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Some Biological Observations of Billfishes Taken in the Eastern Pacific Ocean, 1967-1970

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ABSTRACT

From 1967 through 1970 sport-caught billfishes were sampled at Mazatlán, Sinaloa; and Buena Vista, Baja California, and at San Diego, California. Lengths, weights, morphometrics, meristics, and gonad data were gathered on a total of 2,056 striped marlin, 821 sailfish, 61 blue marlin, and 1 black marlin. This paper presents information on reproduction, average length and condition factor, food habits for 1970, and notes on parasites.

Developing gonads were found only in the Mexican fish. Our data on reproduction indicated that both striped marlin and sailfish spawn once per year with peak spawning activity probably in June and July. There is also the possibility that sailfish spawn in other months. First maturity in striped marlin and sailfish occurred in the 155-165 cm eye-fork length class. Fecundity estimates ranged from 2 to 5 million eggs for four sailfish and from 11 to 29 million eggs for three striped marlin. It appears tnat striped marlin move offshore from the Mexican coastline to spawn while sailfish remain closer to shore.

Much of the interest in billfishes in the eastern Pacific Ocean stems from their popularity among sport fishermen. Commercial fishermen have also been interested in the billfish resources as indicated by their extensive and continuous operation in this area since 1956 (Suda and Schaefer, 1965). Since 1963 this fishery has concentrated off Mexico where it is directed primarily at striped marlin *(Tetrapturus audax)* and sailfish *(Istiophorus platypterus)* (Kume and Schaefer, 1966; Kume and Joseph, 1969a). Throughout the history of the billfish fishery in the eastern Pacific no attempt has been made to manage these resources; this is partly due to the lack of information on the life history and population dynamics of these fishes. This report provides data gathered from billfishes landed at sportfishing sites in southern California and Mexico from 1967 to 1970. Specimens were examined at San Diego, California; Buena Vista, Baja California; and Mazatlán, Sinaloa, Mexico (Fig. 1). A total of 2,056 striped marlin, 821 sailfish, 61 blue marlin *(Makaira nigricans)* and 1 black marlin *(M. indica)* were sampled. This paper is one of a series of publications describing the results of these studies. Evans and Wares (1972) published information of the food habits of fish collected in 1967-1969, and another paper (Wares and Sakagawa, 1973) has been prepared to present meristic and morphometric analyses.

The purpose of this paper is primarily to present

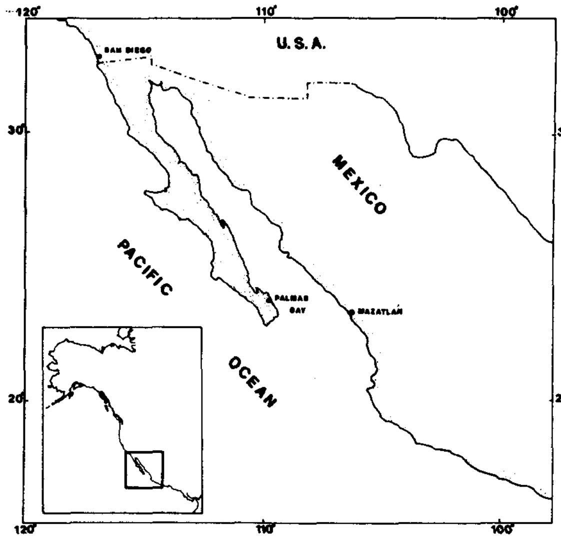

Figure 1.—Location of the three billfish sampling sites.

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data relating to sexual maturation and to make inferences on the reproductive biology of striped marlin and sailfish. The numbers of blue and black marlin were insufficient to add significantly to the knowledge of these species. We also present notes on food habits as observed from data collected in 1970, seasonal abundance, and parasites.

Because of the long established fishery for billfishes in the western and central Pacific, most billfish reproduction information has been derived from that area (Nakamura, 1932, 1940, 1949; Ueyanagi, 1959; Yabe, 1953; Honma and Kamimura, 1958). Merrett (1970, 1971) and Williams (1963, 1964, and 1970) reported on the Indian Ocean billfishes and concluded they are closely related to those in the western Pacific. We have encountered only two major publications (Kume and Joseph, 1969b; Yurov and Gonzales, 1972) dealing with reproduction of billfishes east of long. 130°W.

SEASONALITY

All four of the species studied occur regularly at Mazatlán and Buena Vista where they exhibit seasonal cycles of abundance. San Diego is near the northern extreme of istiophorid ranges on the eastern Pacific coast and except possibly in the warmest years, striped marlin is the only species captured there. The occurrence of striped marlin is highly seasonal.

Based on records kept by several resorts (1963-69) in the Palmas Bay area of Baja California (the area surrounding Buena Vista) and at Mazatlán (1967-69), sailfish and striped marlin show distinct patterns of seasonal abundance. Though these data are probably not highly accurate, the trends (Fig. 2 and 3) agree with our personal observations and with data provided by the Departamento de Tourismo, Terr. Baja California Sur. Seasonalities for blue and black marlin are not presented because of the low numbers in the catch records and because of persistent confusion in the identification of the two species. It appeared, however, that blue marlin were most abundant from late summer through winter, at least in the Palmas Bay area.

Peak abundance of both striped marlin and sailfish tended to occur later in the year at Palmas Bay than Mazatlán. At each location, the time of maximum abundance of sailfish occurred later than that of striped marlin. The seasonal occurrence of striped marlin is much more restricted at San Diego than in Mexico with no fish being caught before July 1 or after December 1. Records of striped marlin landed at three sportfishing clubs in San Diego from 1963 to 1970 show the peak catch to vary between late August and early October. The timing of the apparent abundance of striped marlin off San Diego is believed to be correlated with surface water temperatures (Squire, 1974a).

