SCRS/1976/079

Col.Vol.Sci.Pap. ICCAT, 6 (2): 408-416 (1977)

MATURITY, FECUNDITY AND SEX COMPOSITION OF WHITE MARLIN (TETRAPTURUS ALBIDUS)

by

R. E. Baglin

SUMMARY

A sex ratio of 1.6 females to 1 male (with wide monthly variation) for 1,185 white marlin was obtained from the U.S. sport fishery in the western North Atlantic Ocean. Monthly changes in gonadal weight and egg diameters indicated that spawning occurred in April and May. Fecundity ranged from 4.8 to 10.5 million eggs for females 26.8 to 36.3 kg.

RESUME

Un sex ratio de 1,6 femelles pour 1 mâle (avec de grandes variations mensuelles) a été obtenu pour le makaire blanc dans la pêcherie sportive américaine de l'Atlantique Nord-Ouest. Les modifications mensuelles du poids des gonades et du diamètre des oeufs indiquent que la ponte a lieu en avril et mai. La fécondité va de 4,8 à 10,5 millions d'oeufs pour des femelles de 26,8 à 36,3 kgs.

RESUMEN

La pesquería deportiva estadounidense en el Atlántico noroeste capturó 1.185 agujas blancas, cuyo sex ratio era de 1,6 hembras por 1 macho (con importantes variaciones por mes). Los cambios mensuales observados en el peso de las gonadas y en el diámetro de los huevos indica que el desove tuvo lugar en abril y mayo. La gama de fecundidad es de 4,8 a 10,5 millones de huevos, correspondientes a hembras de 26,8 a 36,3 kgs de peso.

NMFS-SEFC Contribution No. 467

INTRODUCTION

The white marlin, Tetrapturus albidus, is distributed over the Atlantic from latitude 35°S to 45°N (Mather, Clark, Mason, 1975). The major concentrations, however are located in the western North and South Atlantic. A valuable sport fishery revolves around this important species in the North Atlantic. White marlin are also an incidental catch of longliners fishing for tuna in the North Atlantic.

Little is known about the white marlin's biology and no information is available regarding its fecundity (Mather, Clark, Mason, 1975). This study examines sex composition and female gonadal development, and determines fecundity, defined as the potential number of mature eggs (yolked ova in the most advanced mode) that could be spawned during one reproductive season.

MATERIALS AND METHODS

Sex was determined for 1,185 white marlin captured from 1971 to 1975, and ovaries were examined from 186 females caught from 1972 to 1976. These fish were sampled at sport fishing tournaments held along the Gulf of Mexico, the Bahamas, and the Middle Atlantic Bight, and southeastern United States. Some fish were sampled at Pflueger's Taxidermy, Inc., in Hallandale, Florida, and one fish was collected in the Windward Passage during R/V OREGON Cruise 66.

Body lengths (cm) were measured according to Rivas (1956) and weights were recorded in kilograms. Gonads were either removed from the fish, blotted dry, and weighed (g) or stored directly in 10% Formalin and weighed later. An analysis of variance was conducted to find if there was a significant difference in length between left and right ovaries. The gonadosomatic index (GSI) is defined as fresh or preserved ovary weight divided by body weight x 100, and was calculated for 186 fish. Eggs considered mature for estimating fecundity were determined visually after measuring the diameters of randomly selected eggs from mature, partly spent, and spent fish. For fish with small transparent ova, a few drops of aceto-carmine stain were added for easier measuring. Eggs were measured with an ocular micrometer (1 unit = 0.033 mm) at 30X magnification. Orientation was assumed to be random with respect to the micrometer scale. Thin cross sections were taken from the anterior, middle, and posterior parts of one ova of a mature fish. A triangular section was then subdivided into three subsamples representing the center, mid-region, and periphery of the ovary(Otsu and Uchida, 1959). The frequency distribution of ova in each section was determined and an analysis of variance was conducted to find if there was a significant difference in egg size.

