On the Biology of Florida East Coast Atlantic Sailfish, (*Istiophorus platypterus*)[1]

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ABSTRACT

The sailfish, *Istiophorus platypterus*, is one of the most important species in southeast Florida's marine sport fishery. Recently, the concern of Palm Beach anglers about apparent declines in numbers of sailfish caught annually prompted the Florida Department of Natural Resources Marine Research Laboratory to investigate the biological status of Florida's east coast sailfish populations.

Fresh specimens from local sport catches were examined monthly during May 1970 through September 1971. Monthly plankton and "night-light" collections of larval and juvenile stages were also obtained. Attempts are being made to estimate sailfish age using concentric rings in dorsal fin spines. If successful, growth rates will be determined for each sex and age of initial maturity described. Females were found to be consistently larger than males and more numerous during winter. A significant difference in length-weight relationship was also noted between sexes.

Fecundity estimates varied from 0.8 to 1.6 million "ripe" ova, indicating that previous estimates (2.5 to 4.7 million ova) were probably high. Larval istiophorids collected from April through October coincided with the prominence of "ripe" females in the sport catch. Microscopic examination of ovarian tissue and inspection of "ripe" ovaries suggest multiple spawning.

Florida's marine sport fishery has been valued as a $200 million business (de Sylva, 1969). Atlantic sailfish, *Istiophorus platypterus* (Shaw and Nodder), range throughout coastal waters and reside year-round in Florida where they are prominent among some 50 species of marine sport fishes. Sailfishing on Florida's east coast became popular during the 1920's and 1930's (Voss, 1953). Sailfish have been categorized as the most sought-after species by southeast coast marine charter boat anglers (Ellis, 1957). In addition, Ellis showed that sailfish were taken on 20% of the fishing trips sampled, but made up only 3 to 5% of the total numbers of fish caught. McClane (1965) estimated that more than 1,000 sailfish were caught each year between Stuart and Palm Beach; thus, this area became known as the "sailfish capital of the world."

The University of Miami Marine Laboratory (now Rosenstiel School of Marine and Atmospheric Sciences) initiated studies on the biology of sailfish in 1948 at the request of the Florida Board of Conservation (now Florida Department of Natural Resources [FDNR]). Voss (1953, 1956) described post-larval and juvenile stages and discussed the general biology of Florida's sailfish populations. De Sylva (1957) described age and growth from length frequencies from the sport catch (Petersen method), but suggested the results be checked by a more conventional method; specifically, annular marks. Further, de Sylva found a wide range in weight for a given length and age, suggesting the possibility of differential growth and/or mortality of sexes. Gross morphology and histology of gonads from Indian Ocean billfishes were described by Merrett (1970), but a thorough understanding of maturational cycles in Atlantic sailfish has yet to be obtained.

Florida's interest in the species was renewed in March 1970 by local concern for the welfare of the Palm Beach sailfishery. John Rybovich, Jr., representing local charter boat captains and anglers, examined catch statistics compiled by the West Palm Beach Fishing Club and Game Fish Research Association, Inc., and noted that the yearly catch of "gold button" sailfish (specimens eight feet or

[1]Florida Department of Natural Resources Marine Research Laboratory Contribution No. 208.

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FROM Shomura, R. S., and F. Williams (editors), Proceedings of the International Billfish Symposium, Kailua-Kona, Hawaii, 9-12 August 1972. Part 2. Review and contributed papers. NOAA Technical Report NMFS SSRF-675, 1974.

longer) had decreased significantly since 1947 (Fig. 1). Two gold button sailfish were reported in 1970, six in 1971, and three in 1972. In addition, total numbers of sailfish of all sizes declined during the famous Silver Sailfish Derby from 1948 to 1967 (Fig. 2).

Palm Beach anglers presumed that these declines represented a reduction in numbers of locally available sailfish. However, verification of their conclusion relies upon careful examination of several contributing factors.

