegible] 1/
1960	112.51	11	.98	25.67	0	0	553.27	187	3.38	713.59	1462	20.49	12.75
1961	50.50	125	24.75	33.36	11	3.3	125.25	196	15.65	141.16	395	27.98	20.08
1962	0	0	0	1876.86	3677	19.59	1368.45	2640	19.29	56.50	70	12.39	19.34
1963	94.66	163	17.22	1526.54	3049	19.97	1681.06	2701	16.07	1659.44	2521	15.19	16.99
1964	819.29	1116	13.62	1846.18	4211	22.81	2548.14	6759	26.53	724.25	2626	36.26	26.56
1965	984.99	761	7.73	1120.70	737	6.58	1622.24	3756	23.15	1462.2	3778	25.84	19.63
1966	498.78	479	9.60	908.6	760	8.36	3698.35	2836	7.67	715.84	726	10.14	8.11
1967	120.29	67	5.57	73.08	49	6.71	516.32	311	6.02	312.39	116	3.71	5.24
1968	124.52	81	6.5	277.25	346	12.48	873.92	579	6.63	109.47	103	9.41	9.15
1969	43.56	8	1.84	116.41	47	4.04	882.92	4355	49.33	457.88	335	7.32	32.50
1970	0	0	0	258.1	266	10.31	1020.82	877	8.59	487.29	914	18.76	11.64
1971	130.53	174	13.33	613.3	192	3.13	1967.81	3519	17.88	1207.05	5726	47.44	24.91
1972	119.83	124	10.35	396.9	387	9.75	254.89	1000	39.23	67.73	109	16.09	20.79
1973	0	0	0	17.70	39	22.03	297.83	431	14.47	247.83	371	14.97	14.92
1974	12.93	14	10.83	0	0	0	404.35	464	11.48	512.67	537	10.47	10.91

1/ Not used in MSY calculations

TABLE 2. Estimated Yearly Removals of Blue Marlin (in metric tons) from the Atlantic Ocean North of the Equator and West of 40 Degrees1/ and Values of the Catch Per Unit of Effort Index Used to Calculate Relative Effort (see text).

YEAR	LONGLINE COUNTRIES JAPAN 2/	TAIWAN 3/	CUBA 4/	VENEZUELA 5/	TOTAL 6/	U.S. RECREATIONAL LOW	HIGH	TOTAL LOW	HIGH	INDEX 7/ CPUE
1960	282	----	----	----	282	530	1749	812	2031	.741
1961	124	----	----	----	124	598	1964	722	2088	1.303
1962	2888	----	----	----	2888	592	1974	3408	4862	1.222
1963	4128	----	----	----	4128	658	2181	4786	6309	1.295
1964	4067	----	400	----	4467	828	2780	5295	7247	1.751
1965	3025	----	510	----	3535	838	2749	4373	6248	2.479
1966	1500	60	420	----	1980	765	2554	2745	4534	1.306
1967	290	215	1160	----	1665	1012	3404	2677	5069	.534
1968	342	414	800	300	1583	864	2907	2447	4490	.819
1969	598	294	600	400	1896	1070	3611	2966	5507	2.254
1970	715	392	300	400	1807	1049	3478	2856	5285	1.002
1971	1208	180	300	500	2188	917	3053	3105	5241	1.480
1972	251	258	150	600	1259	981	3249	2240	4508	1.533
1973	248	157	130	300	1194	1072	3572	2266	4766	1.126
1974	259	248	300	70	877	1200	3908	2077	4785	0.873

1/ Estimates exclude allowance for removals by countries such as Guadeloupe and Martinique which are not members of ICCAT and either do not report billfish landings to FAO or report billfish with unspecified tuna-like fishes.

2/ Whole Atlantic catch in weight according to ICCAT apportioned to the western North Atlantic according to the proportion of blue marlin, by number, taken within the area.

3/ Whole Atlantic catch of billfish in weight apportioned to species assuming that the species composition of the Taiwanese billfish catch by weight is identical to that of Japan. Apportionment to western North Atlantic is according to the proportion, by number, of blue marlin taken in the area by Japan.

4/ ICCAT weight statistics apportioned by areal distribution of FAO.

5/ As reported to FAO, except for 1974

6/ Includes landings by Panama and Korea in some years,

7/ See Table 1 and Figure 10 for numeric catch rates and average weights.

TABLE 3 Estimation of Blue Marlin Landings by Cuba and Venezuela from the Western North Atlantic.

C U B A 1/

YEAR	FAO BLUE MARLIN AREA 31	FAO BLUE MARLIN AREA 34	FAO BLUE MARLIN AREA 41	TOTAL	ICCAT TOTAL BILLFISH	ESTIMATED BLUE MARLIN 2/
1964	----	----	----	----	400	400 3/
1965	600	100	----	700	600	510
1966	500	100	----	600	500	420
1967	1300	200	400	1900	1700	1160
1968	800	200	300	1300	1300	800
1969	500	----	----	500	600	600
1970	300	300	----	600	600	300
1971	300	200	----	500	500	300
1972	300	300	----	600	300	150
1973	300	800	----	1100	800	130
1974	300	2000	----	2300	----	300 4/

V E N E Z U E L A 1/

YEAR	FAO AREA 31	ICCAT TOTAL BILLFISH	EST. TOTAL BILLFISH	EST. BLUE MARLIN	REMAINDER
1968	300	360	360	300	60
1969	400	480	480	400	80
1970	400	480	480	400	80
1971	500	600	600	500	100
1972	400	600	600	600	0
1973	300	----	300	300 4/	0
1974	300	92	92	74 5/	18

1/ Cuba and Venezuela report catches of blue marlin, but not white marlin or sailfish.

2/ ICCAT total apportioned to stock area as for FAO blue marlin.

3/ From ICCAT alone.

4/ From FAO alone.

5/ ICCAT total apportioned according to proportion of blue marlin in previous years.

Table 4. A summary of MSY calculations for blue marlin

BLUE MARLIN

CASE	MSY R-SQUARE	MSY TONS	MSY NO. OF FISH
LONGLINE ALONE	.03	5700	57,000 - 71,000
LOW RECREATIONAL	.17	4000	40,000 - 50,000
HIGH RECREATIONAL	.38	5900	59,000 - 74,000
PREVIOUS ESTIMATE	.01	---	26,000

PROGNOSIS:
A. LOW RECREATIONAL CASE SEEMS MOST REASONABLE, BUT MSY APPEARS HIGH RELATIVE TO HISTORICAL CATCH.
B. STOCK DOES NOT APPEAR TO BE FULLY EXPLOITED.
C. QUESTION OF "EQUILIBRIUM POPULATION".

Table 5. Derivation of Index catch per unit of effort for White Marlin in the Caribbean Index Area. Effort (E) in thousands of hooks, catch (C) in numbers of fish, and catch per unit effort (CPUE) in numbers of fish per 10,000 hooks.

	QUARTER												INDEX CPUE
YEAR	(1) JANUARY-MARCH			(2) APRIL-JUNE			(3) JULY-SEPTEMBER			(4) OCTOBER-DECEMBER			QUARTERS 1,2
	E	C	CPUE	E	C	CPUE	E	C	CPUE	E	C	CPUE	1/
1956	0	0	0	2.24	0	0	0	0	0	0	0	0	0.00 1/
1957	0	0	0	0	0	0	10.35	0	0	0	0	0	0.00 1/
1958	0	0	0	273.63	98	3.58	449.82	15	.33	589.55	3	.05	3.58 1/
1959	176.28	0	0	433.57	36	.83	206.95	0	0	864.68	148	1.71	0.59 1/
1960	112.51	106	9.42	25.67	3	1.17	553.27	34	.61	713.59	27	.38	7.88 1/
1961	50.50	1	.20	33.36	3	.90	125.25	61	4.87	141.16	130	9.21	0.48
1962	0	0	0	1876.86	4132	22.02	1368.45	1694	12.38	56.50	214	37.87	22.02
1963	94.66	1276	134.80	1526.54	2548	16.69	1681.06	1662	9.89	1659.44	1527	9.20	23.58
1964	819.29	3280	40.03	1846.18	7244	39.24	2548.14	4413	17.32	724.25	1233	17.02	39.48
1965	984.99	4785	48.58	1120.70	3244	28.95	1622.24	1553	9.57	1462.2	3350	22.91	38.13
1966	498.78	4987	99.98	908.6	10251	112.82	3698.35	11284	30.51	715.84	1543	21.56	108.27
1967	120.29	636	52.87	73.08	542	74.17	516.32	352	6.82	312.39	401	12.84	60.92
1968	124.52	773	62.08	277.25	1443	52.05	873.92	1455	16.65	109.47	80	7.31	55.16
1969	43.56	305	70.02	116.41	155	13.32	882.92	1125	12.74	457.88	5250	114.66	28.76
1970	0	0	0	258.1	594	23.01	1020.82	569	5.57	487.29	750	15.39	23.01
1971	130.53	469	35.93	613.3	536	8.74	1967.81	1368	6.95	1207.05	241	2.00	13.51
1972	119.83	151	12.60	396.9	359	9.05	254.89	687	26.95	67.73	52	7.68	9.87
1973	0	0	0	17.70	36	20.34	297.83	340	11.42	247.83	122	4.92	20.34
1974	12.93	4	3.09	0	0	0	404.35	444	10.98	512.67	886	17.28	3.09

1/ Not used in MSY calculations

TABLE 6. Estimated Yearly Removals of White Marlin (in metric tons) from the Atlantic Ocean North of the Equator and West of 40 Degrees1/ and Values of the Catch Per Unit of Effort Index Used to Calculate Relative Effort (see text).

	LONGLINE COUNTRIES				U.S. RECREATIONAL		TOTAL		
YEAR	JAPAN 2/	TAIWAN 3/	VENEZUELA 4/	TOTAL	LOW	HIGH	LOW	HIGH	INDEX CPUE 5/
1960 6/	17	----	----	17	195	650	212	667	.074
1961 6/	6	----	----	6	193	647	199	653	.008
1962	180	----	----	180	239	800	419	980	.233
1963	658	----	----	658	206	829	864	1487	.554
1964	1398	----	----	1398	226	751	1624	2149	.821
1965	1635	----	----	1635	245	818	1880	2453	1.810
1966	1531	12	----	1533	244	812	1777	2345	3.501
1967	134	32	----	166	262	876	428	1024	.999
1968	248	111	30	389	282	940	671	1329	1.323
1969	443	221	40	704	244	815	948	1519	.900
1970	398	145	40	583	336	1120	919	1703	.499
1971	899	296	50	1245	305	1018	1550	2263	.372
1972	274	439	0	713	319	1066	1032	1779	.294
1973	399	148	0	547	336	1118	883	1665	.561
1974	411	349	9	769	350	1174	1119	1943	.348

1/ Estimates exclude allowance for removals by countries such as Guadeloupe and Martinique, which are not members of ICCAT and either do not report billfish landings to FAO or report billfish with unspecified tuna-like fishes.