Fecundity was estimated using a dry gravimetric method. For four fish in which the entire ovaries were available, a thin cross section was taken from the anterior, middle, and posterior parts of each ovary. The eggs from each section and from the remainder of the ovaries were separated from the ovarian tissue by straining them over a wire screen, under running water. Next, the eggs from the anterior, middle, and posterior parts of each ovary were stirred, and a subsample of approximately 1 to 2 g wet weight was removed with a pipette. The number of yolked eggs in the most advanced state were counted. The subsample and remaining eggs were dried separately at 60°C in a drying oven to get a constant weight. The subsample was weighed to the nearest 0.1 mg, and the weight of the remaining eggs recorded in grams. For six other fish, only a center cross section of the ovary was available. Eggs were also separated and the largest eggs counted--the subsample was dried and weighed. A dry/wet weight regression was used to estimate the total dry weight of the eggs in the ovaries. From each fish used for estimating fecundity, 25 eggs 0.30 mm and larger were randomly selected and measured. Fecundity rounded to the nearest 0.1 million mature eggs, was determined by a proportion.

RESULTS

Sex ratios of white marlin from the Gulf, Bahamas, and northeastern and southeastern United States show there is a large amount of monthly variation (Table 1). For the entire period during which sexes were determined, there were more females than males in each area. The sex ratio was significantly different for the Gulf (χ^2_{1df} = 68.96), the Bahamas (χ^2_{1df} = 6.88), and the southeastern United States (χ^2_{1df} = 12.66). The sex ratio for the northeastern United States did not deviate from a 1:1 ratio (χ^2_{1df} = 0.032). The sex ratio for the 1,185 fish was significantly different from a 1:1 ratio (χ^2_{1df} = 65.6), being 1.6 females to 1 male.

There was a significant difference ($F_{(1, 196)}$ = 35.7) between the length of the right ovary ($\bar{X}$ = 19.4 cm, SE = 0.561) and the left ovary ($\bar{X}$ = 25.0 cm, SE = 0.732).

Well developed ovaries were present only in some fish collected during April and May (Table 2). Fish with a GSI about 6% or greater were used for estimating fecundity.

The mean GSI showed that ovarian weights were lowest during October, increased November through April, and reached a peak in May (figure 1). The high mean GSI values for April and May, and the much lower values in later months, showed that spawning probably occurred during April and May.

Mostly eggs 0.15 mm in diameter and smaller were found in spent fish caught during May and June (figure 2). Eggs from a partly spent fish caught during June had a frequency peak about 0.35 mm. There were few eggs present larger than 0.60 mm. Some of the larger eggs appeared to be undergoing reabsorption. There were frequency peaks about 0.35 and 0.65 mm in a mature fish caught in April. Only eggs measuring 17 ocular micrometer units or 0.56 mm and larger were included when estimating fecundity.

A significant difference was found between the anterior, middle, and posterior sections of an ovary from a mature fish ($F_{2,\ 2,676}$ = 7.7). There was no significant difference in mean diameter between the center, mid-region, and periphery of each of the three sections.

Since some heterogeneity occurred, estimates of fecundity were based, when possible, on eggs from each section of both ovaries. From the 25 eggs measured for each of the 10 fish used for fecundity, an average of 42% were smaller than 0.56 mm.

Fecundity ranged from 4.8 to 10.5 million eggs ($\bar{X}$ = 7.7) for white marlin weighing 26.8 to 36.3 kg (Table 3). The number of mature ova per gram of body weight ranged from 179 to 332 ($\bar{X}$ = 238).

DISCUSSION

Variation in sex ratios for white marlin has previously been reported by De Sylva and Davis (1963). Rivas (1976) found that female bluefin tuna, Thunnus thynnus, outnumber the males by seven to three in part of the spawning grounds (Straits of Florida) during the May spawning season. The possibility of a similar occurrence in the white marlin is suggested.

Some variability in the estimate of fecundity given here may be due to heterogeneity of ova in the ovaries. Only the center section on one ovary was available from six of the fish studied.

Eldridge and Wares (1974) reported differential growth in ovaries for striped marlin, Tetrapturus audax, and for sailfish, Istiophorus platypterus. Both were similar to the white marlin in having larger left ovaries.