An objective examination into the apparent decline of total numbers of sailfish (Fig. 2) revealed

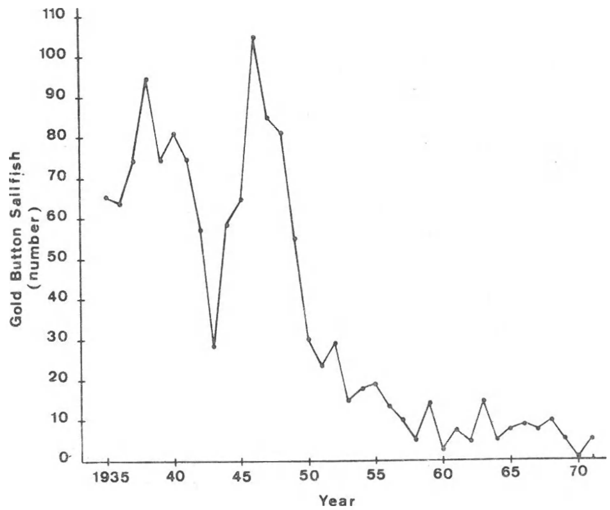

Figure 1.—Total number of "gold button" sailfish recorded by the West Palm Beach Fishing Club, 1935 to 1971.

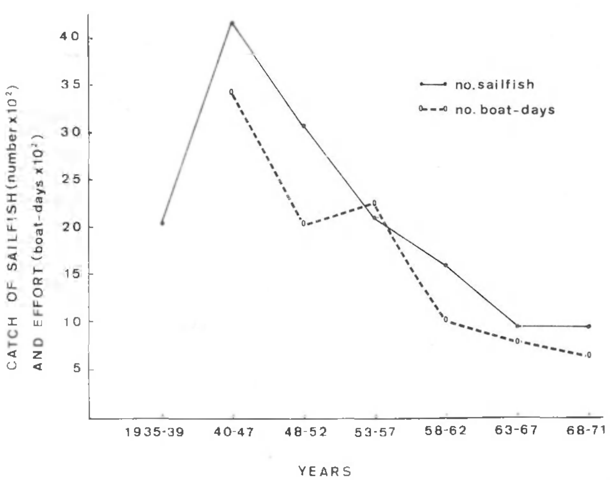

Figure 2.—Sailfish catch and effort data reported for five-year periods during the Silver Sailfish Derby, 1935 to 1971.

that Silver Sailfish Derby tournament effort (boat-days) decreased concomitantly (except during 1953-57) and apparently has stabilized since 1967. Reasons for this decline are not known. Calculations of catch per unit of effort (Fig. 3) from three popular

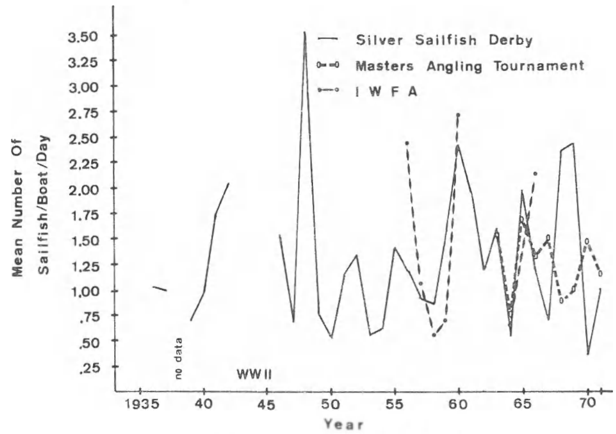

Figure 3.—Mean catch per unit of effort calculated from records of three popular sailfishing tournaments.

sailfishing tournaments held in the Palm Beaches (Silver Sailfish Derby, 1935 to 1971; International Women's Fishing Association, 1956 to 1966; and Masters Angling Tournament, 1963 to 1971) revealed fluctuating patterns of relative abundance, but did not suggest a continued decline. Combined mean catch per unit of effort for these tournaments was 1.31 sailfish/boat-day (approximately 0.16 to 0.22 sailfish per hour). These figures exceed those reported for sailfisheries in the Gulf of Mexico (Nakamura, 1971; Nakamura and Rivas, 1972) and those at Malinda, Kenya (Williams, 1970). Wise and Davis (1973) found that Japanese longline catches in the Atlantic during 1956 to 1968 showed a significant increase in sailfish and spearfish per 1,000 hooks fished. This apparently suggests that the magnitude of Atlantic sailfish stocks had not been affected adversely up to 1968.

Obviously there is much contradictory information. Many knowledgeable anglers and boat captains insist that tournament catch per unit of effort has been maintained only by extending the fishing area northward in recent years and improving fishing methods. Thus the FDNR initiated studies designed to fully investigate the biological status of the species. Further assessment of the welfare of southeast Florida sailfish stocks may then be made.