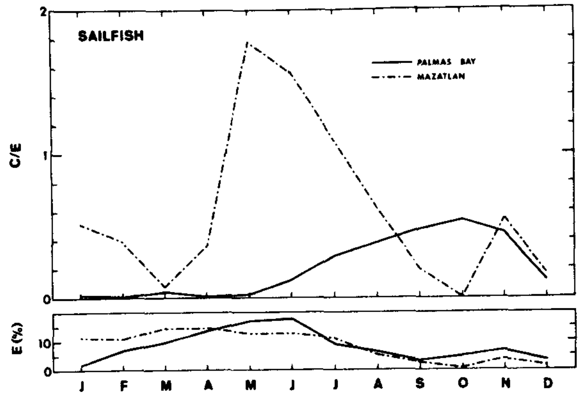

Figure 2.—Catch per unit effort (number per boat-day) and percent effort for sailfish sport fishery from Palmas Bay (1963-1969) and Mazatlán (1967-1969).

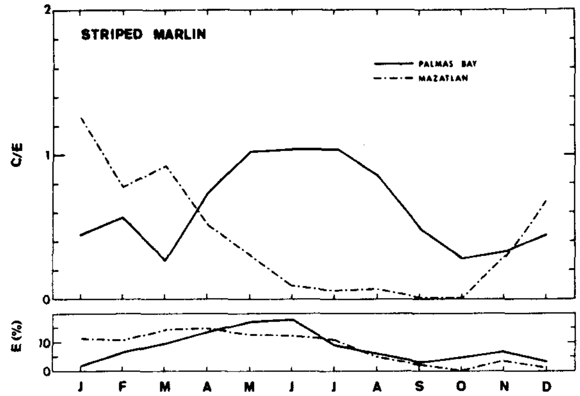

Figure 3.—Catch per unit effort (number per boat-day) and percent effort for striped marlin sport fishery from Palmas Bay (1963-1969) and Mazatlán (1967-1969).

REPRODUCTION

Collection and Processing of Samples

Gonad weights and fish length and weight were measured and sex noted of each fish examined. During 1969 and 1970 core samples of ovaries were also taken. Also in 1970, Japanese longliners provided us with gonads and detailed information of six additional mature striped marlin caught near the Revillagigedo Islands (lat. 19°N, long. 111°W).

Field sampling of specimens involved examination of fishes during the same day in which they were caught. Each fish was weighed and measured (eye-fork length). The body cavity was then opened and the gonads excised. Adhering fascia were removed and the gonads weighed. In 1970 the length and volume of each gonad was measured. During 1969 and 1970 ovarian tissue was sampled with a cork borer following a method used by Yuen (1955) wherein two transverse borings through the ovary are made at approximately ⅓ the distance from each end. These two samples from each fish were preserved in Gilson's fluid (Simpson, 1951), which rendered the ova much easier to measure and handle. This treatment appears to have no obvious differential effect on the ova diameters or shape (Schaefer and Orange, 1956).

The samples were kept in Gilson's fluid from 2 to 18 mo during which time the ova became separated from the ovarian tissue. Each sample was then gently stirred and a random sample of ova was measured with an ocular micrometer at 30× magnification. Ova diameter measurements were taken on whatever axis fell parallel to the micrometer graduations. Several authors (Clark, 1925, 1934; June, 1953; Otsu and Uchida, 1959; and Yuen, 1955) have concluded that random measurements regardless of the axis produced reliable results.

Because differential maturation of ova was found in bigeye tuna (Yuen, 1955) we took integrated samples with the cork borer. Later examination of mature striped marlin and sailfish ovaries, however, showed no evidence of either cross-sectional or longitudinal variation in ova size within ovaries. We tested for cross-sectional variation by taking radial subsamples from a 10 mm thick transverse section near the middle of one of the largest, most mature striped marlin ovaries. The ova diameter frequency distributions (Fig. 4) of three samples radiating from the center were similar. Likewise, anterior, middle, and posterior subsamples from two striped marlin and one sailfish ovaries showed no evidence of longitudinal variation (Fig. 5).

The 95th centile egg diameter was determined from the size frequency distribution of 300 eggs measured at random as described by Schaefer and Orange (1956). "Maximum ova diameter" as used by us was the largest size class interval (0.066 mm increments) containing ova from a sample of 50 ova measured at random.

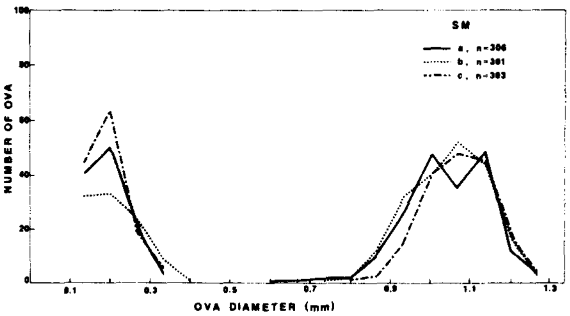

Figure 4.—Ova diameter frequency polygons of subsamples taken near the middle of a mature striped marlin ovary; a—central, b—intermediate, c—peripheral.

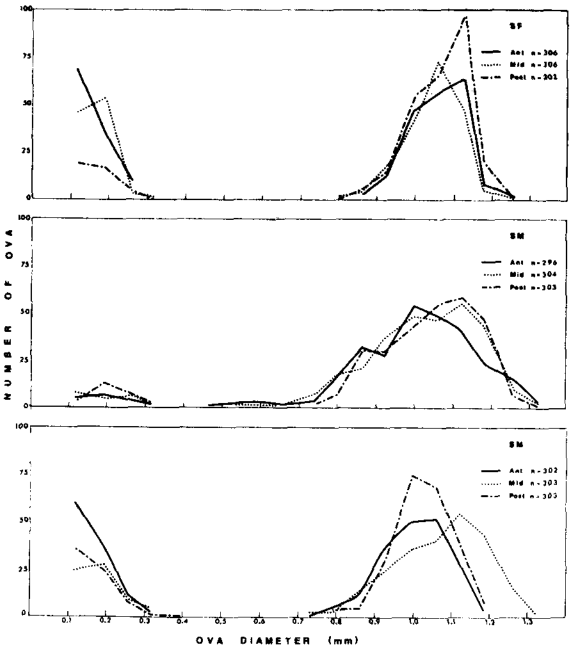

Figure 5.—Ova diameter frequency polygons from one mature sailfish and two striped marlin. Samples were taken from the anterior, middle, and posterior areas of the left ovary.