2/ Whole Atlantic catch in weight according to ICCAT apportioned to the western North Atlantic according to the proportion of white marlin, by number, taken within the area by Japan.

3/ Whole Atlantic catch of billfish in weight apportioned to species assuming that the species composition of the Taiwanese billfish catch by weight is identical to that of Japan. Apportionment to western North Atlantic is according to the proportion, by number, of white marlin taken in the area by Taiwan.

4/ The difference between total billfish reported to ICCAT and blue marlin reported to FAO was assumed to be 50 percent white marlin and 50 percent sailfish.

5/ See Table 5 and Figure 15 for numeric catch rates and average weight.

6/ Data for these years were not included in MSY calculations.

Table 7. A summary of MSY calculations for white marlin.

WHITE MARLIN

CASE	R-SQUARE	MSY TONS	MSY NO. OF FISH
LONGLINE ALONE	.24	1250	42,000 - 50,000
LOW RECREATIONAL	.36	1900	63,000 - 76,000
HIGH RECREATIONAL	.47	2850	95,000 - 114,000
PREVIOUS ESTIMATE	.01	---	281,000

PROGNOSIS: A. LOW RECREATIONAL CASE APPEARS REASONABLE.
B. STOCK APPEARS TO BE FULLY EXPLOITED.

Table 8. Derivation of Index catch per unit of effort for Sailfish in the Caribbean Index Area. Effort (E) in thousands of hooks, catch (c) in numbers of fish, and catch per unit effort (CPUE) in numbers of fish per 10,000 hooks.

YEAR	(1) JANUARY-MARCH E	C	CPUE	(2) APRIL-JUNE E	C	CPUE	(3) JULY-SEPTEMBER E	C	CPUE	(4) OCTOBER-DECEMBER E	C	CPUE	INDEX CPUE QUARTERS 2,3,4
1956	0	0	0	2.24	0	0	0	0	0	0	0	0	0.00 1/
1957	0	0	0	0	0	0	10.35	0	0	0	0	0	0.00 1/
1958	0	0	0	273.63	639	23.35	449.82	430	9.56	589.55	29	.49	8.36 1/
1959	176.28	0	0	433.57	38	.88	206.95	0	0	864.68	431	4.98	3.12 1/
1960	112.51	0	0	25.67	0	0	553.27	104	1.88	713.59	13	.18	0.91
1961	50.50	0	0	33.36	21	6.30	125.25	151	12.06	141.16	405	28.69	19.25
1962	0	0	0	1876.86	3045	16.22	1368.45	754	5.51	56.50	462	81.77	12.91
1963	94.66	212	22.40	1526.54	1002	6.56	1681.06	726	4.32	1659.44	679	4.09	4.95
1964	819.29	1462	17.84	1846.18	1819	9.85	2548.14	5775	22.66	724.25	1447	19.98	17.67
1965	984.99	3806	38.64	1120.70	3591	32.04	1622.24	9354	57.66	1462.2	3801	26.00	39.82
1966	498.78	562	11.27	908.6	798	8.78	3698.35	10232	27.67	715.84	603	8.42	21.86
1967	120.29	430	35.75	73.08	48	6.57	516.32	381	7.38	312.39	1787	17.48	24.57
1968	124.52	258	20.72	277.25	600	21.64	873.92	816	9.34	109.47	258	23.57	13.28
1969	43.56	59	13.54	116.41	0	0	882.92	2452	27.77	457.88	763	16.66	22.06
1970	0	0	0	258.10	111	4.30	1020.82	3917	38.37	487.29	860	17.65	27.68
1971	130.53	319	24.44	613.3	1300	21.20	1967.81	1405	7.14	1207.05	1041	8.62	9.89
1972	119.83	169	14.10	396.9	2004	50.49	254.89	273	10.71	67.73	90	13.29	32.90
1973	0	0	0	17.70	9	5.08	297.83	251	8.43	247.83	199	8.03	8.15
1974	12.93	2	1.55	0	0	0	404.35	826	20.43	512.67	1127	21.98	21.30

1/ Not used in MSY calculations

(in metric tons)

TABLE 9. Estimated Yearly Removals of Sailfish/from the Atlantic Ocean North of the Equator and West of 40 Degrees1/ and Values of Catch Per Unit of Effort Index Used to Calculate Relative Effort (see text).

	LONGLINE COUNTRIES				U.S. RECREATIONAL		TOTAL		INDEX 5/
YEAR	JAPAN 2/	TAIWAN 3/	VENEZUELA 4/	TOTAL	LOW	HIGH	LOW	HIGH	CPUE
1960 6/	18	----	----	18	172	574	190	592	.020
1961 6/	14	----	----	14	245	821	259	835	.549
1962	55	----	----	55	233	775	288	830	.310
1963	124	----	----	124	264	882	388	1006	.122
1964	406	----	----	406	312	1035	718	1441	.470
1965	812	----	----	812	187	622	999	1434	.572
1966	499	5	----	504	293	979	797	1483	.483
1967	75	19	----	94	107	356	201	450	.117
1968	140	61	30	231	261	870	492	1101	.253
1969	137	20	40	197	260	863	457	1060	.388
1970	242	186	40	468	356	1185	824	1653	.654
1971	305	58	50	413	277	924	690	1337	.203
1972	107	9	0	116	264	879	380	995	.501
1973	84	12	0	96	263	875	359	971	.122
1974	172	35	9	216	351	1167	567	1383	.405

1/ Estimates exclude allowance for removals by countries such as Guadeloupe and Martinique, which are not members of ICCAT and either do not report billfish landings to FAO or report billfish with unspecified tuna-like fishes.

2/ Whole Atlantic catch in weight according to ICCAT apportioned to the western North Atlantic according to the proportion of sailfish, by number, taken within the area. Japanese do not separate sailfish and spearfish in their statistics; spearfish landings are considered minor.

3/ Whole Atlantic catch of billfish in weight apportioned to species assuming that the species composition of the Taiwanese billfish catch by weight is identical to that of Japan. Apportionment to western North Atlantic is according to the proportion, by number, of sailfish taken in the area by Taiwan.

4/ The difference between total billfish reported to ICCAT and blue marlin reported to FAO was assumed to be 50 percent white marlin and 50 percent sailfish.

5/ See Table 8 for numeric catch rates and average weights.

6/ Data for these years were not used to compute MSY.

Table 10. A summary of MSY calculations for sailfish.

SAILFISH

CASE	R-SQUARE	TONS	NO. OF FISH
LONGLINE ALONE	.07	450	22,500
LOW RECREATIONAL	.44	960	48,000
HIGH RECREATIONAL	.42	2700	135,000
PREVIOUS ESTIMATE	.12	---	16,950

PROGNOSIS: A. LOW RECREATIONAL CASE APPEARS MOST REASONABLE.

B. STOCK APPEARS FULLY EXPLOITED.

Figure 1. Distribution of Japanese longline fishing effort in the North Atlantic Ocean, 1956-1973.

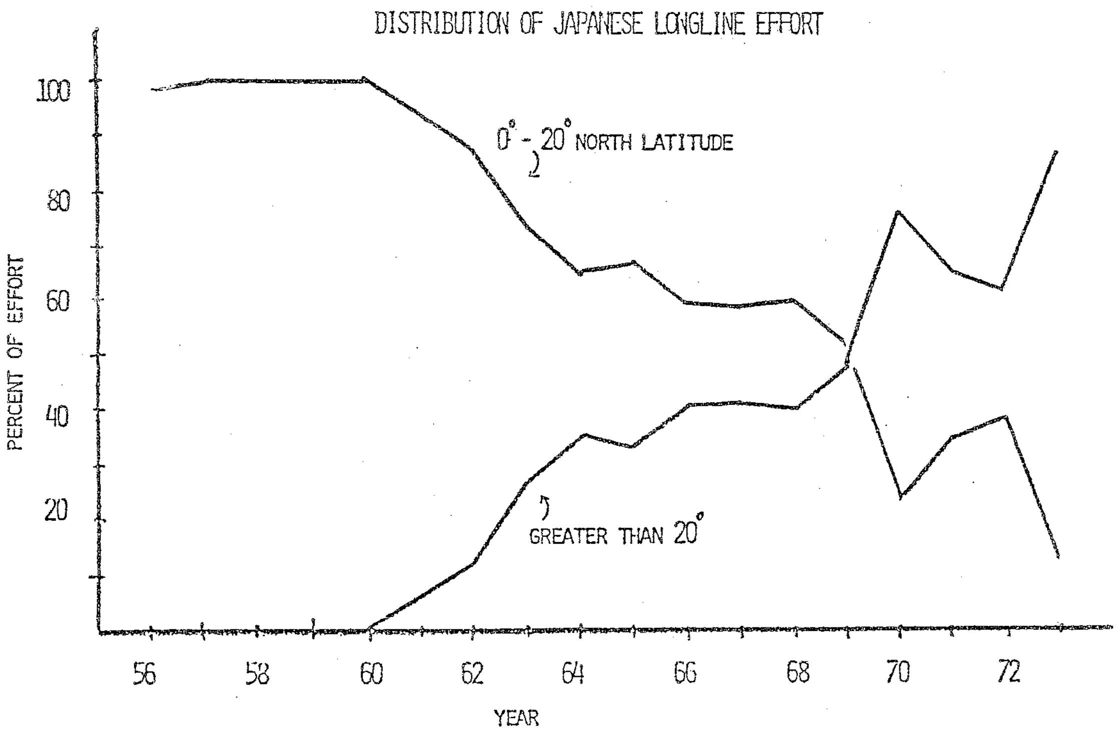
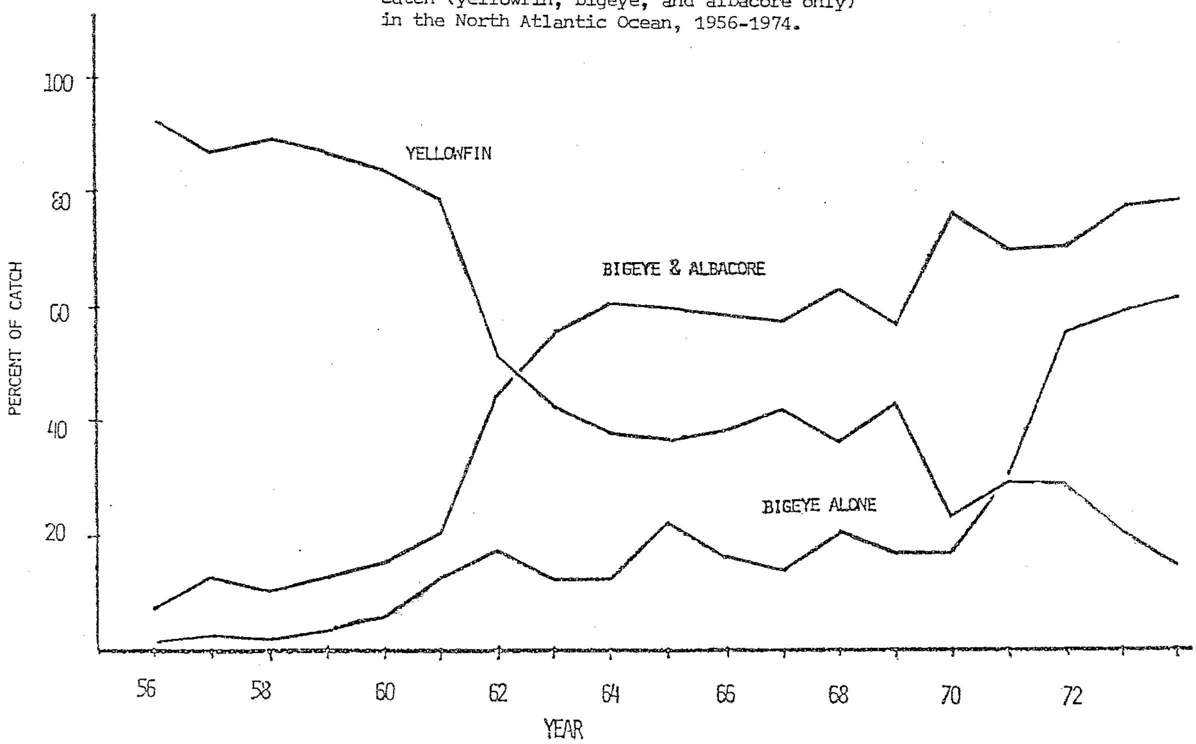


Figure 2. Species composition of the Japanese tuna catch (yellowfin, bigeye, and albacore only) in the North Atlantic Ocean, 1956-1974.