METHODS AND MATERIALS

Sailfish taken by the sport fishery were examined from May 1970 through September 1971. Weekly visits to Pflueger Taxidermy in Hallandale and West Palm Beach, and Reese Taxidermy in Fort Lauderdale, facilitated examination of moderate numbers of specimens taken mainly from offshore Fort Pierce to Miami (Fig. 4). Occasionally, specimens from Georgia, Virginia, Bahamas, Florida Keys, and Destin, Florida were also examined.

Twenty-five to 35 fresh specimens were selected each month from a size range representative of the sport catch. Total, fork, standard, "body" (Rivas, 1956), and "trunk" (de Sylva, 1957) lengths were obtained to the nearest 0.5 cm with a 3 m measuring board. Total weight was taken to the nearest 0.2 kg, using a 68.0 kg capacity Chatillon (Model 100)[3] spring scale. Additional information was recorded concerning position of hook, bait used in capture, stomach contents, and presence of parasites.

Two or three anterodorsal fin spines from each specimen were cleaned and placed in numbered envelopes. Spines were allowed to dry for several months before sectioning with a No. 409 emery disk (24.0 mm diameter × 0.5 mm thickness) mounted in a high speed Dremel Moto Tool (Model 270) with speed control (Model 219). This unit was mounted on an aluminum platform. A spring-loaded battery clamp was attached to a 180° rotating lever approximately 1 inch in front of the tool chuck. This securely held each spine during sectioning. Two or three cross sections were cut at 2.5 to 5.0 mm above the expanded base (condyle) of each spine (Fig. 5). Each section was then ground to approximately 0.75 mm with a No. 85422 grinding stone at low speed. Spinal sections were stored dry because water or glycerol causes excessive clearing. During examinations, however, spinal sections were temporarily immersed in glycerol and examined with a binocular dissecting microscope against a black background under reflected light. Circuli in each section have been counted once, but three additional independent readings will be made later by two biologists without reference to collection data.

Gonadal condition was evaluated macroscopically and a sample of tissue was removed for histological preparation. Gonadal tissue was initially

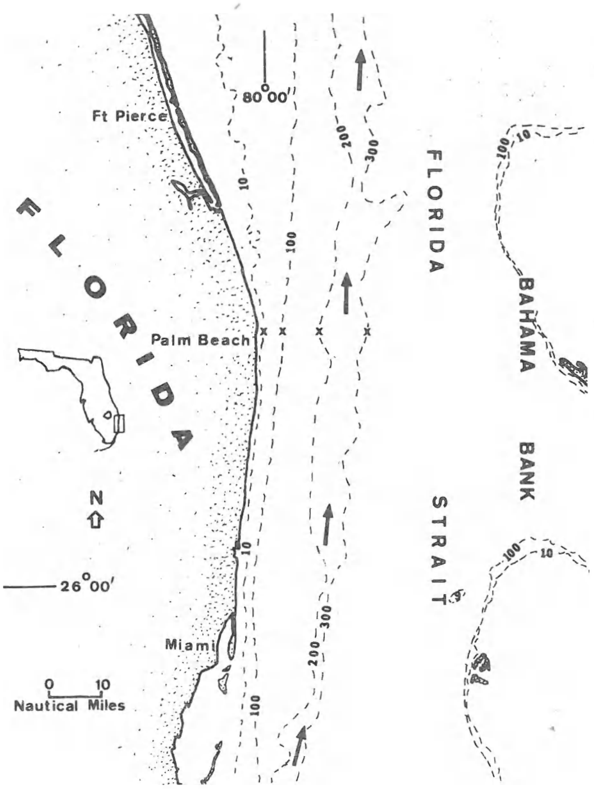

Figure 4.—Chart of southeast Florida showing area where most sailfish were obtained (almost the entire catch was taken between 10 and 100 fathoms). X's indicate station locations of monthly plankton and night-light collections. Aperiodic daylight collecting trips were conducted 5 to 15 nautical miles north and south of Palm Beach. Arrows indicate axis of Florida current; soundings in fathoms.

Figure 5.—Dorsal spine base, shaft and two sections after cutting.

preserved with Zenker's fixative. Tissue was rinsed with tap water and stored in Lugol's solution 18 to 36 h after collection. It was necessary to thoroughly leach out all fixative before final storage. At the St. Petersburg laboratory, gonadal tissue was imbedded in paraffin and sectioned at 6 μ . Slides were stained with Papanicolaou Haematoxylin (Harris) and Eosine Y, and with another stain developed by the

[3] Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

histology laboratory. These slides are presently available for microscopic examination.