The GSI values show well developed ovaries were present only during April and May and, therefore, only one spawning season per year is indicated. The GSI values also substantiate the findings of De Sylva and Davis (1963) that white marlin spawn somewhere between the Bahamas and Cape Hatteras.

Some spawning also occurs farther south, since one fish captured in April 1976 in the Windward Passage had ripe eggs measuring to 1.16 mm. Hayasi et al. (1970) found white marlin with mature gonads during April-June in the northern Caribbean. In April Erdman (1956) found well developed ovaries in white marlin from Puerto Rico and reported well-formed eggs from a fish taken in June. Mather et al. (1975) gave a description by Hemingway of white marlin spawning off Cuba during May.

The maximum GSI of 9.28 agrees closely with the largest GSI value of 9.76 found by Krumholz (1958). The highest mean GSI's of 2.1 and 3.2 for April and May are much smaller than the 4.5 mean GSI found by Krumholz for late April.

The smallest fish approaching a ripe condition with large ovaries weighed 26.8 kg. Ueyanagi et al. (1970) said white marlin reach sexual maturity at 130 cm in body length. Using the conversion equation of Lenarz and Nakamura (1974), this would be equal to about 20.3 kg.

De Sylva and Davis (1963) also found eggs in recently spent ovaries which were apparently undergoing reabsorption. Heterogeneity of ova within an ovary has also been shown for albacore, Thunnus alalunga (Otsu and Uchida, 1959), swordfish, Xiphias gladius (Uchiyama and Shomura, 1974), and bluefin tuna (Baglin, 1976).

In post-spawning fish, mostly small eggs 0.15 mm and less were present. Fecundity was based on the number of eggs 0.56 mm and larger, which were fully yolked, and formed a group distinct from another group of developing eggs starting at 0.30 mm. Fecundity would vary depending on whether smaller eggs develop further or are reabsorbed. As already pointed out, an average of 42% of eggs 0.30 mm and larger were smaller than 0.56 mm. If fractional spawning occurs, the eggs in the next distinct group should be included in seasonal fecundity estimates.

LITERATURE CITED

Baglin, R. E. Jr. 1976. A preliminary study of the gonadal development and fecundity of the western Atlantic bluefin tuna. ICCAT, SCRS. Collective Volume of Scientific Papers (Madrid 1975), 5: 279-289.

De Sylva, D. P., and W. P. Davis. 1963. White marlin, Tetrapturus albidus, in the Middle Atlantic Bight with observations on the hydrography of the fishing grounds. Copeia, 1963(1): 81-99.

Eldridge, M. B., and P. G. Wares. 1974. Some biological observations of billfishes taken in the eastern Pacific Ocean, 1967-1970. Proc. Int. Billfish symp., Kailua-Kona, Hawaii 9-12 Auguat 1972. Part 2. Review and Contributed Papers: R. S. Shomura and F. Williams, editors: 89-100.

Erdman, D. S. 1956. Recent fish records from Puerto Rico. Bull. Mar. Sci. Gulf Caribbean, 6: 315-340.

Hayasi, S., T. Koto, C. Shingu, S. Kume, and Y. Morita. 1970. Status of the tuna fisheries resources in the Atlantic Ocean, 1956-1967. In: Resources and fisheries of tunas and related fishes in the Atlantic Ocean. Far Seas Fish. Res. Lab., S. Ser. 3: 1-72.

Krumholz, L. A. 1958. Relative weights of some viscera in the Atlantic marlins. Bull. American Mus. Nat. Histo., 114: 402-405.

Lenarz, W. H., and E. L. Nakamura. 1974. Analysis of length and weight data on three species of billfish from the western Atlantic Ocean. Proc. Int. Billfish Symp., Kailua-Kona, Hawaii, 9-12 August 1972. Part 2. Review and Contributed Papers. R. S. Shomura and F. Williams, editors: 121-125.