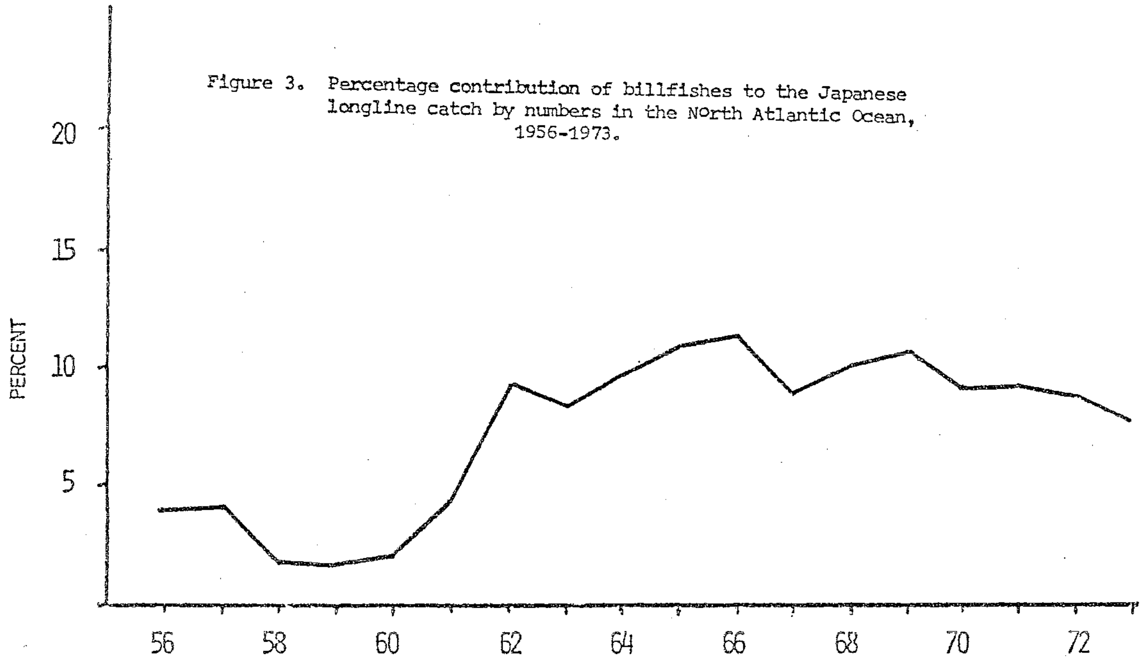


Figure 3. Percentage contribution of billfishes to the Japanese longline catch by numbers in the North Atlantic Ocean, 1956-1973.

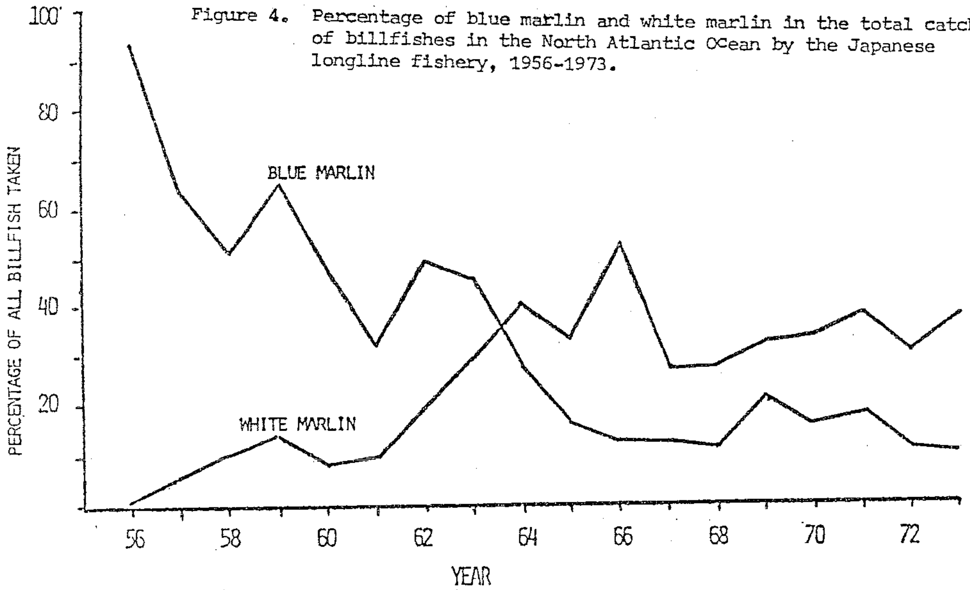


Figure 4. Percentage of blue marlin and white marlin in the total catch of billfishes in the North Atlantic Ocean by the Japanese longline fishery, 1956-1973.

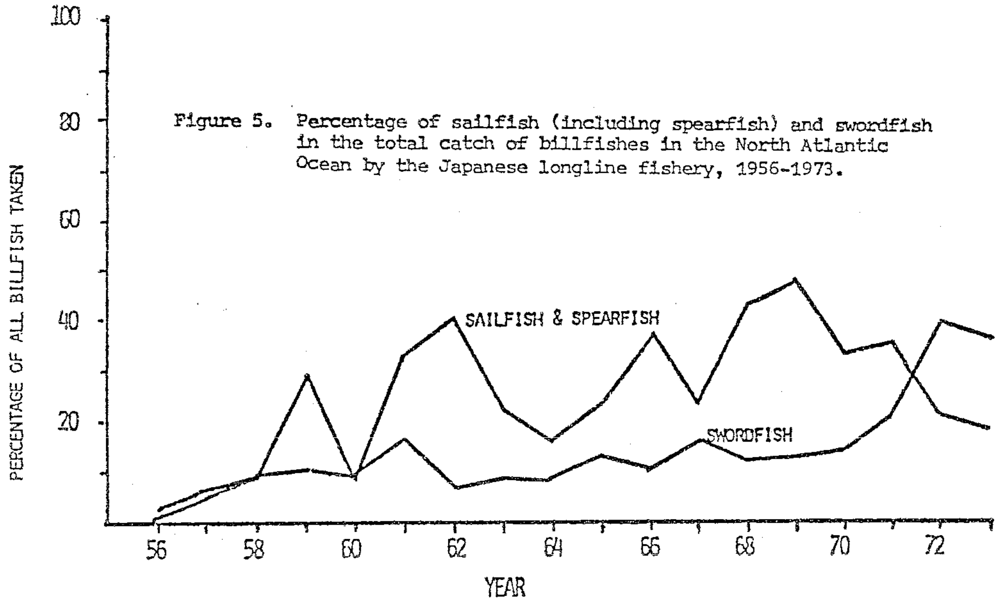


Figure 5. Percentage of sailfish (including spearfish) and swordfish in the total catch of billfishes in the North Atlantic Ocean by the Japanese longline fishery, 1956-1973.

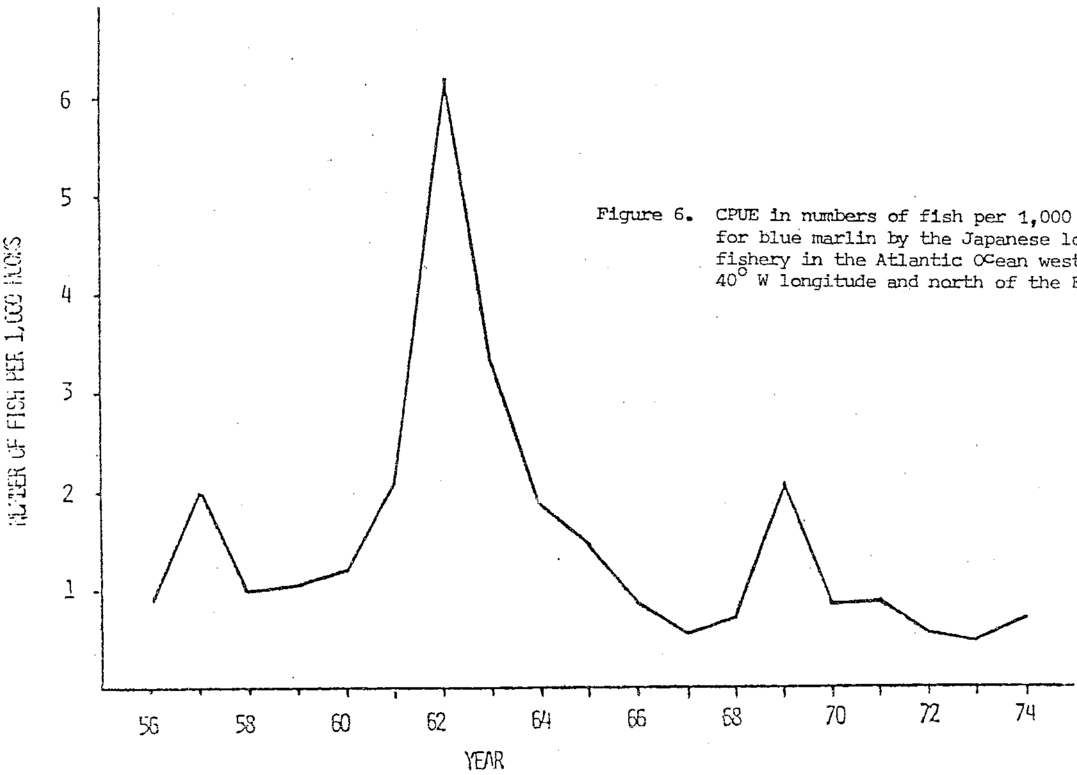


Figure 6. CPUE in numbers of fish per 1,000 hooks for blue marlin by the Japanese longline fishery in the Atlantic Ocean west of 40° W longitude and north of the Equator.