Description of Gonads

Detailed description of the gonads and spawning products of billfishes were published by Merrett (1970) and La Monte (1958). In our studies we found strong evidence of gonadal assymetry (Table 1). For striped marlin, the left gonad averaged larger than

Table 1.—Percent frequency of specimens in which the left gonad was larger in weight than the right; left gonad expressed as average percentage of combined gonad weight and length.

	Freq. L>R (%)	Left gonad as percent of combined		N
		Weight	Length	
Striped Marlin				
Male	80	53.1	53.7	40
Female	95	60.5	54.5	44
Sailfish				
Male	73	48.5	53.3	11
Female	79	55.5	52.9	24

the right in both sexes. The left ovary of sailfish also averaged larger but the left testis averaged smaller in weight. Females exhibited the greatest gonadal asymmetry and the difference in size between right and left ovaries was often obvious without measurement. Williams (1963) observed similar differences in Indian Ocean striped marlin with the left gonad always larger in both length and displacement volume.

Several noteworthy gonadal abnormalities were also seen. In ten striped marlin, five sailfish, and one blue marlin, one ovary was lacking; in two striped marlin and one sailfish one testis was lacking. This phenomenon can result from the fusion of the two gonad primordia during development, or simply from the failure of one gonad to develop (Hoar and Randall, 1969). In one striped marlin the ovary had proliferated into many different sized lobes filling much of the coelomic cavity (Fig. 6). It was filled with large eggs which were visibly misshapen. Another striped marlin was noted to have a testis which had divided into separate anterior and posterior lobes. Four ovaries were tumorous, brown-red in color, consisting of dense, odiferous tissue. Penellid copepods were found encysted in the gonads of three striped marlin and one sailfish.

Measures of Sexual Maturity

The general problem of finding an accurate and efficient means of measuring sexual maturity in fishes has resulted in the development of many techniques. Testes have not been found to be suitable because of problems encountered in measuring accurately their sex products (June, 1953). In addition, Merrett (1970) has shown by histological examination that unlike the case in most teleosts, there is differential maturation of spermatozoa in the testicular lobules of billfishes. There is thus only a small

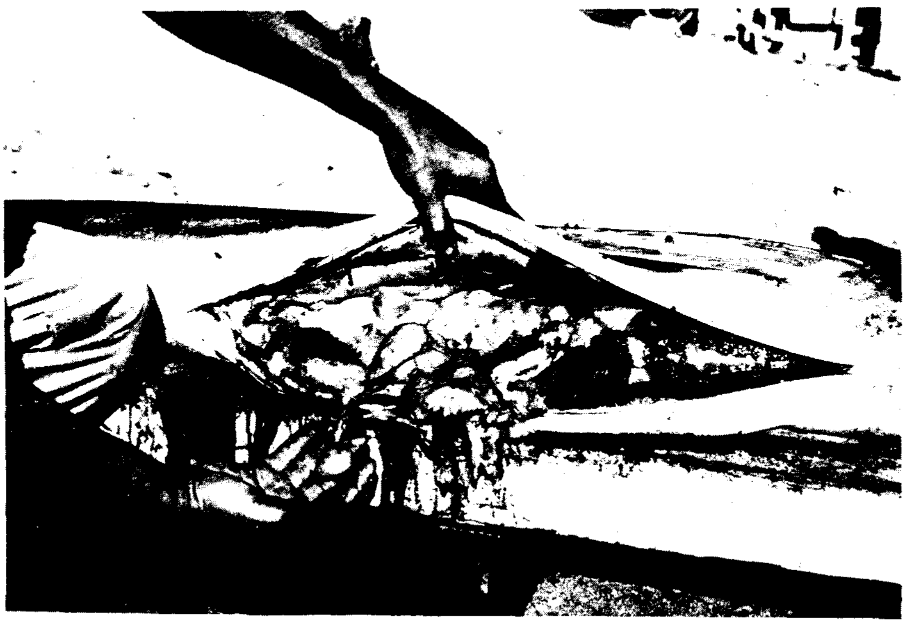

Figure 6.—Illustration of an abnormal striped marlin ovary with different sized lobes throughout the coelomic cavity.

overall seasonal increase in size of the testes, and some milt is usually present throughout the year.

On the other hand, the ovary as an indicator of maturity has been well documented (Clark, 1925, 1929, 1934; Hickling and Rutenberg, 1936). As oogenesis proceeds, characteristic changes occur which can be easily detected macroscopically or microscopically. We therefore chose to use ovarian characteristics to represent maturity of billfishes in this study.

The most precise method of determining the stage of ovarian maturity is to histologically examine the tissues as performed by Merrett (1970) or Moser (1967). This procedure, however, is lengthy and time-consuming. Another reliable technique is to measure a large number of ova from the same ovary, a method used for many species (Clark, 1929, 1934; June, 1953; and Brock, 1954). This method is based on the assumption that as the spawning season progresses, the group or groups of maturing ova will be distinguished as advancing modes in size-frequency distributions. This method is also time-consuming and laborious, but has a definite advantage in characterizing the frequency of spawning when a fully mature specimen is examined. When many fish are examined over a time interval, the progression of the modes of developing ova may provide information on the rate of maturation, time of spawning, and size at maturity. Two variations of this process which require the measurement of fewer ova are the use of "maximum ova diameter" (Otsu and Uchida, 1959) and the position of the 95th centile (Schaefer and Orange, 1956). The latter is particularly useful when the exact position of the developing mode is difficult to distinguish, as in early maturation stages.

Indirect methods to measure sexual maturity involve the relationship between some measure of the fish's size (either length or weight) and gonad weight. The use of fish length assumes that fish weight is nearly proportional to the cube of the length, a true situation with regard to the billfishes in this study as determined by length-weight analyses for eastern Pacific billfish. It is also assumed that fecundity is proportional to size. Kume and Joseph (1969b) have plotted ovary weight versus eye-fork length and also utilized the gonad index *(GI)* computed as

$$GI = (W/L^3) \cdot 10^4$$

where
W = total weight of gonads in grams, and
L = eye-fork length in cm.