Mather, F. J. III, H. L. Clark, and J. M. Mason, Jr. 1975. Synopsis of the biology of the white marlin, Tetrapturus albidus Poey (1861). Proc. Int. Billfish Symp., Kailua-Kona, Hawaii, 9-12 August 1972. Part 3. Species Synopses. R. S. Shomura and F. Williams, editors: 55-94.

Otsu, T., and R. N. Uchida. 1959. Sexual maturity and spawning of albacore in the Pacific Ocean. U.S. Fish Wildlife Ser. Fish. Bull. 59(148): 287-305.

Rivas, L. R. 1956. Definitions and methods of measuring and counting in the billfishes (Istiophoridae, Xiphiidae). Bull. Mar. Sci. Gulf Caribbean, 6(1): 18-27.

Rivas, L. R. 1976. Variation in sex ratio, size differences between sexes, and changes in size and age composition in western North Atlantic giant bluefin tuna (Thunnus thynnus). ICCAT, SCRS. Collective Volume of Scientific Papers (Madrid, 1975), 5:297-301.

Uchiyama, J. H., and R. S. Shomura. 1974. Maturation and fecundity of swordfish Xiphias gladius, from Hawaiian waters. Proc. Int. Billfish Symp., Kailua-Kona, Hawaii, 9-12 August 1972. Part 2. Review and Contributed Papers. R. S. Shomura and F. Williams, editors: 142-148.

Ueyanagi, S., S. Kikawa, M. Uto, and Y. Nishikawa. 1970. Distribution, spawning, and relative abundance of billfishes in the Atlantic Ocean. Far Seas Fish. Res. Lab., Bull. 3: 15-55.

Table 2. Weight and maturity information by month of female white marlin for 1972-76.

Month	Year	Body Weight kg	Ovary Weight g	GSI
January	1973	39.0	293	0.75
March	1972	22.7	196	.86
	1973	44.0	484	1.10
		24.5	316	1.29
		33.6	438	1.30
		42.6	362	.85
		30.4	288	.95
		24.5	99	.40
		44.0	484	1.10
		40.0	201	.50
		25.4	155	.61
		39.0	550	1.41
		44.5	222	.50
		40.9	342	.84
		35.0	283	.81
		30.9	199	.64
	1974	25.0	525	2.10
		46.3	500	1.08
		49.5	425	.86
		44.5	610	1.37
		35.4	525	1.48
		34.5	225	.65
		28.1	225	.80
	1976	30.9	283	.92
		28.6	283	.99
		43.6	432	.99
		59.0	1,400	2.37
April	1972	32.7	2,693	8.23*
		29.0	443	1.52
		27.2	239	.88
		28.6	217	.76
		37.7	736	1.95
		32.2	485	1.50
		33.6	2,161	6.43*
	1973	44.9	784	1.70
		54.4	1,177	2.20
		28.1	324	1.20
		22.7	124	.54
		25.9	187	.72
		27.7	199	.72
	1974	23.6	130	.55
		34.0	510	1.50
		31.3	415	1.32
		25.4	431	1.70
		26.3	196	.74
		26.8	1,600	5.97*
		46.8	450	.96
		41.3	450	1.09
June	1974	23.6	210	.89
		22.2	150	.67
		20.0	190	.95
		26.1	160	.61
		22.7	210	.92
		35.6	310	.87
		20.6	190	.92
	1975	31.8	348	1.09

Table 1. Sex composition of white marlin from the Gulf, Bahamas, Middle Atlantic Bight of the United States, and southeastern Atlantic coast of the United States for 1971-75.