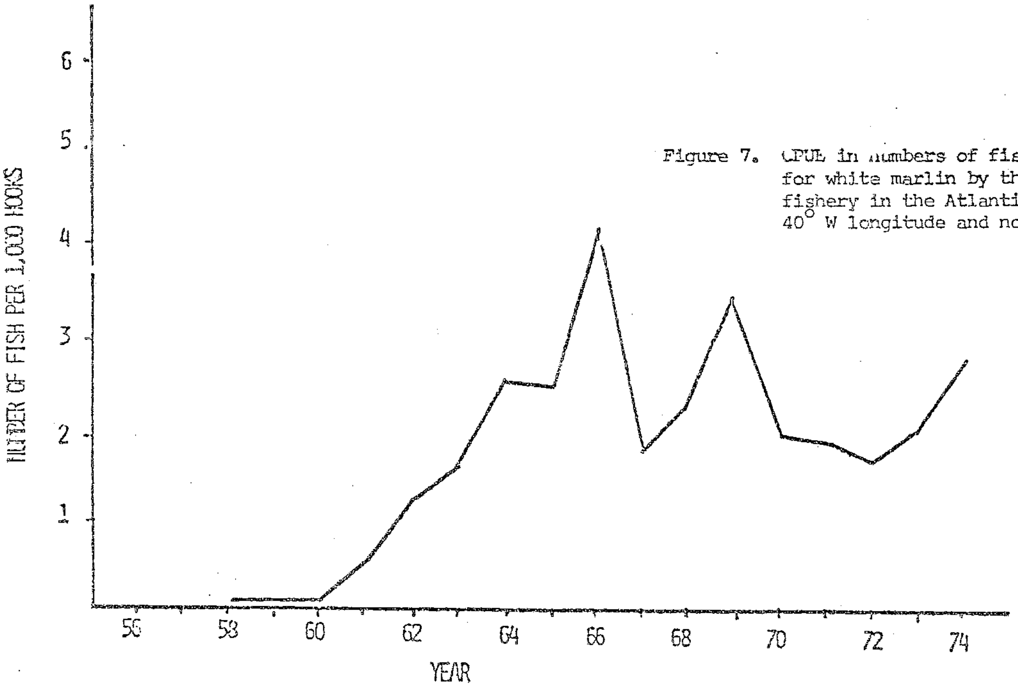


Figure 7. CPUE in numbers of fish per 1,000 hooks for white marlin by the Japanese longline fishery in the Atlantic Ocean west of 40° W longitude and north of the Equator.

Figure 8. CPUE in numbers of fish per 1,000 hooks for sailfish (including spearfish) by the Japanese longline fishery in the Atlantic Ocean west of 40° W longitude and north of the Equator.

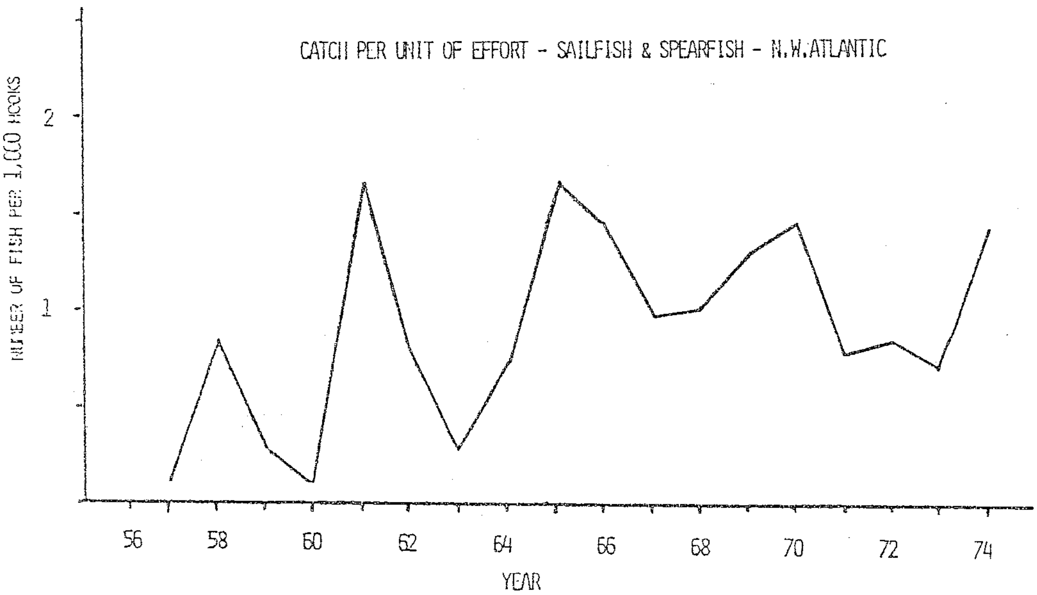


Figure 10. Average weights of blue marlin in the Atlantic Ocean from the Japanese longline fishery and U.S. exploratory longline efforts (dashed lines connect discontinuous points).

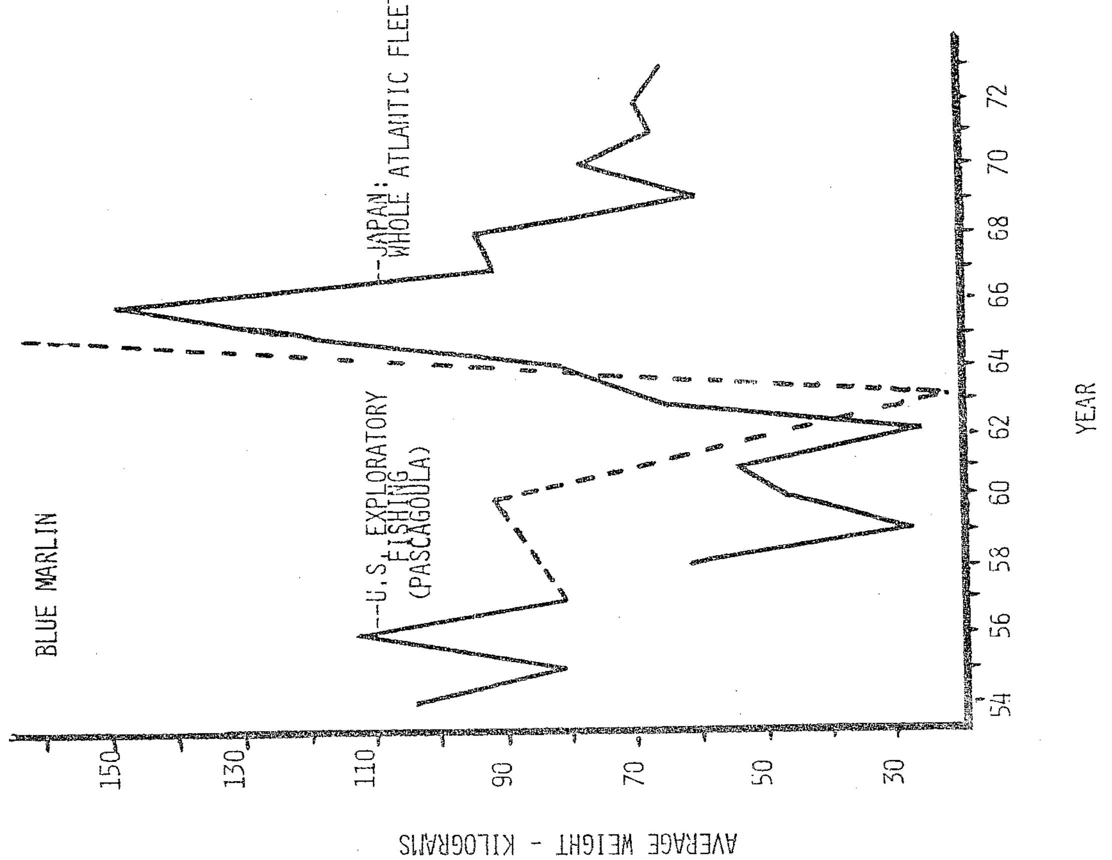


Figure 9. Index catch rates in metric tons per 10,000 hooks for marlins and sailfish (including spearfish) in the Caribbean Index Area. The Index Area is bounded by 50° W longitude, 20° N latitude, and Central and South America.

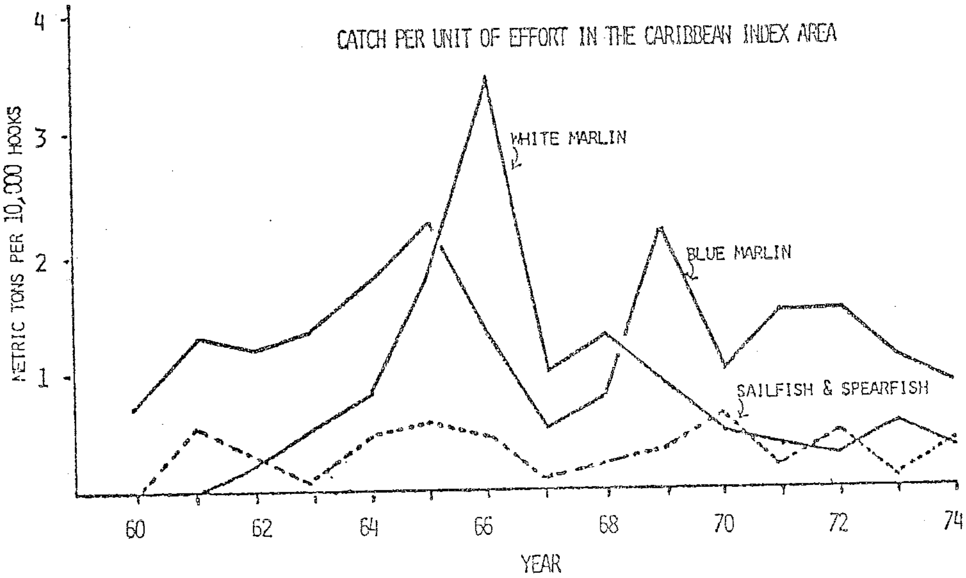


Figure 11. Estimated landings of blue marlin in the Western North Atlantic Ocean, 1960-1974. The points on the figure indicate total landings. For example, the high recreational case gives estimated total landings by the total longline fishery and the recreational fishery using the high estimate of recreational landings.