During the spawning season, whole "ripe" ovaries from fish weighing 15.9 to 38.0 kg (35.0 to 84.0 lb) were removed, weighed to the nearest 10 grams, and injected with 10% Formalin for fecundity estimates. These ovaries were usually "running ripe," i.e., large ova had ruptured from follicles and were flowing into the center of the lumen. Fecundity estimates were obtained by the subsampling by weight method described by Bagenal and Braum (1968) and Moe (1969). Techniques for determining distribution of mature ova within various sections of the ovary followed Otsu and Uchida (1959). Ova were successfully disassociated from ovarian tissue with microdissecting needle and forceps.

Monthly plankton and night-light collections were conducted from June 1970 through October 1971. Surface and oblique tows were made with 1 m plankton nets (mesh size 602 μ for body section and 295 μ for cod end). Supplemental daylight collecting trips were conducted aperiodically.

RESULTS AND DISCUSSION

Age and Growth

De Sylva (1957) reported that sailfish grow rapidly, attaining a weight of 9.1 kg (20 lb) within a year. Using the Petersen method, he estimated the average life span as 2-3 yr, but suggested that these results be checked by the more conventional assessment method of utilizing annular marks. Although Koto and Kodama (1962) indicated that circuli in scales, otoliths, centra, and fin rays of "Marlin" could not be recognized as annular, considerable effort is being expended to develop a technique to age individual sailfish. Sailfish pectoral and dorsal fin spines, branchiostegal rays, operculi, and vertebral centra were examined for growth marks; scales and statoliths were considered too small to be used. Two structures, vertebral centra and dorsal fin spines, showed distinct circuli which appeared to increase in number with fish length. However, each sailfish centrum is fused to part of the adjacent neural arch, and it is extremely difficult to remove the centra without damaging a specimen destined for trophy mounting. Therefore, dorsal fin spines III, IV, and V were selected as the aging structure since each of these spines has a relatively large base and is easily extracted. Spine removal poses no problem for the taxidermist because dorsal fins are not used in trophy preparation.

Increase in trunk length was compared with increase in width of the fourth (IV) spine for 132 specimens (Fig. 6). The linear equation, $y = 47.600 + 9.881x$, describes a line fitting the regression. An analysis of variance (Table 1) attests to the goodness of fit, thus satisfying the proportional growth requirement for use of a bony structure in aging (Parrish, 1958; Watson, 1967).

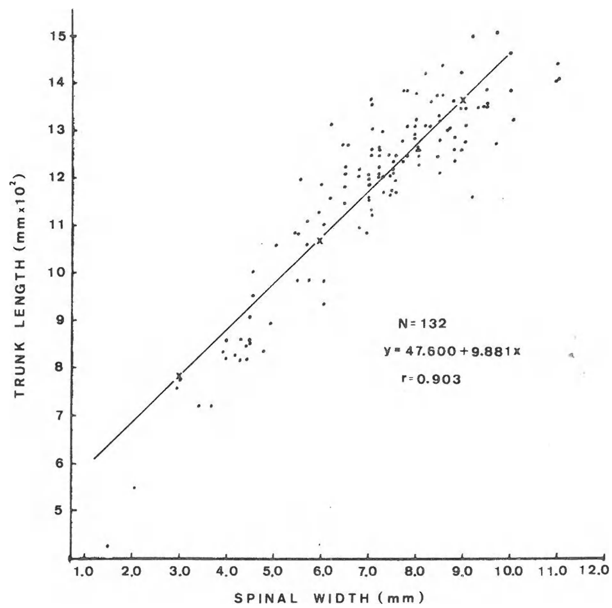

Figure 6.—Relationship of trunk length and fourth dorsal spine width. Spinal width was measured at 0.5 mm above the dorsalmost portion of each condyle.

Table 1.—ANOVA regression of trunk length on fourth spine width.

Source	*d.f.*	Sum of squares	Mean square	*F*
Spine width	1	42,426.8363	42,426.8363	[1]576.807
Residual	130	9,562.0936	73.5546	
Total	131	51,988.9299		

$y = 47.600 + 9.881x$
S^2b 0.169
% variation = 81.607
$r = 0.903$

[1] Sig. at $P = 0.05$.