	Sex	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Gulf of Mexico	M	0	0	0	0	3	8	46	94	29	10	0	0	190
	F	1	0	0	1	13	30	124	169	30	21	1	0	390
Bahamas	M	0	1	34	48	1	1	1	0	0	0	0	0	86
	F	0	1	29	88	3	2	1	0	0	0	0	0	124
Northeastern U.S.	M	0	0	0	0	0	6	19	102	6	0	6	0	139
	F	2	0	0	0	0	14	28	75	19	2	2	0	142
Southeastern U.S.	M	3	1	4	1	18	5	2	1	0	0	2	1	38
	F	1	0	12	18	24	6	8	2	0	1	4	0	76
Total	M	3	2	38	49	22	20	68	197	35	10	8	1	
	F	4	1	41	107	40	52	161	246	49	24	7	0	

Month	Year	Body Weight kg	Ovary Weight g	GSI
July	1972	18.2	224	1.23
		17.2	165	.95
		20.4	140	.69
		22.7	132	.58
		25.0	160	.64
		25.0	143	.57
		22.2	75	.34
		17.7	54	.31
		19.5	112	.58
		19.5	188	.96
		27.2	180	.66
		22.2	215	.96
		18.6	152	.81
		23.6	166	.70
		20.9	121	.58
		21.3	132	.62
		25.9	135	.52
		21.3	109	.51
		27.7	206	.74
		22.2	105	.47
		32.7	163	.50
		25.4	73	.29
		26.8	123	.46
		26.3	134	.51
		20.0	96	.48
		28.6	109	.38
		30.0	149	.50
		26.3	120	.45
		24.5	194	.79
		33.1	149	.45
		21.3	118	.55
		34.5	138	.40
		19.5	89	.46
	1973	19.5	110	.56
		18.2	75	.41
		20.4	50	.24
		22.7	46	.20
		20.4	120	.58
	1974	34.5	169	.49
		19.1	200	1.05
April	1974	27.2	375	1.38
		40.4	550	1.36
		40.4	325	.80
		28.1	216	.77
		37.2	2,050	5.51
	1975	33.6	400	1.19
		28.8	260	.90
		40.9	650	1.59
		29.1	1,060	3.65
		25.4	270	1.06
		30.6	840	2.74
		35.4	2,320	6.55*
		29.1	350	1.20
		35.4	310	.88
		32.7	360	1.10
		32.9	400	1.21
		25.0	660	2.64
		30.4	240	.79
		29.5	350	1.19
		27.7	820	2.96
		34.5	310	.90
		35.0	2,250	6.44
	1976	25.0	511	2.04
		27.7	466	1.68
		45.4	2,100	4.62
May	1972	40.4	414	1.02
		36.3	2,488	6.85*
		24.5	223	.91
		20.9	213	1.02
		32.7	2,150	6.57*
		22.2	257	1.16
		25.4	208	.82
		31.3	2,908	9.28*
		20.0	126	.63
		31.3	405	1.29
		21.8	109	.50
		30.4	2,324	7.65*
	1973	24.1	700	2.91
	1974	26.8	2,050	7.65*
		30.4	1,700	5.59
		25.9	450	1.74
		25.9	425	1.64
		22.2	375	1.68
		24.1	400	1.66
	1975	27.2	750	2.75
June	1972	28.6	501	1.75
		20.9	198	.95
		19.5	110	.56
		20.4	124	.60
		20.4	191	.93
		23.2	156	.67
		20.4	188	.92
		24.5	118	.48

	Year	Body Weight kg	Ovary Weight g	GSI
August	1972	18.6	35	.18
		23.2	166	.72
		27.7	147	.53
	1973	31.8	104	.33
		23.2	125	.54
		38.6	147	.38
		23.2	130	.56
		25.4	110	.43
		20.9	146	.70
		26.3	124	.47
		18.6	53	.28
		25.0	145	.58
		31.3	145	.46
		26.3	138	.52
		25.4	139	.54
		27.7	134	.48
	1974	23.6	148	.63
		29.0	161	.55
		21.8	73	.34
		26.3	114	.43
		28.6	178	.62
September	1973	23.2	126	.54
		22.2	70	.32
		23.6	77	.33
		25.9	138	.53
		24.5	137	.56
		30.9	139	.45
	1974	24.1	35	.14
		22.2	26	.12
October	1974	20.4	91	.44
		24.5	46	.19
		18.2	42	.23
		21.8	28	.13
November	1972	25.0	139	.56
	1974	15.4	124	.80
		17.7	57	.32
		22.2	117	.53

*Selected for fecundity estimates.