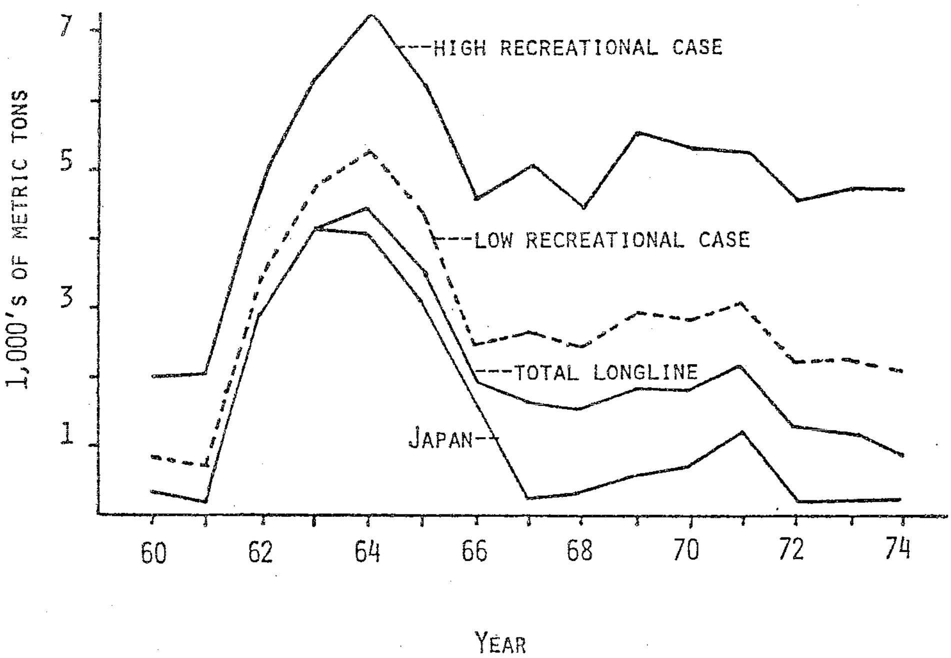


Figure 12. An historical catch-relative effort plot and Schaefer yield curve for blue marlin in the longline fishery in the western North Atlantic Ocean.

BLUE MARLIN - LONGLINE

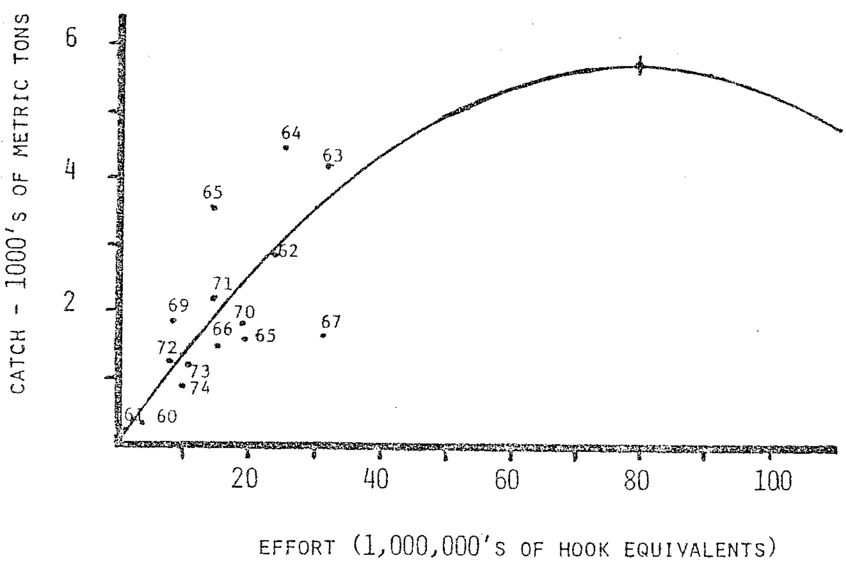


Figure 13. An historical catch-relative effort plot and Schaefer yield curve for blue marlin in the western North Atlantic assuming a low recreational catch.

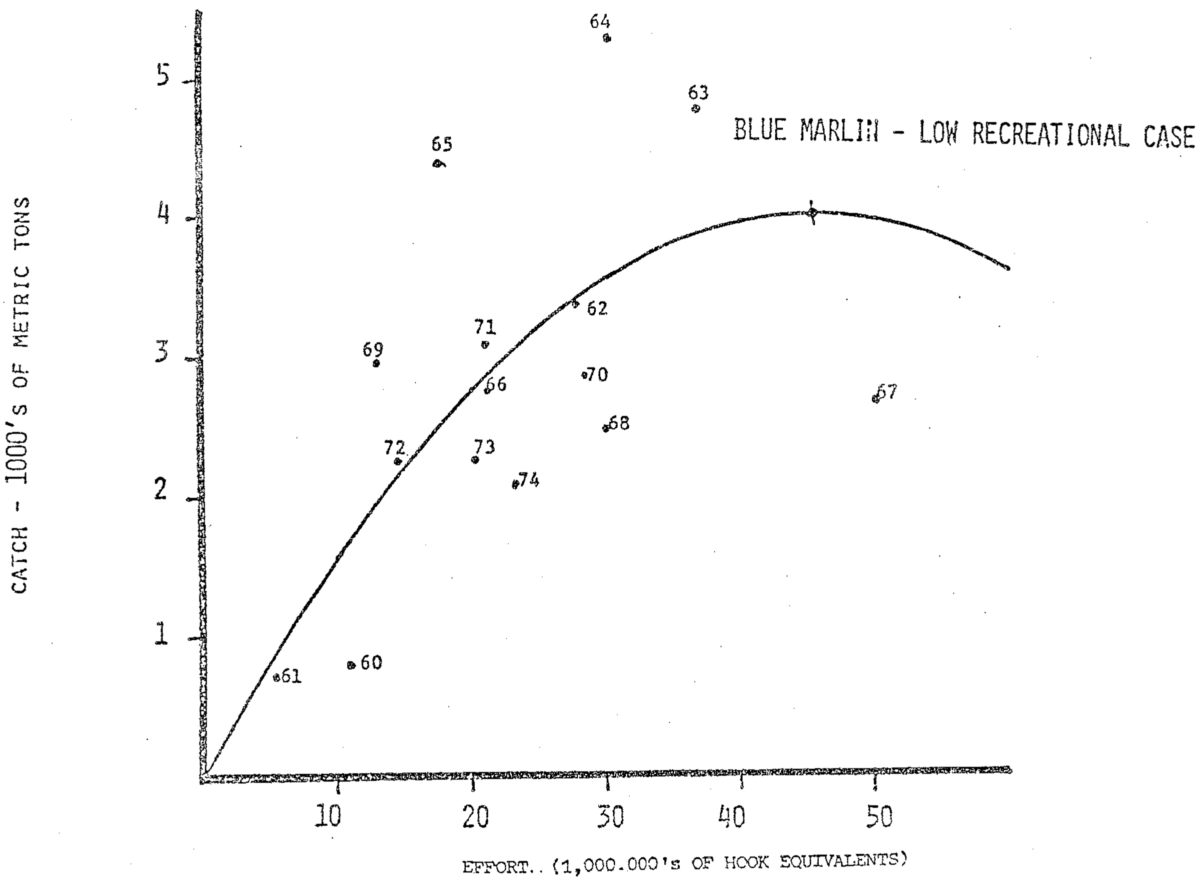


Figure 14. An historical catch-relative effort plot and Schaefer yield curve for blue marlin in the western North Atlantic OCean assuming a high recreational catch.

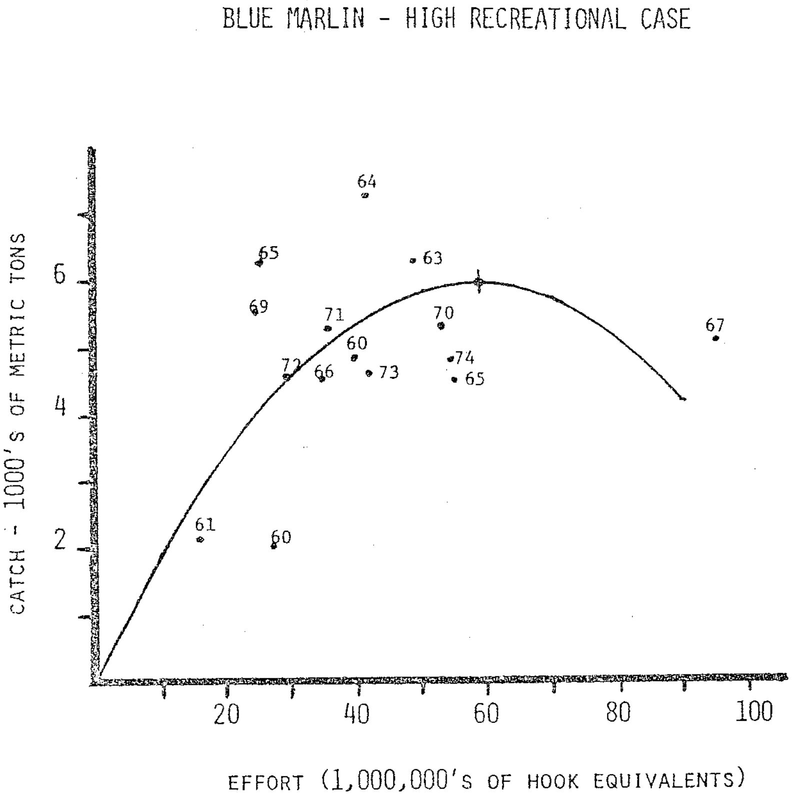
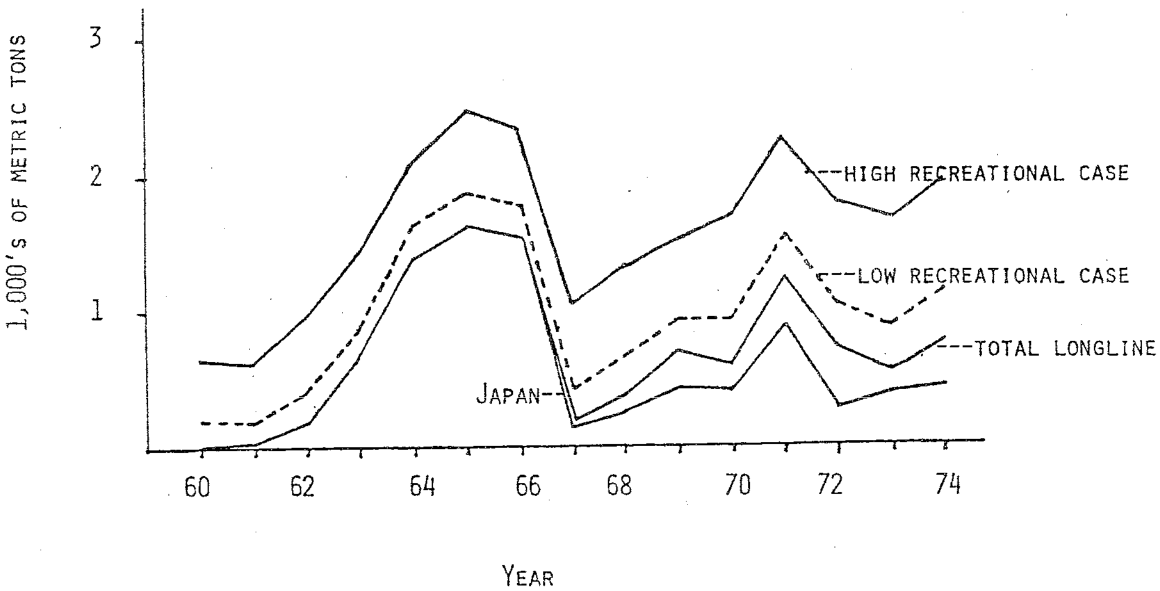


Figure 16. Estimated landings of white marlin in the Western North Atlantic Ocean, 1960-1974. The points on the figure indicate total landings. For example, the high recreational case gives estimated total landings by the entire longline fishery and the recreational fishery using the high estimate of recreational landings.