Table 2.—Regression of maximum ova diameter and 95th centile of ova diameter on gonad index (n = sample size, r = coefficient of correlation, b = slope, a = y axis intercept.)

	n	r	b	a
Striped Marlin				
95th centile on GI	31	0.936*	3.02	1.46
Max. ova diameter on GI	269	0.797*	3.78	1.48
Sailfish				
95th centile on GI	21	0.913*	3.91	2.47
Max. ova diameter on GI	184	0.859*	4.78	3.43

*Significant at 0.01 level.

Merrett (1971) used another type of gonad maturation index which related the macroscopic appearance (color, yolk presence, egg diameter, and general appearance) of the gonad to recognizable stages in its histology.

To evaluate these different measures of maturity and to determine the degree of correlation between them, we applied regression analyses to our data (Table 2). As can be seen, the gonad index is highly correlated. In each of the four regressions, the correlation coefficients exceeded the 0.01 significance levels when tested against a Student's t-distribution. The lower r values for regression of maximum ova diameter on gonad index can be explained by the fact that maximum egg diameters do not always represent the size of the advanced mode. For example, the presence of a few residual eggs in an ovary which is in the resting or early maturation stages will not reflect the true stage of development of the ovary.

We have included both direct and indirect methods to analyze the spawning of striped marlin and sailfish. But, based on the above comparison and considering the time and manpower costs and the degree of accuracy desired, we conclude that the gonad index represents the most practical indicator of the stage of sexual maturity for a study of this type.

Size at First Spawning

The reported size at which striped marlin attain sexual maturity varies little among previous studies. Merrett (1971) reported first maturity at 140-160 cm eye-fork length. This agrees with the conclusion of Williams (1963). Kume and Joseph (1969b) stated that individuals greater than 160 cm from the eastern Pacific regularly occur in the spawning group (3.0 *GI*), however, they did collect a mature specimen in the 148-cm class.

Our criteria for evidence of sexual maturity were based on a minimum egg diameter and a minimum gonad index. Fish with maximum ova diameters equal to or greater than 0.3 mm were considered mature based on the work of Merrett (1970) who considered eggs of this size as maturing, having completed yolk and chorion formation. We somewhat conservatively chose $GI = 1.0$ as the other criterion based on our data (Fig. 7 and 8) which show that no gonad index exceeded 1.0 in Quarter I and, further, the gonad indices for immature fish below 145-150 cm in Quarter II were remarkably consistent and did not exceed 0.3. The increase in average gonad index with increasing fish lengths between 150 and 190 cm in Quarter II suggests that larger fish either mature earlier or have larger gonad index values at given maturity stages than smaller fish. The presence of higher gonad indices for large fish in Quarter I than those of small fish in both Quarters I and II suggests that the latter is the case. Based on these criteria first maturity of striped marlin occurred in the 155-165 cm length classes and in the 160-165 cm length classes of sailfish (Fig. 7, 8, 9, 10).

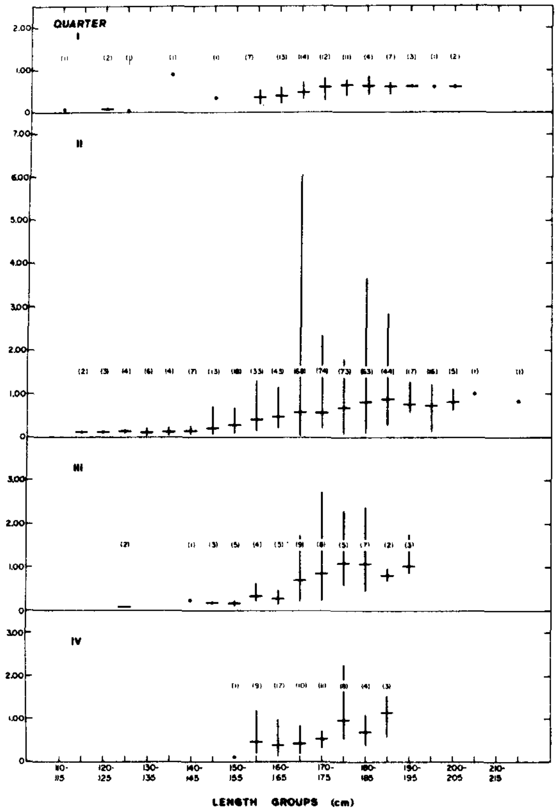

Figure 7.—Striped marlin gonad indices versus eye-fork length groups presented in quarters of the year. Numbers of striped marlin sampled are given in parentheses.

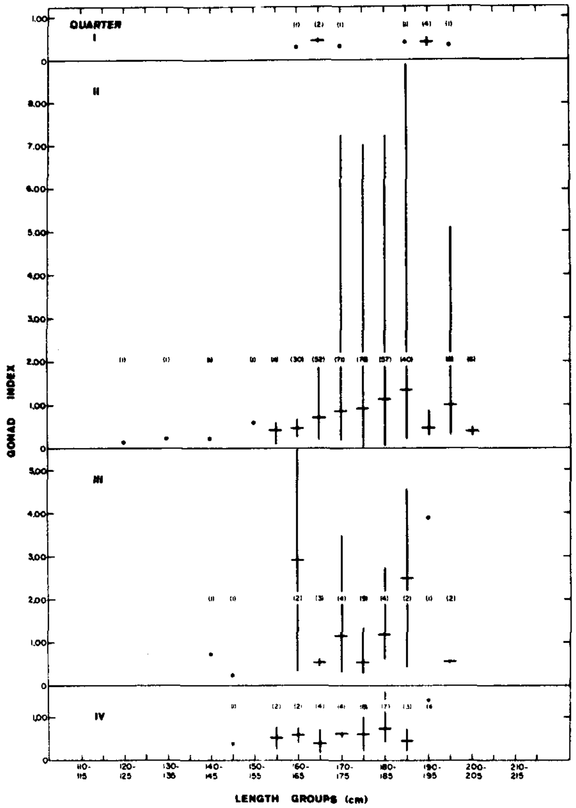

Figure 8.—Sailfish gonad indices versus eye-fork length groups presented in quarters of the year. Numbers of sailfish sampled are given in parentheses.