Table 3. Weight, length, and reproductive data for 10 female white marlin from the Bahamas and Florida collected during 1972, 1974, and 1975.

Body Weight (kg)	Body Length (cm)	Ovary Weight Wet (g)	GSI %	Estimate of number of eggs 0.56 mm in diameter and larger (millions)	Estimate of numbers of eggs 0.30 mm in diameter and larger (millions)
26.8	160	1,600	6.0	5.4	9.3
26.8	169	2,050	7.6	4.8	8.3
30.4	168	2,324	7.6	7.0	12.1
31.3	168	2,908	9.3	10.4	17.9
32.7	166	2,150	6.6	7.1	12.2
32.7	166	2,693	8.2	10.1	17.4
33.6	167	2,161	6.4	7.6	13.1
35.0	169	2,250	6.4	6.5	11.2
35.4	170	2,320	6.6	7.5	12.9
36.3	171	2,488	6.8	10.5	18.1

Estimated using value of 42% for number of eggs from 0.30 to 0.55 mm in diameter.

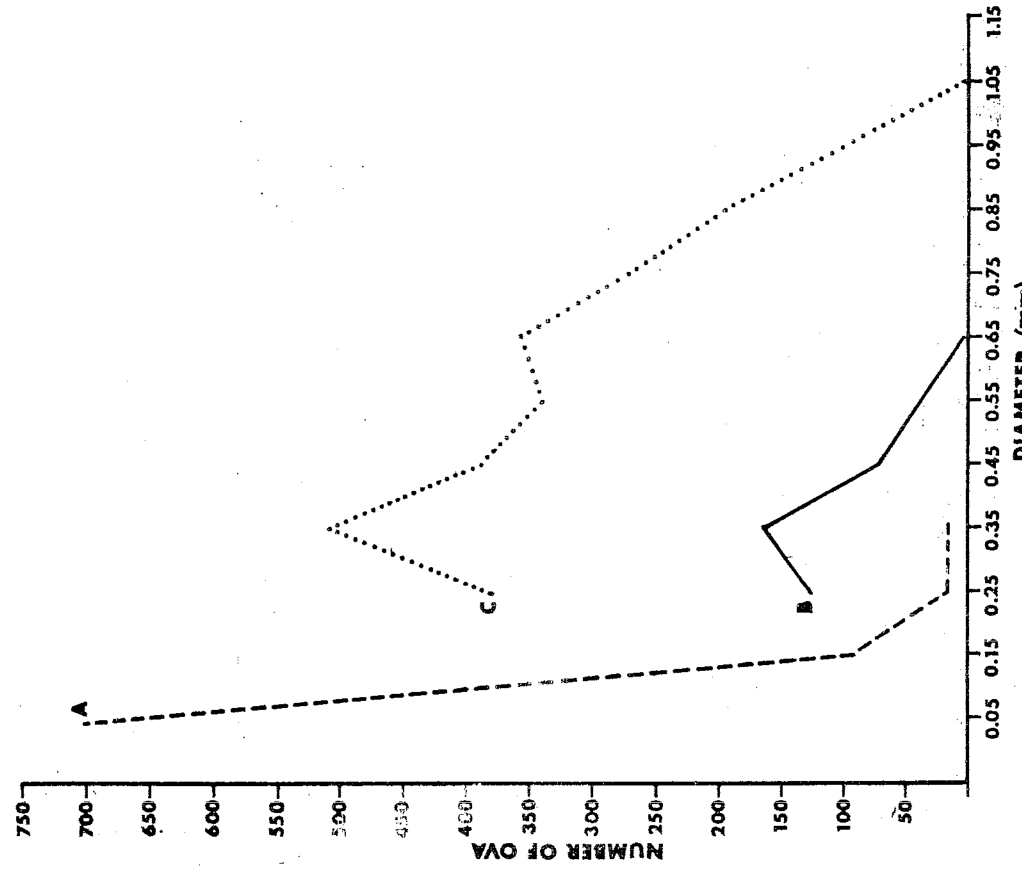

Figure 2. Frequency distribution of white marlin ovum diameter measurements for:
A - 4 spent fish (827 ova) from May, June
B - 1 partially spent fish (406 ova) from June
C - 1 mature fish (2,679 ova) from April