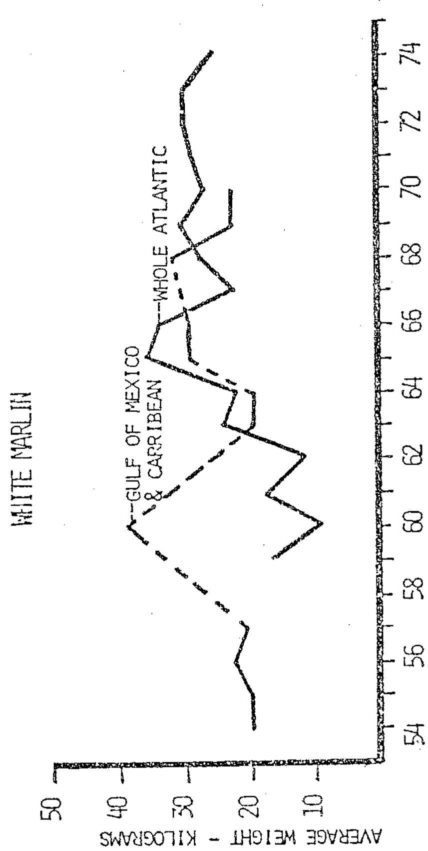


Figure 15. Average weights of white marlin in the Atlantic Ocean from the Japanese longline fishery and U.S. exploratory longline efforts (dashed lines connect discontinuous points).

Figure 17. An historical catch-relative effort plot and Schaefer yield curve for white marlin in the longline fishery in the western North Atlantic Ocean.

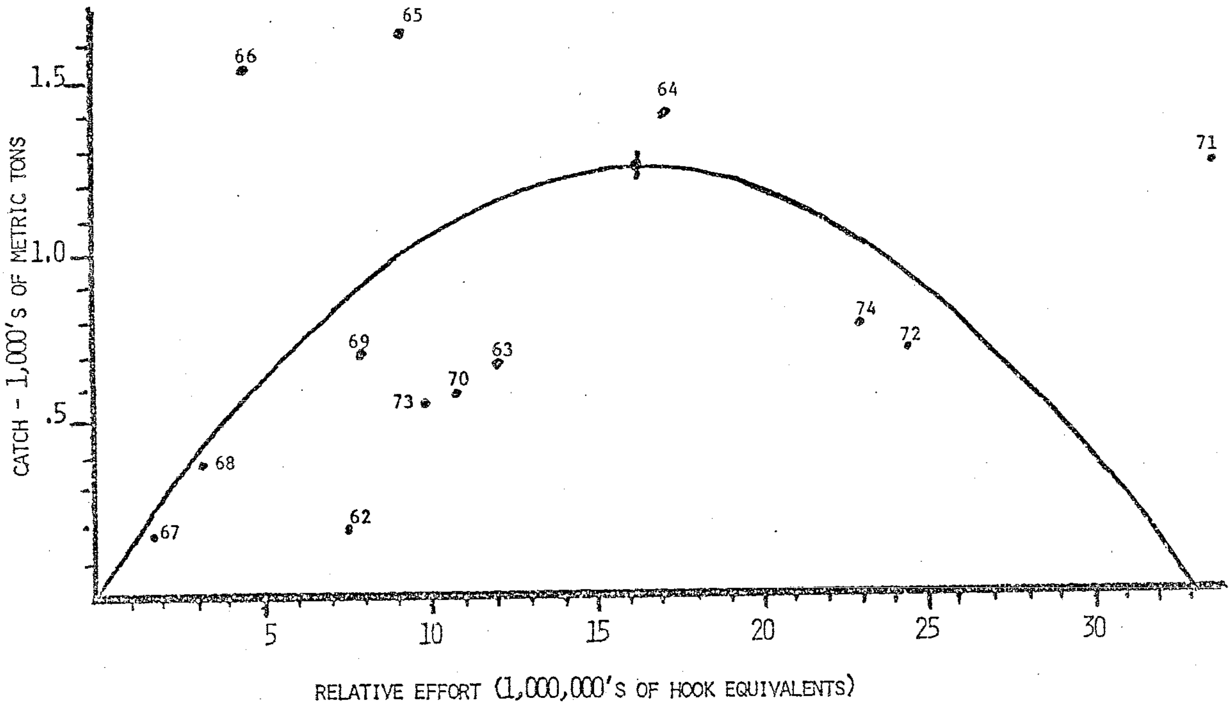


Figure 18. An historical catch-relative effort plot and Schaefer yield curve for white marlin in the western NOrth Atlantic assuming a low recreational çatch.

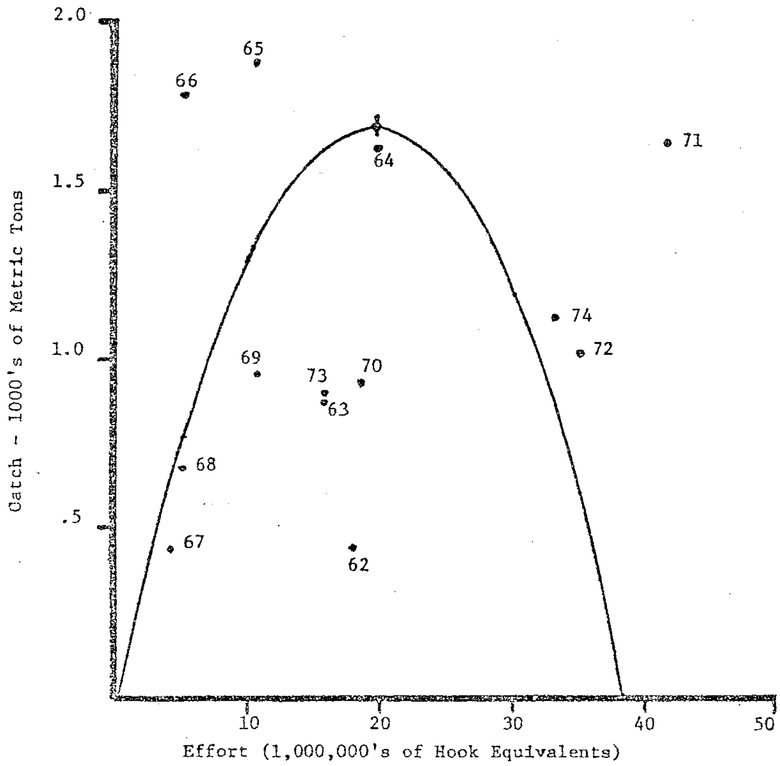


Figure 20. Average weights of sailfish in the Atlantic Ocean from the U.S. recreational fishery and exploratory fishing operations (dashed lines connect discontinuous points).

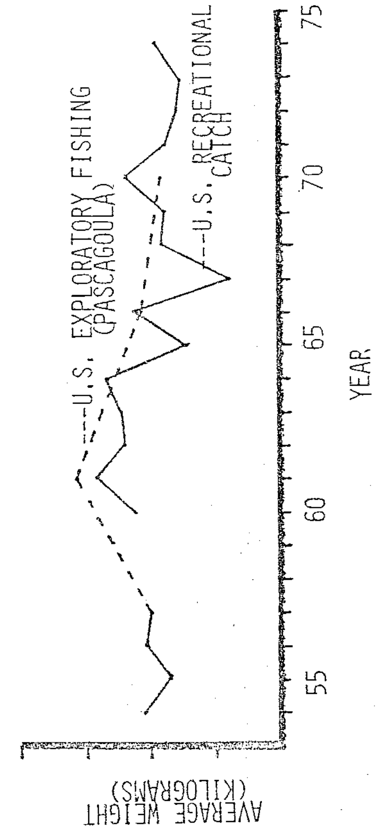


Figure 19. An historical catch-relative effort plot and Schaefer yield curve for white marlin in the western North Atlantic assuming a high recreational catch.

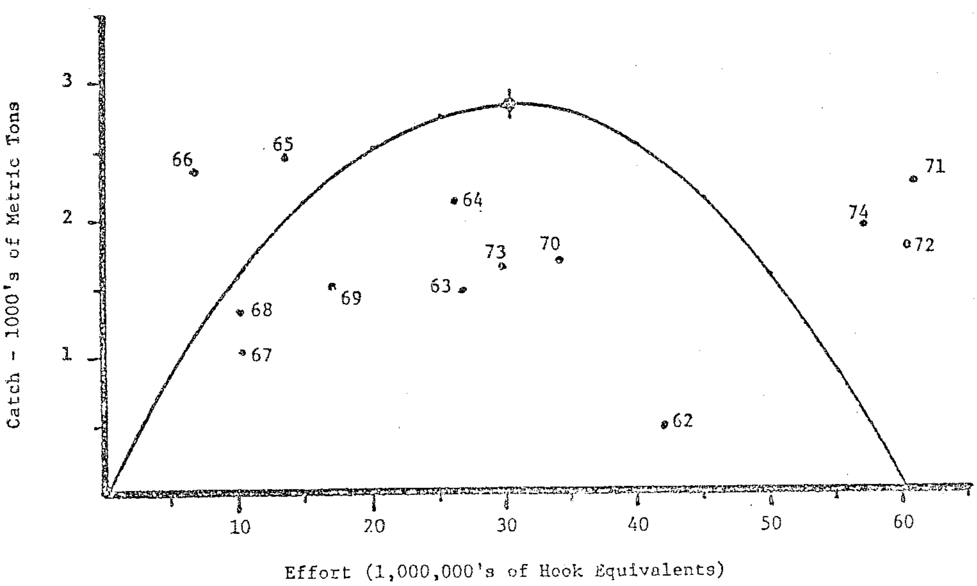


Figure 21. Estimated landings of sailfish from the western North Atlantic Ocean, 1960-1974. The points on the figure represent total landings. For example, the high recreational case gives estimated total landings by the entire longline fishery and the recreational fishery using the high estimate of recreational landings.