Frequency of Spawning

Simultaneous presence of both mature, nonatretic ova in the lumen and developing ova in the follicles is possible evidence of multiple spawning. However, lack of these conditions does not necessarily rule out multiple spawning. We plotted ova diameter frequency polygons of 300 ova from specimens with the highest gonad indices in each 2-wk period throughout 1969 and 1970. In addition, larger numbers of eggs were measured for one striped marlin and two sailfish, which had high gonad indices (Fig. 11). We found no indication of multiple spawning.

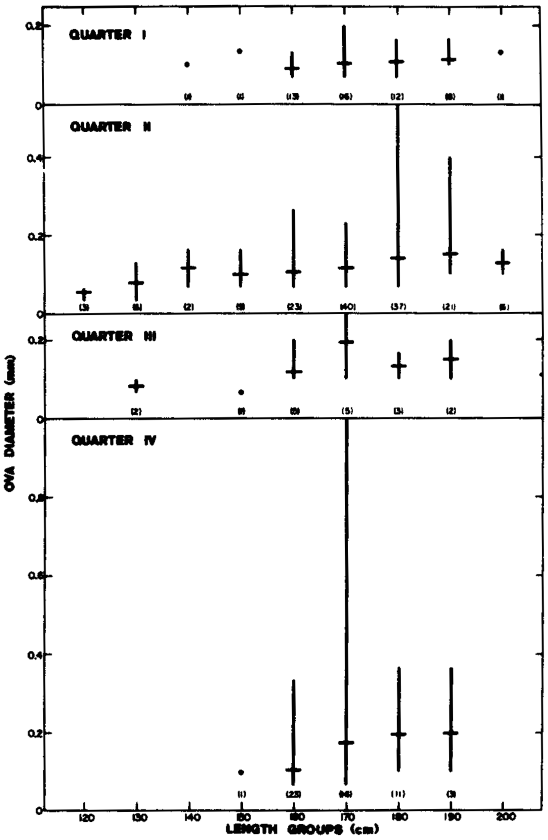

Figure 9.—Striped marlin ova diameters versus eye-fork length groups presented in quarters of the year. Numbers of striped marlin sampled are given in parentheses.

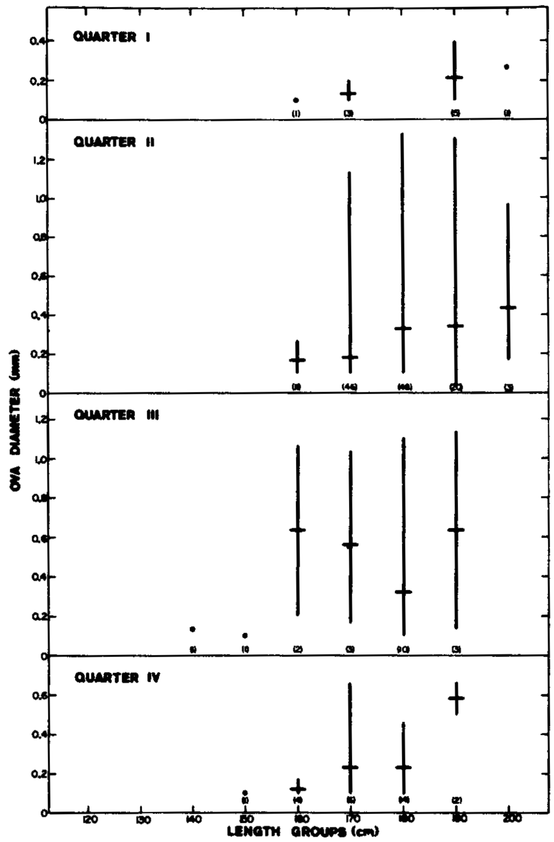

Figure 10.—Sailfish ova diameters versus eye-fork length groups presented in quarters of the year. Numbers of sailfish sampled are given in parentheses.

Fecundity

Little information is available on the fecundity of striped marlin or sailfish. Nakamura (1949) conservatively stated for billfishes in general that fecundity ranges from 1.0 to 1.2 million eggs depending on size and species. Merrett (1971) estimated a fecundity of 12 million eggs for an Indian Ocean striped marlin of 182 cm eye-fork length, with an ovary weight of 1.53 kg and a mean maximum egg diameter of 0.470 mm. In the central Pacific, Gosline and Brock (1960) estimated 13.8 million eggs for one striped marlin ovary.

We estimated the fecundities of four fully mature sailfish and three striped marlin by subsampling by weight. All specimens had high gonad indices and the striped marlin were specimens with the largest

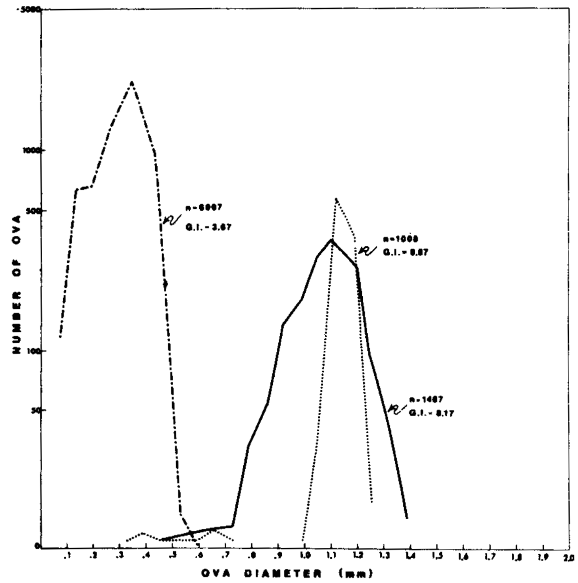

Figure 11.—Size frequency polygons for two mature sailfish (righthand curves) and one mature striped marlin.

ovaries encountered in this study. The fecundity estimates (Table 3) ranged from 11.3 to 28.6 million

Table 3.—Fecundity and related information on sailfish and striped marlin from the eastern North Pacific collected in 1969 and 1970.