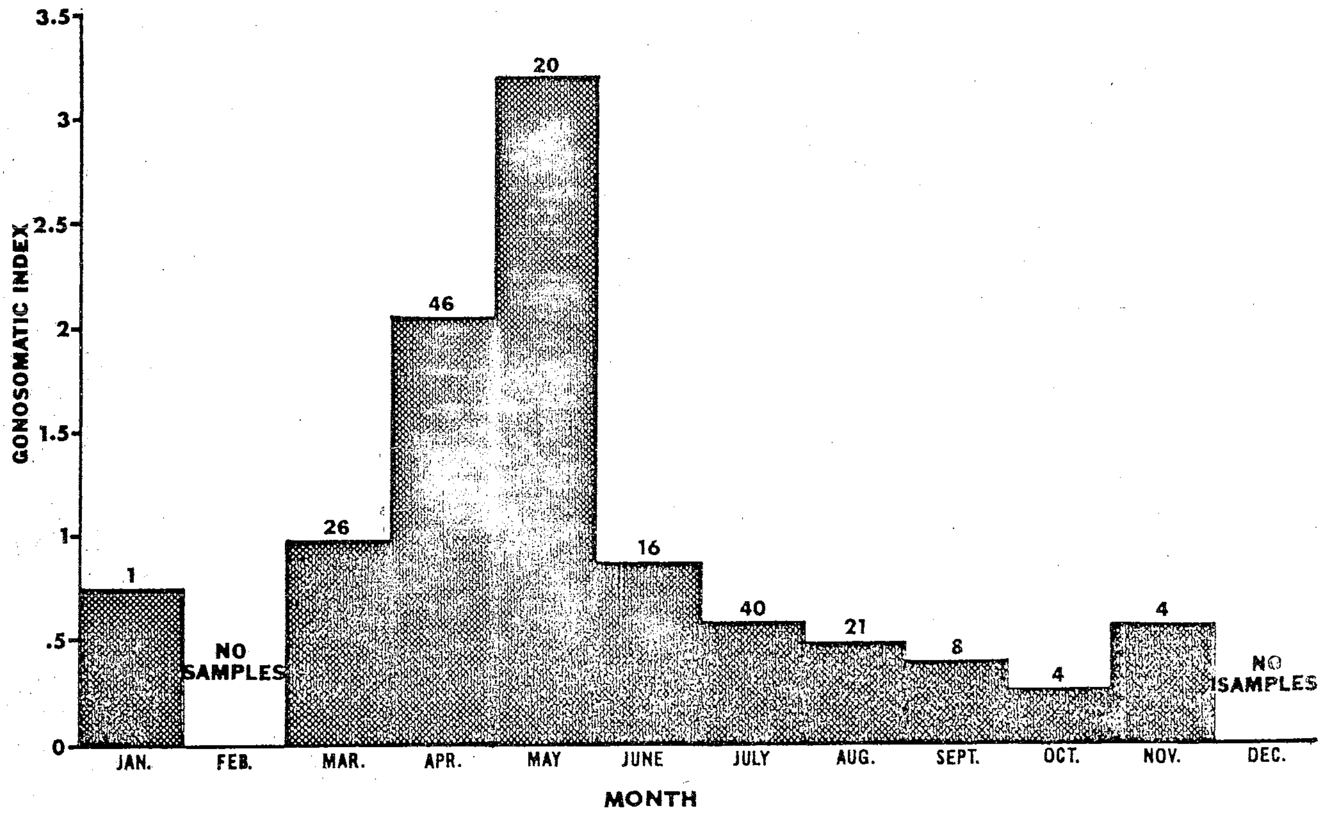

Figure 1. Seasonal variation in mean gonosomatic index of 186 white marlin collected from 1972-76 (number of fish indicated).