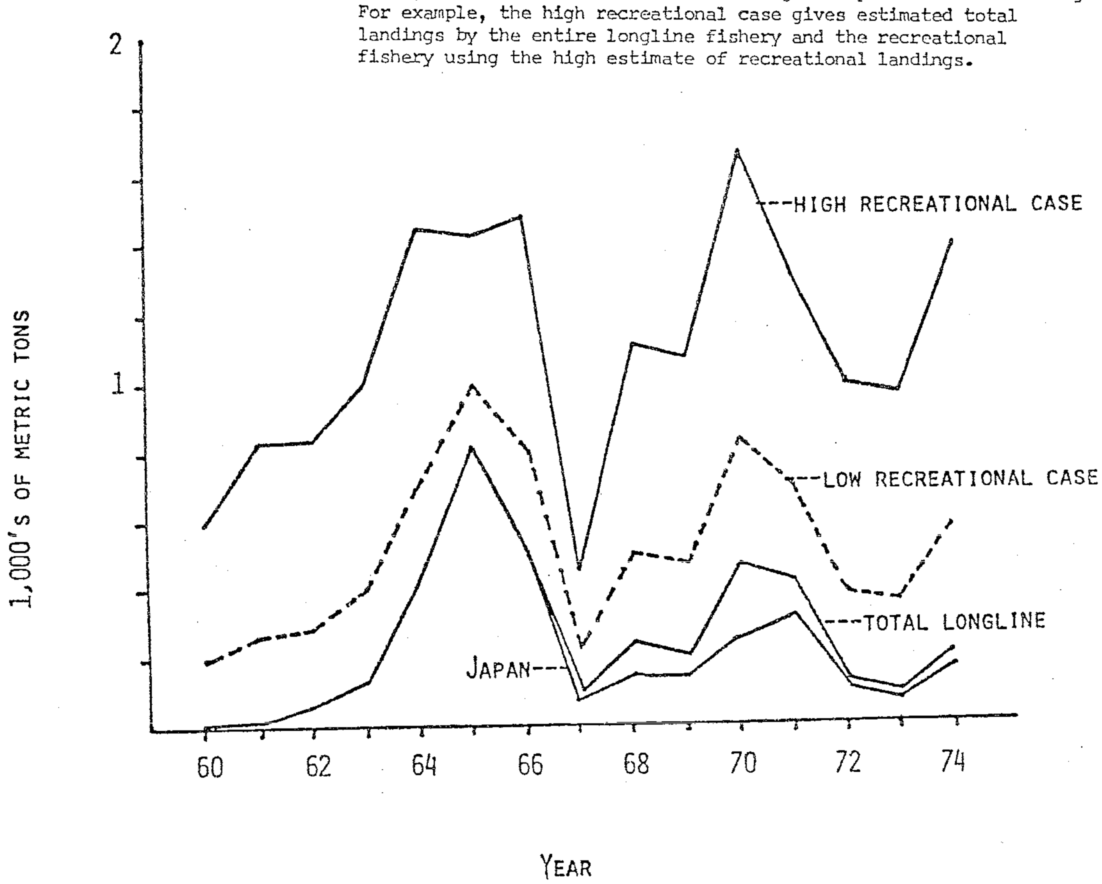


Figure 22. An historical catch-relative effort plot and Schaefer yield curve for sailfish in the longline fishery in the western North Atlantic.

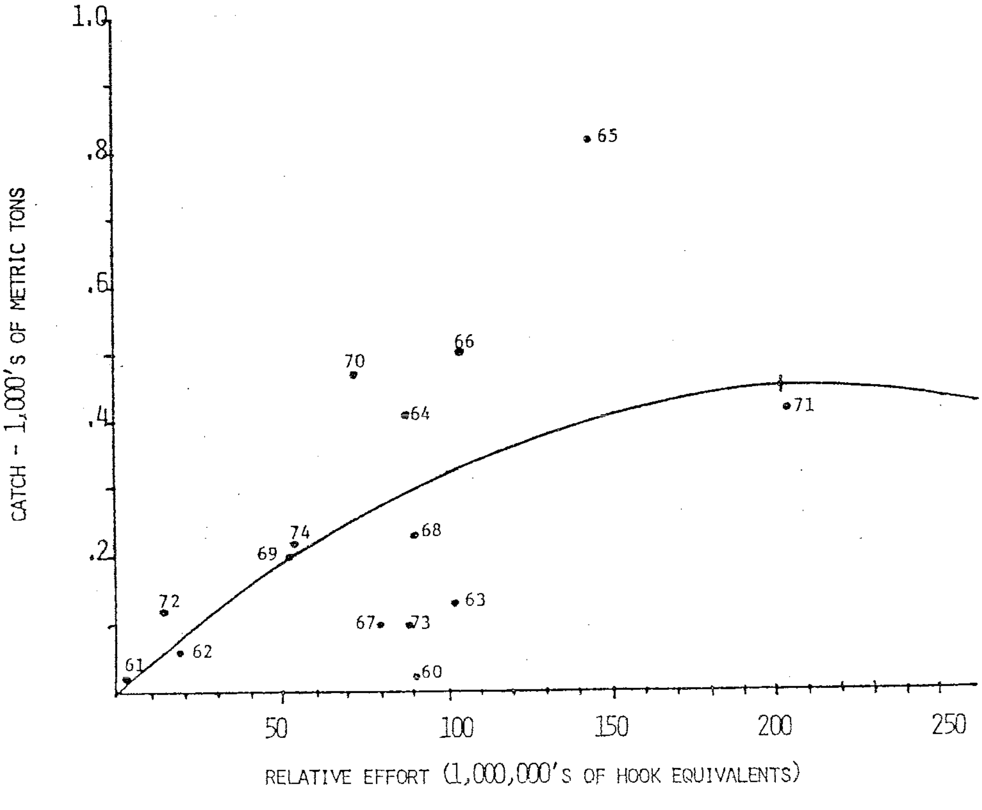


Figure 23. An historical catch-relative effort plot and Schaefer yield curve for sailfish in the western North Atlantic assuming a low recreational catch.

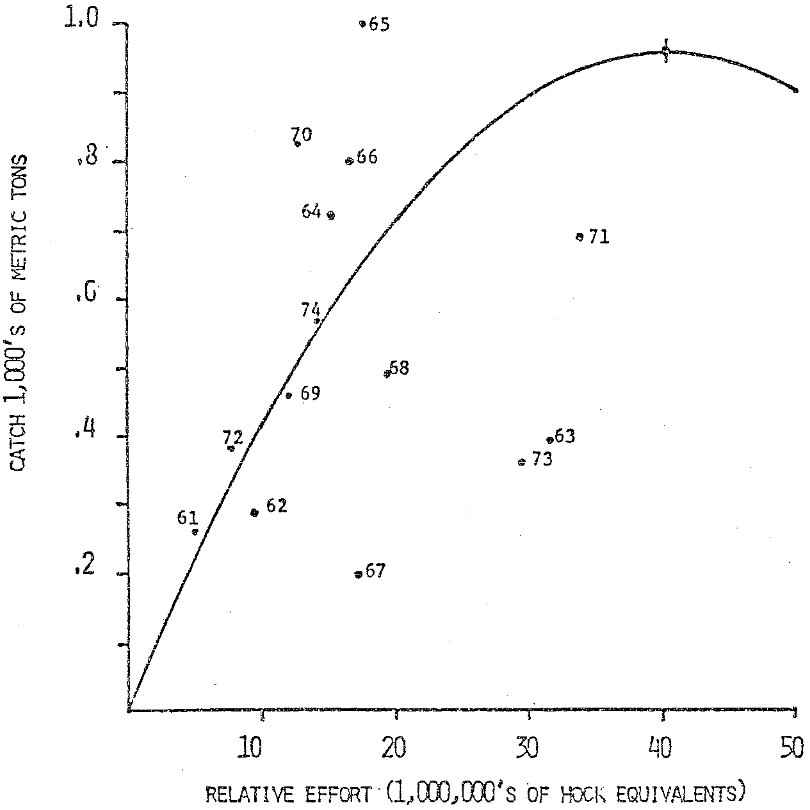
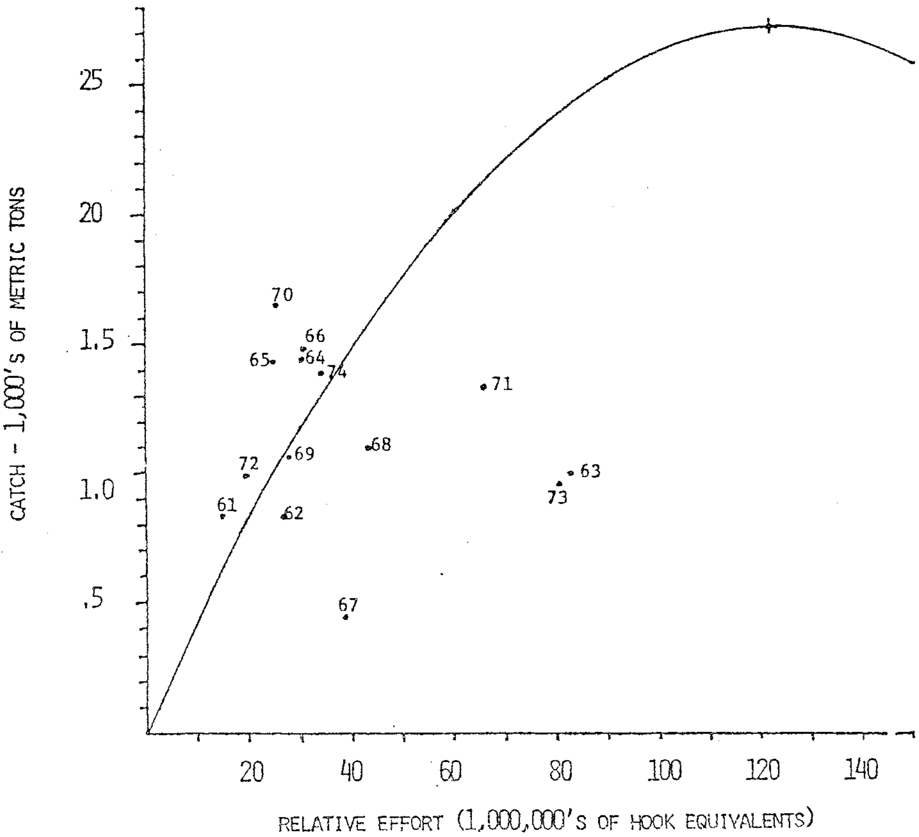


Figure 24. An historical catch-relative effort plot and Schaefer yield curve for sailfish in the western North Atlantic assuming a high recreational catch



APPENDIX

ESTIMATION OF RECREATIONAL CATCHES FOR BILLFISH AND PELAGIC SHARKS

Estimates of recreational catch were derived from NMFS saltwater angling surveys (Clark, 1962; Deuel and Clark, 1968; Deuel, 1973; and NMFS. 1975) and from unpublished NMFS survey data of the Southeast Region. The last data set was used for estimates of catch rates. These were assumed relatively constant over all years. Obviously, this is only a first approximation. The derivation of catch estimates for 1960, 1965, and 1970 is shown in Table A1. Estimates for 1975 were linearly extrapolated from the 1960, 1965, and 1970 estimates. Those for intervening years were interpolated. This procedure is illustrated in Figures A2, A3, and A4. The resulting catch estimates for "low" and "high" are shown in Table A5. The estimates are given as numbers of fish. These were converted to weight by use of the annual average weight in the recreational fishery (Beardsley, 1976) before being used in production models.

TABLE A1 ESTIMATION OF HIGH AND LOW RECREATIONAL CATCH OF SAILFISH AND MARLINS.