	Gonad Index	Eye-Fork Length (cm)	Ovary Weight (gm)	Maximum Ova Diam. (mm)	Fecundity Estimate (million eggs)
Sailfish	3.7	185	2359	1.2	1.8
	5.5	163	2359	0.9	2.4
	7.0	176	3810	1.3	3.0
	8.9	187	5760	1.3	5.1
Striped Marlin	4.42	180	2580	0.6	11.3
	8.17	150	2760	0.6	17.2
	9.53	155	3550	0.6	28.6

eggs for striped marlin and from 1.8 to 5.1 million eggs for sailfish.

Spawning Season and Locality

We are aware of only two publications that deal with spawning seasons of striped marlin and sailfish in the eastern Pacific (Kume and Joseph, 1969b and Yurov and Gonzales, 1972). Kume and Joseph

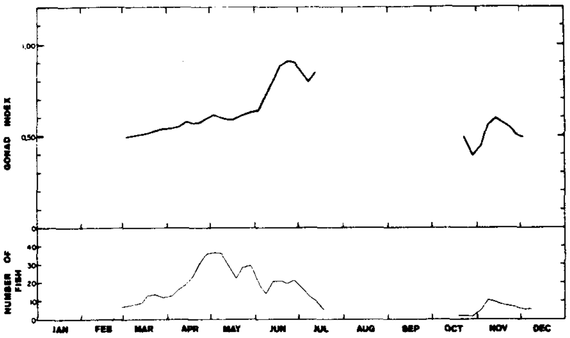

Figure 12.—Mean gonad index distribution and the number of striped marlin sampled by month from Buena Vista and Mazatlán.

(1969b) found that the highest frequency of striped marlin in spawning condition occurred in Quarter IV in the southern hemisphere and in Quarter II in the northern. Some were also in spawning condition in Quarter III in the northern hemisphere. These authors concluded that two spawning seasons existed at opposite times of the year in the northern and southern latitudes. This spawning pattern was also noticed in the western Pacific (Ueyanagi, 1959; Honma and Kamimura, 1958) and in the Indian Ocean (Williams, 1963; Merrett, 1971).

Our data (Fig. 12 and 13) show a gradual increase

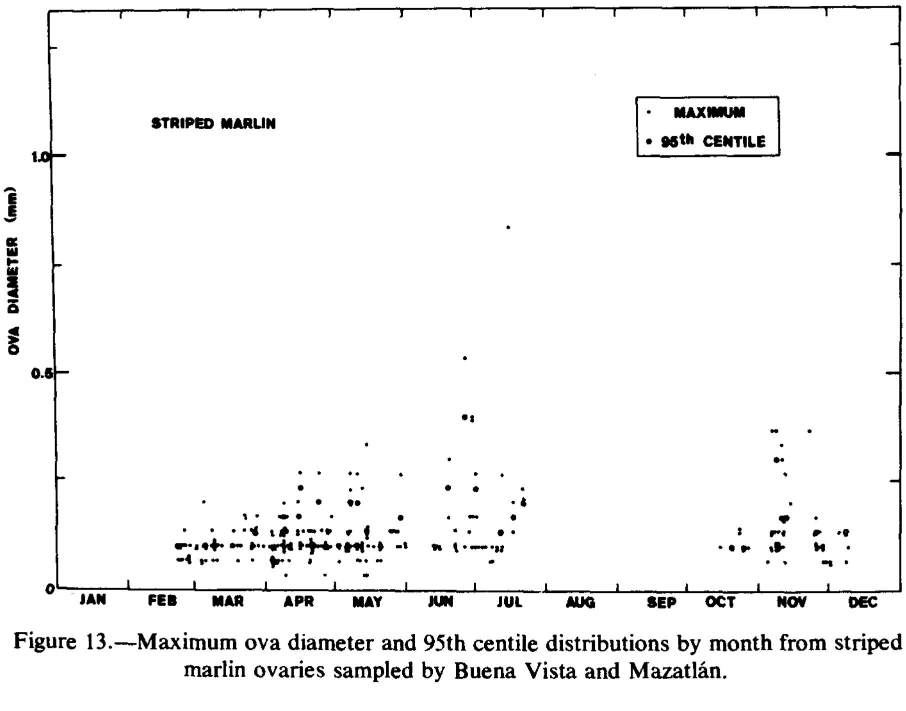

Figure 13.—Maximum ova diameter and 95th centile distributions by month from striped marlin ovaries sampled by Buena Vista and Mazatlán.

in maturation through June and July, at which time our sampling stopped. Several factors suggest that striped marlin move away from our sampling area at this time. Migration patterns indicated by Kume and Joseph (1969a) and Squire (1974b) showed that striped marlin move west-southwesterly from the coastal areas as the year progresses. Also, the data from the sport fishery (Fig. 2) show concentrations of striped marlin decreasing after March at Mazatlán and after July at Buena Vista. During July, Japanese longline fishermen have noted fully mature striped marlin in increased concentrations around the Revillagigedo Islands (G. Adachi, pers. comm.). The fish appeared in pairs and when one was hooked the other would remain alongside until the fish was hauled aboard. This behavior was not noticed in other areas of the eastern North Pacific or during other times of the year. Ovaries provided to us by the longliners from that area were all ripe and ranged in gonad index from 4.42 to 9.53 and the ova diameters were all in excess of 1.25 mm.

Sex ratio for striped marlin showed a slight but not significant predominance of males at Mazatlán from late February to July. In the larger and seasonally later catches at Buena Vista, males tended towards 60% from April through early June. The ratio then remained close to 50% into August. The October-early November ratios were also near 50%. Off San Diego, male striped marlin averaged only about 30% up to late September but rose to almost 50% for the rest of the season.

From these data it is logical to suggest that striped marlin migrate away from the coastal areas near the Gulf of California to spawn during July and possibly August. Females sampled at San Diego in August were in a post spawning condition and all had gonad indices less than 1.0.

Available evidence suggests that sailfish spawn nearshore in the eastern North Pacific with a northward progression of spawning activity during the year. Kume and Joseph (1969b) noted that some sailfish from Costa Rica coastal waters were in spawning condition from February to March. At the same time sailfish from offshore waters from lat. 0° to 15° were immature. Yurov and Gonzales (1972) reported spawning in the Gulf of Tehuantepec extending from February to April. We measured 36 larval and juvenile sailfish collected by Scripps Institution of Oceanography and the National Marine Fisheries Service along the Central American coast. Estimated spawning dates for these specimens based on back calculations using the growth rates of de Sylva (1957) indicated spawning of Costa Rican specimens from December through March, Guatemalan specimens mostly from January through April (with two in August), and Mexican specimens from April through November.