Spinal sections from 193 specimens were read once. Initial results indicated that about 64 of the sections were clearly legible. These readings ranged from age groups 0 through VII (Table 2). Age group III was most numerous.

Narrow translucent (dark) and wider opaque (white) zones can be easily distinguished in a spinal section from one specimen (Fig. 7). The radius of the first circulus is greater than each successive radius. The central portion of all spines is vascular, and in large specimens this area often obscures the first and second circuli. Consequently, determination of the placement of these first circuli will depend upon careful examination of their positions in younger specimens.

Several additional methods have been tried to facilitate readings. A "burning technique" used by Christensen (1964) to emphasize annular marks on otoliths of the North Sea sole, *Solea solea,* was not effective on sailfish spinal sections. Staining with various concentrations of methylene blue was likewise ineffective. A magnified image produced by projection with a Bausch and Lomb overhead projector was not sufficiently clear to enumerate all circuli. Several spinal sections have been decalcified and stained with varying degrees of success. Some progress is now being made using these techniques.

Table 2.—Age readings of Atlantic sailfish using best sections from fourth dorsal fin spines.

No. circuli	0	I	II	III	IV	V	VI	VII
Frequency	3	4	15	21	12	5	2	2

$N = 64/193$

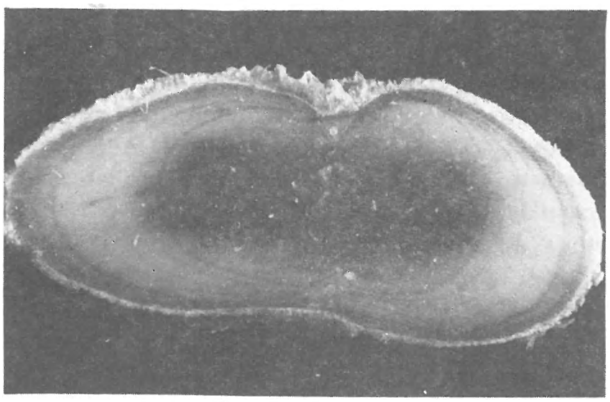

Figure 7.—Section from the fourth dorsal fin spine of a female in at least age group VI, wt=19.958kg, Dec. #10 - 1970.

Results thus far available from this study express the need for growth equations based upon accurate methods of aging. Females were found to be consistently larger than males (Table 3 and Fig. 8), and the sex ratio changed appreciably during the season; 65% of the sailfish examined from December through May were females (Fig. 9).

Nakamura and Rivas (1972) also noted that female sailfish from the Gulf of Mexico sport fishery were typically larger and more numerous than males. Considerable variation in sailfish weight at a given

Table 3.—Weight and trunk length of Atlantic sailfish examined May 1970 through September 1971.

Number individuals	Mean weight (kg)	Weight range (kg)	Trunk length range (cm)
Total = 412	17.0	0.5-39.5	
Males 182	14.9	2.3-27.4	70.0-144.0
Females 230	18.7	0.5-39.5	42.5-151.5
Total >18.1 kg = 177			
Males 50	20.6		
Females 127	23.6		

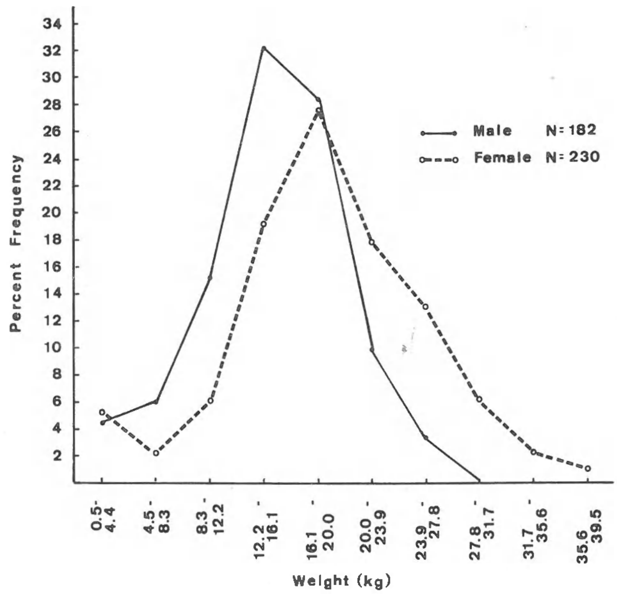

Figure 8.—Percent frequency distribution of 412 male and female sailfish by weight.