	MILLIONS OF ANGLERS		
	1960	1965	1970
Total "Substantial" Anglers	6.2	8.2	9.4
Minus "Non-billfish-area" Anglers	-2.6	-2.0	-2.1
Arbitrary Adjustment for Traveling	+0.2	+0.2	+.2
Anglers: "Low" estimate	3.8	6.4	7.5
Anglers: "High" estimate 1/	12.7	21.3	25.0
	--------- thousands of fish	-------------------	
Sailfish: "Low" estimate 2/	7.6	12.8	15.0
"High" estimate	25.4	42.6	50.0
White Marlin: "Low" estimate 3/	6.1	10.2	12.0
"High" estimate	20.3	34.1	40.0
Blue Marlin: "Low" estimate 4/	5.0	8.3	9.8
"High" estimate	16.5	27.7	32.5

1/ Low represents the estimated number of "Substantial" anglers potentially fishing for billfish; high is low/0.3, the factor being derived from the estimated ratio of substantial anglers to total anglers.

2/ Sailfish catch rate 2.0 fish per 1,000 anglers.
3/ White marlin catch rate 1.6 fish per 1,000 anglers.
4/ Blue marlin catch rate 1.3 fish per 1,000 anglers.

Figure A2. Interpolation and extrapolation of low and high estimates of the U.S. recreational catch of blue marlin from the Atlantic Ocean.

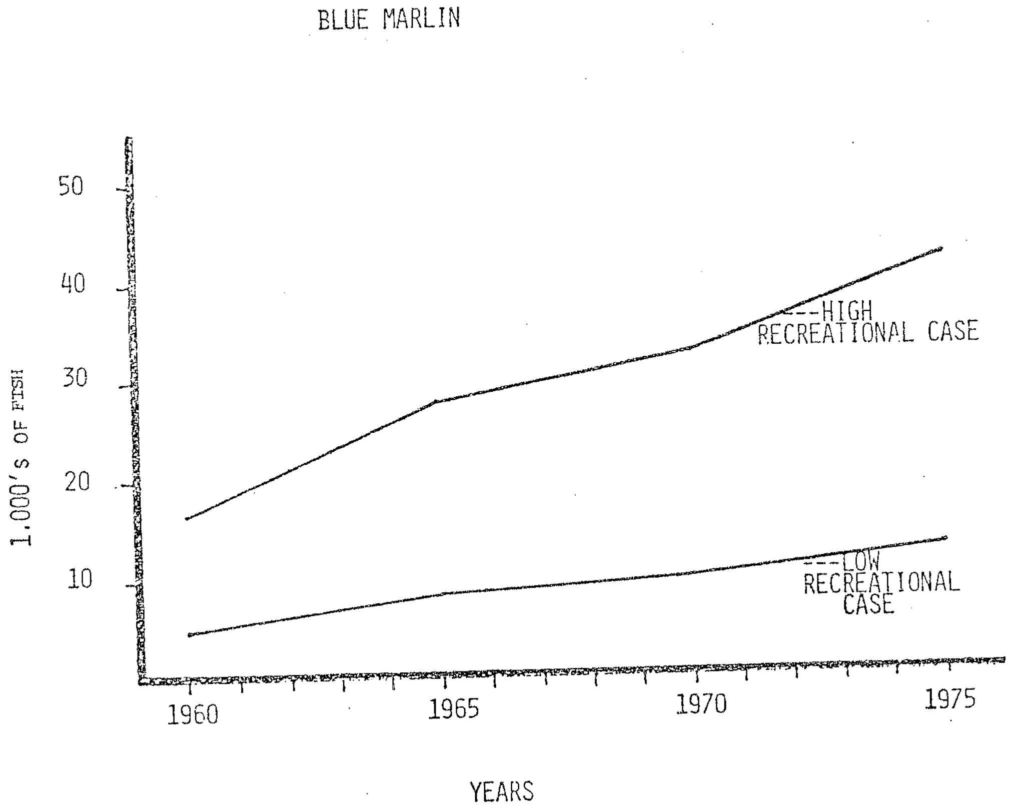


Figure A3. Interpolation and extrapolation of low and high estimates of the U.S. recreational catch of white marlin from the Atlantic Ocean.

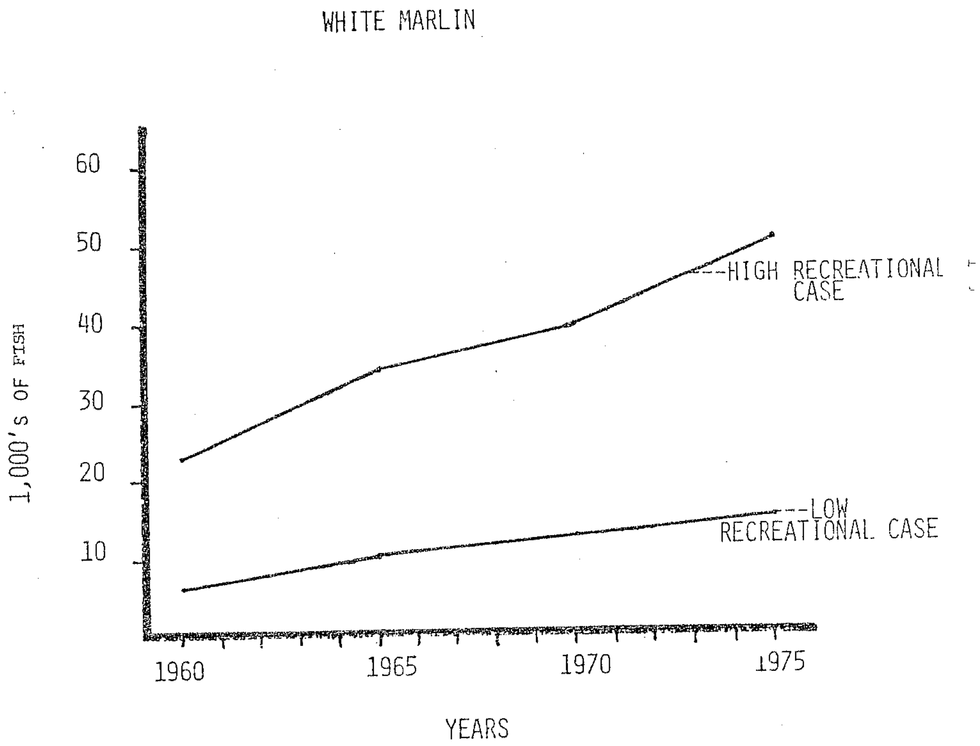


Figure A4. Interpolation and extrapolation of low and high estimates of the U.S. recreational catch of sailfish from the Atlantic Ocean.

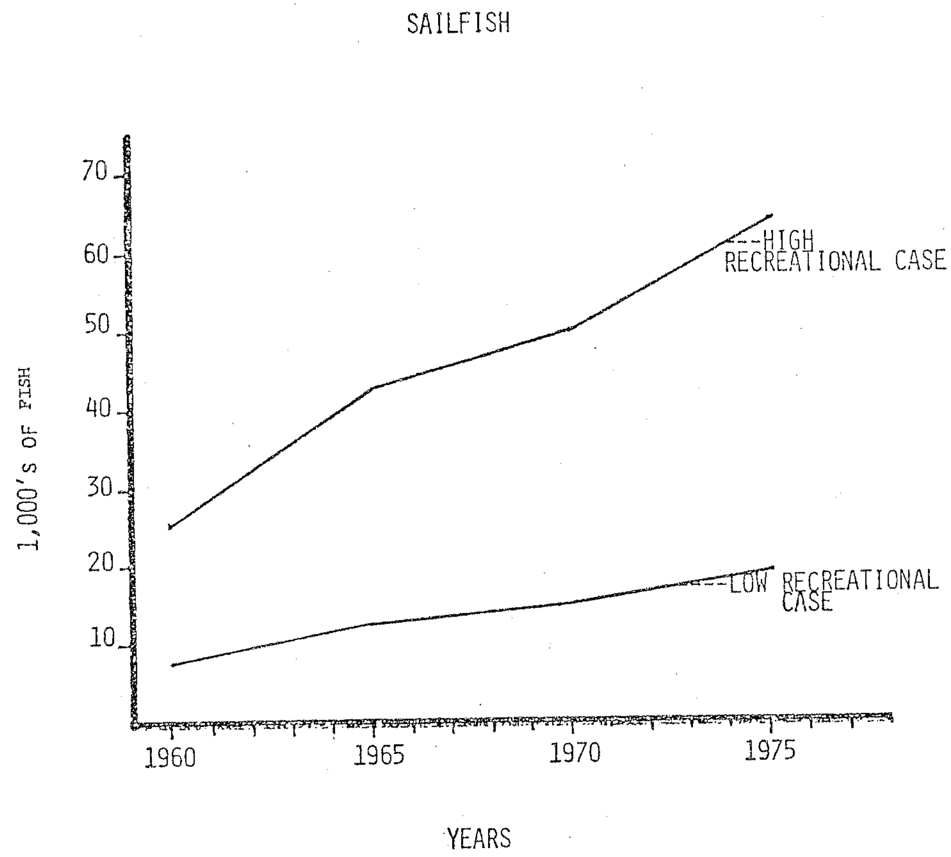


TABLE A5 LOW AND HIGH ESTIMATES OF U.S. RECREATIONAL CATCH OF BILLFISH AND PELAGIC SHARKS FROM THE ATLANTIC (Thousands of Fish) 1/

YEAR	SAILFISH Low	SAILFISH High	BLUE MARLIN Low	BLUE MARLIN High	WHITE MARLIN Low	WHITE MARLIN High	SHARKS
1960	7.6	25.4	5.0	16.5	6.1	20.3	-
1961	8.6	28.8	5.7	18.7	6.9	23.1	-
1962	9.7	32.3	6.3	21.0	7.7	25.8	-
1963	10.7	35.7 [2]	7.0	23.2	8.6	28.6	-
1964	11.8	39.2	7.6	25.5	9.4	31.3	-
1965	12.8	42.6	8.3	27.7	10.2	34.1	2.6
1966	13.2	94.1	8.6	28.7	10.6	35.3	4.0
1967	13.7	45.6	8.8	29.6	10.4	36.5	5.5
1968	14.1	47.0	9.1	30.6	11.3	37.6	7.0
1969	14.6	48.5	9.3	31.4	11.6	38.8	8.2
1970	15.0	50.0	9.8	32.5	12.0	40.0	9.9
1971	15.8	52.8	10.3	34.3	12.7	42.2	11.0
1972	16.7	55.6	10.4	36.1	13.3	44.4	13.0
1973	17.5	58.3	11.4	38.0	14.0	46.6	14.0
1974	18.4	61.1	12.0	39.8	14.6	48.9	16.0
1975	19.2	63.9	12.5	41.6	15.3	51.2	-

1/ Swordfish catch by anglers considered as negligible.

2/ Shark landings were simply extrapolated from recreational survey data, hence there is only one estimate.