Our data conform to this pattern. Sailfish began to mature in late May and reached spawning condition in June and July (Fig. 14 and 15). The average gonad index showed a rapid decline in July, but this may be an artifact of a sharply reduced sample size. The ova remained large.

From April through July the sex ratio of Mazatlán sailfish remained close to 50%. Slightly more females than males were found until early June, after which time the ratio tended towards males. The smaller numbers of sailfish caught in Palmas Bay were predominantly female with males never exceeding 50%.

PARASITES

Among the incidental observations of parasites perhaps the most significant was the discovery of *Philichthys xiphiae* Steenstrup in the opercular bone in several striped marlin at Buena Vista and Mazatlán. Previously this species had been reported from the mucous canals of swordfish *(Xiphias gladius)* but not from any of the istiophorids and not from the eastern Pacific. The parasites were embedded in the preopercle just beneath the skin. The differences between parasitized and normal bones are readily seen in the x-ray photos in Figure 16. Other possible infection sites (bones) were not checked for this parasite nor were other billfish species.

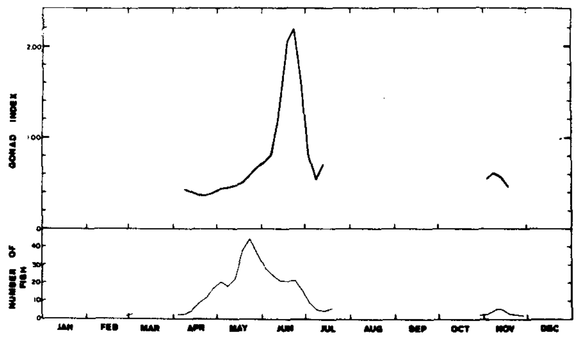

Figure 14.—Mean gonad index distribution and the number of sailfish sampled by month from Buena Vista and Mazatlán.

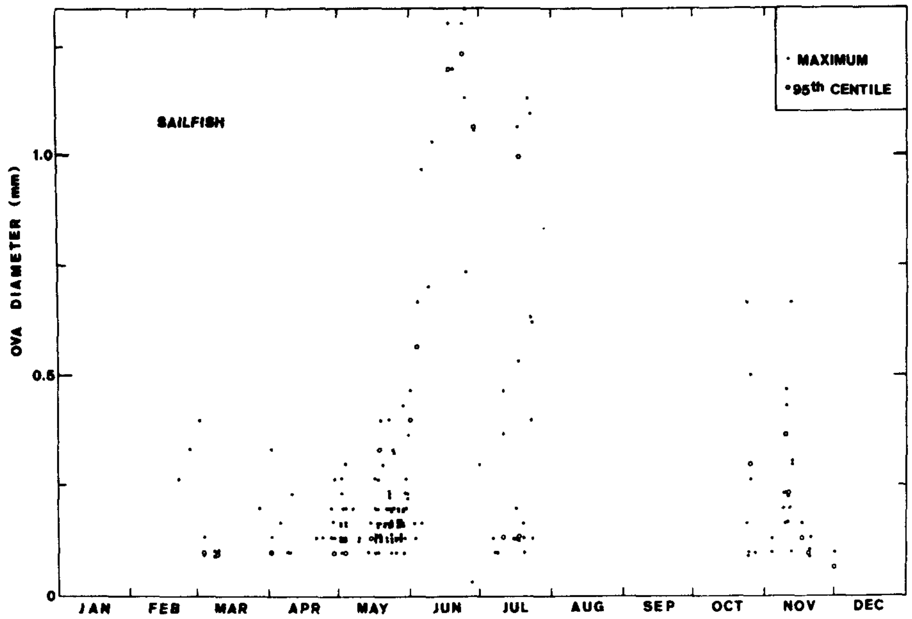

Figure 15.—Distribution of sailfish maximum ova diameters and 95th centiles by month from Buena Vista and Mazatlán.

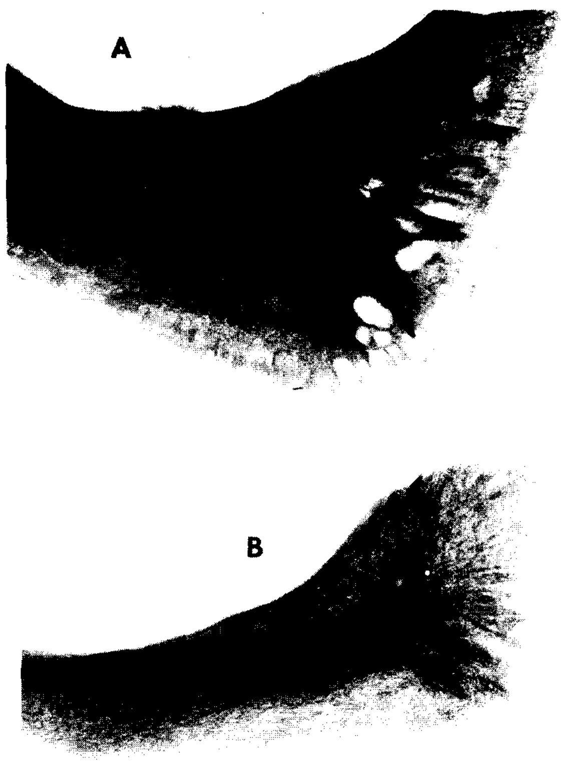

Figure 16.—X-ray photos of preopercular bones of striped marlin from Buena Vista showing (A) cavities caused by *Philichthys xiphiae* (B) a non-parasitized bone.

Caligoid copepods (some identified as *Pandarus* sp.) were common on the body surface and often very numerous, particularly in the ventral region just anterior to the anal fin. Large concentrations of these parasites appeared to irritate the skin, causing redness. White capsalid trematodes were commonly seen on the body surface. A different species of capsalid was found commonly in the nasal cavities. Isopods (some identified as *Nercila* sp.) were quite common on the body surface (usually on the fins) of sailfish at Mazatlán. Up to 57 isopods were recovered from a single sailfish. Nematodes were present, often numerous, in most of the billfish stomachs examined.