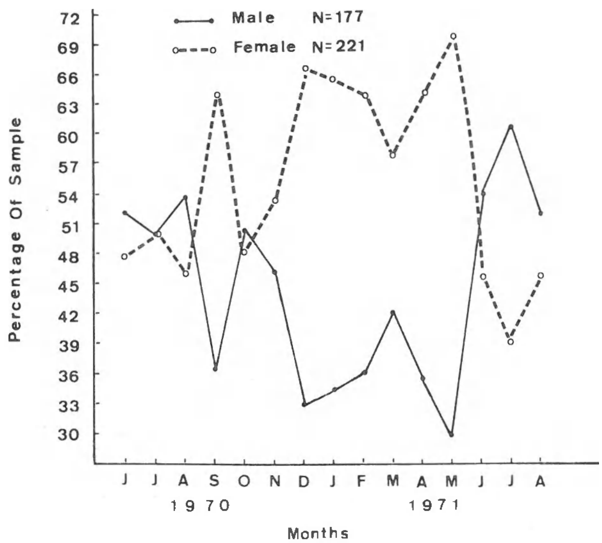

Figure 9.—Sex ratio of 398 sailfish expressed as a percent of each monthly sample.

age has been observed by de Sylva (1957) and Williams (1970), but no specific correlations have yet been made with regard to sex. Perhaps a difference in growth rate would account for the size disparity between sexes.

A significant difference was observed between the length-weight relationships by sex ($t.05=3.121$, *d.f.* 410). Females smaller than 137 cm trunk length were notably heavier than males of comparable length (Fig. 10). Merrett (1968:165) found no sexual distinction in the length-weight relationship of 120 Indian Ocean sailfish 126-194 cm "eye to fork length" (11.3 to 47.6 kg). Many of the fish he examined were considerably larger than those I weighed and measured (see Table 3). However, Williams (1970) acknowledged that a sexual difference in the length-weight relationship may exist, as is the case in marlins.

Reproduction

Gonadal tissues have not yet been fully evaluated microscopically. However, in assessing reproductive development from slides of Indian Ocean billfish gonadal tissue, Merrett (1970) reported that ovulation was probably not an all-or-none process, and that many resting oocytes were "reabsorbed." Similarly, Moe (1969) found that not all developing oocytes reached maturity in red grouper, *Epinephelus morio*. Many "rejuvenilized" during a resting stage subsequent to the spawning period. Beaumariage (in

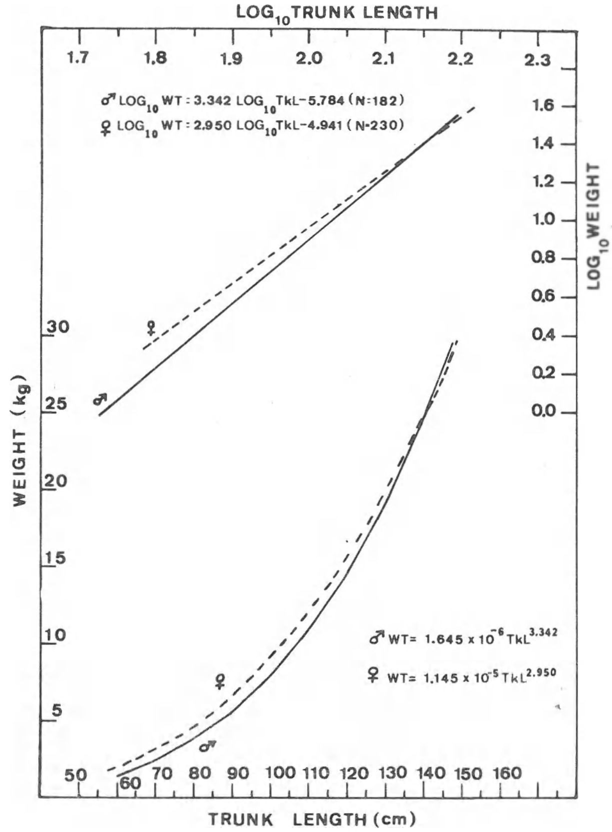

Figure 10.—Relationship of trunk length to weight for 412 Atlantic sailfish.

press) noticed a similar condition in young king mackerel, *Scomberomorus cavalla*. Such developmental characteristics will be considered when sailfish slides are examined.

Fecundity was estimated for eight sailfish varying in size from 17.2 to 27.4 kg (38.0 to 62.5 lb) (Table 4). Counts of "ripe" oocytes yielded fecundity estimates varying from 0.8 to 1.6 million ova. These oocytes constituted fewer than half the total number in the ovary. Voss (1953) estimated total fecundity of sailfish to be 2.3 to 4.7 million ova, probably an exceedingly high number of "ripe" oocytes. His counts were made from an ovary only 4.2% of specimen weight (Voss, 1953:227). Although he gave no size range for oocytes counted, I suspect they were not fully developed. I counted only the largest ova, 1.2 to 1.4 mm in diameter, from ovaries 8.1 to 12.7% ($\bar{x}$ = 9.9%) of specimen weight.

Correlation of gonadal tissue evaluations, larval sailfish abundance, and age estimates will allow definition of spawning frequency and age at maturity.

Table 4.—Results of fecundity studies for eight Atlantic sailfish ranging from 17.2 to 27.4 kg (38.0-62.5 lb).

Specimen	Total wt[1] (kg)	Ovary wt[1] (kg)	Body wt[1] (%)	Ova/gram wt	Est. fecundity
VI-14'	18.1	2.3	12.7	467	819,412
VI-15'	17.2	2.0	11.6	555	750,000
Not recorded	28.4	ca 2.4	8.5	457	1,075,321
VIII-1'	28.1	ca 2.6	9.3	498	1,148,918
VII-14'	19.1	2.0	10.5	890	1,557,574
IX-8	28.4	ca 2.3	8.1	616	1,297,850
VIII-3'	23.1	1.9	8.2	580	919,300
VI-17'	22.2	2.3	10.4	462	891,270

[1]Fresh weights recorded during field examination.

Initial observations from plankton collections confirm that sailfish spawn throughout summer. Larval and juvenile istiophorids 3 to 105 mm total length were collected during April through October. "Ripe" females were also prominent among adults sampled during May through September (Fig. 11). Spawning appears to be intense in mid-May through September. Two peaks were apparent during the spawning seasons (Fig. 11). A preliminary microscopic examination of gonadal tissue from "ripe" specimens and variation in the ovaries' percent of total body weight and number of ova per gram weight of ovary suggest multiple spawning.

ACKNOWLEDGMENTS

Special appreciation is expressed to John Rybovich, Jr., who helped organize and establish a field laboratory in West Palm Beach. Mr. Rybovich has been a constant source of help and enthusiasm during the entire project. Frances Doucet and staff of the West Palm Beach Fishing Club provided professional and secretarial services. The Phipps Foundation and Don J. S. Merten (Tournament of Champions winner, 1972) have provided financial assistance through cooperation with Game Fish Research Association, Inc. of West Palm Beach. Appreciation is extended to all anglers, sport fishing captains, and other local interests who directly or indirectly contributed to the project's success but who are too numerous to mention by name.

I am indebted to Al Pflueger, Jr. and James D. Smith of Pflueger Taxidermy for providing fresh specimens. Walter C. Jaap provided photographs of spines and spinal sections and Henry Kamiya

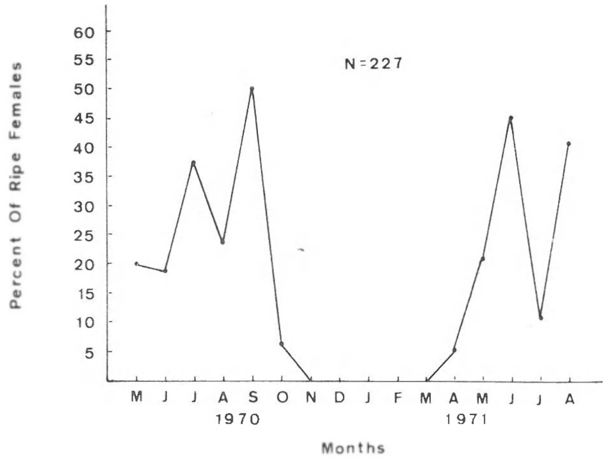

Figure 11.—"Ripe" sailfish expressed as a percentage of total females examined monthly.

drafted figures. Robert M. Ingle, Edwin A. Joyce, Jr., Robert W. Topp, Charles R. Futch, and especially Dale S. Beaumariage provided guidance and editorial review.

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