FOOD HABITS

Evans and Wares (1972) presented the data for 1967-1969. The contents of additional stomachs examined in 1970 (Table 4) are analyzed below. Table 5 presents the new data as percent occurrence and percent of total food volume. Table 6 compares the top ranked food items based on volume from the two studies. Except at San Diego, where the sampling dates were similar (August-October) in both studies, the comparison is between seasons as well as between years. The 1970 sampling in Mexico was from October through December whereas most of the earlier data was gathered from April through July.

The major departures from the results found in the previous study were the low importance of anchovies in San Diego striped marlin and of squid in Buena Vista sailfish stomachs.

Table 4.—Sample sizes and condition of billfish stomachs sampled during 1970.

	Striped Marlin			Blue Marlin	Sailfish
	SD	BV	Maz	BV	BV
No. Stomachs					
Total	37	59	8	15	33
With Food	20	37	4	8	22
Empty	16	5	1	2	2
Regurgitated	1	17	3	5	9
Total Vol. of Food (ℓ)	7.35	8.25	0.97	1.86	6.83

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Table 5.—Food species of billfishes observed in 1970 (% Occurrence/% Volume).

	Striped Marlin			Blue Marlin	Sailfish
	SD	BV	Maz	BV	BV
ALGAE	7.5/0.5	—	—	—	—
INVERTEBRATES					
Crustacea					
Decapods	—	3.0/0.2	—	—	—
Cephalopoda					
Argonauta sp.	—	—	50/6.2	—	—
Squid	5.0/0.4	62/24	25/1.2	13/1.1	12/3.1
FISHES					
Elasmobranchs	2.5/T	—	—	—	—
Clupeidae					
Etrumeus teres	—	43/39	—	—	18/24
Sardinops sagax	5.0/3.1	—	—	—	—
Opisthonema sp.	—	—	—	—	2.0/0.3
Engraulidae					
Engraulis mordax	2.5/2.2	—	—	—	—
Myctophidae	—	3.0/0.7	—	—	2.0/0.5
Scomberesocidae					
Cololabis saira	7.5/23.8	—	—	—	—
Atherinidae					
Atherinopsis californiensis	2.5/16	—	—	—	—
Exocoetidae					
Cypselurus californicus	2.5/0.2	—	—	—	—
Unidentified sp.	—	—	—	13/0.4	—
Fistularidae					
Fistularia sp.	—	—	—	—	8.2/21
Syngnathidae	—	—	25/0.4	—	—
Echeneidae					
Remora brachyptera	—	—	—	12/1.6	—
Carangidae					
Caranx caballus	—	3.0/0.8	—	—	2.0/0.6
Decapterus hypodus	—	3.0/1.7	—	—	2.0/4.4
Hemicaranx sp.	—	5.0/1.0	—	—	—
Trachurus symmetricus	38/62	—	—	—	—
Unidentified sp.	—	3.0/1.2	—	—	8.2/1.0
Coryphaenidae	—	—	—	—	2.0/10
Scorpidae					
Medialuna californiensis	5.0/2.4	—	—	—	—
Chaetodontidae	—	—	75/12	—	—
Mugilidae					
Mugil cephalus	—	—	25/79	—	—
Sphyraenidae					
Sphyraena sp.	—	3.0/2.3	—	—	—
Scombridae					
Auxis thazard	—	3.0/0.4	—	37/36	6.1/13
Euthynnus lineatus	—	5.1/17	—	12/19	8.2/13
Sarda chiliensis	2.5/0.8	—	—	—	—
Scomber sp.	—	3.0/2.1	—	—	4.1/2.3
Unidentified sp.	—	—	—	25/39	—
Balistidae					
Balistes sp.	—	3.0/0.1	—	—	6.1/0.4
Tetraodontidae					
Sphoeroides sp.	—	3.0/2.2	—	—	—
Lagocephalus lagocephalus	—	19/6.4	—	—	10/4.0
Unidentified Fish	20/3.9	8/1.4	50/1.4	38/2.2	6.1/1.4

Table 6.—Comparison of major billfish foods in 1970 with those for 1967-1969 (n = no. of stomachs with food).

		STRIPED MARLIN			
		1967-1969		1970	
	Rank	Species	%Vol.	% Vol.	Species
San Diego		$n = 116$			$n = 20$
	1.	*Engraulis mordax*	60	62	*Trachurus symmetricus*
	2.	*Trachurus symmetricus*	27	16	*Atherinopsis californiensis*
	3.	*Cololabis saira*	5	8	*Cololabis saira*
Buena Vista		$n = 303$			$n = 37$
	1.	Squid	49	39	*Etrumeus teres*
	2.	*Etrumeus teres*	30	24	Squid
	3.	*Scomber japonicus*	7	17	*Euthynnus lineatus*
	4.			6	*Lagocephalus lagocephalus*
Mazatlán		$n = 14$			$n = 4$
	1.	Squid	63	79	*Mugil cephalus*
	2.	*Argonauta* sp.	7	12	*Chaetodon* sp.
	3.	*Balistes* sp.	7	6	*Argonauta* sp.
	4.	*Fistularia* sp.	5		
		SAILFISH			
Buena Vista		$n = 14$			$n = 22$
	1.	Squid	35	24	*Etrumeus teres*
	2.	*Etrumeus teres*	29	21	*Fistularia* sp.
	3.	*Fistularia* sp.	22	14	*Euthynnus lineatus*
	4.	*Naucrates ductor*	7	13	*Auxis thazard*
		BLUE MARLIN			
Buena Vista		No Data			$n = 8$
	1.			39	Scombrids (unidentified)
	2.			36	*Auxis thazard*
	3.			19	*Euthynnus lineatus*

Douglas Evans, Stewart Luttich, Howard Ness, and David Tolhurst. Roger Cressey identified *Philichthys xiphii* and Ernest Iversen identified the parasites *Pandarus* sp. and *Nercila* sp.

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