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Analysis of Length and Weight Data On Three Species of Billfish From the Western Atlantic Ocean

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ABSTRACT

Estimates of parameters of relations among weight, girth, total length, fork length, body length, trunk length, and caudal spread were made for blue marlin, white marlin, and sailfish captured in the western Atlantic. Some sexual differences were found.

Estimates of relations between length and weight of fish are important, because weight is often the desired measure when only length measurements are practical. For example, obtaining accurate weights on vessels at sea is difficult, especially when specimens may weigh hundreds of pounds, as is often the case for billfish. Both sport and commercial fishermen are more interested in weight than in length, for game fish records are listed by weight and commercial fishermen are paid by the weight of their catch.

Although length measurements of billfish have been taken in numerous ways (Rivas, 1956; Royce, 1957), we chose eye-fork length as the most meaningful, because it involves parts of the body that are least apt to be damaged.

In this study we estimated relations between eye-fork length and weight for blue marlin *(Makaira nigricans)*, white marlin *(Tetrapturus albidus)*, and sailfish *(Istiophorus platypterus)* in the western Atlantic Ocean. The relations between girth, eye-fork length, and weight were also estimated, for weight can be more accurately estimated from eye-fork length and girth than from eye-fork length alone. The relations between total length, fork length, body length, caudal spread, and eye-fork length were estimated so that measurements of the first four types could be converted to eye-fork length for comparative purposes. We also examined sexual, spatial, and temporal differences among some of the relations.

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SOURCES OF DATA AND TYPES OF MEASUREMENTS

Most of the data were obtained by personnel of the Panama City Laboratory, Gulf Coastal Fisheries Center, National Marine Fisheries Service, from sportfishermen's catches in the northeastern Gulf of Mexico during 1971. Weights, lengths, girths, and sex were determined for billfishes landed at Port Eads, Louisiana, and at three ports in northwest Florida: Pensacola, Destin, and Panama City.

Data were also obtained from cooperative scientists for catches made in various years off the coasts of New Jersey, North Carolina, and Florida, around the Bahama Islands, in the Caribbean Sea, and off Rio de Janeiro.

Most measurements were made in English units, a few in metric units. All weights were recorded in pounds. Lengths were recorded in inches or in centimeters. Metric measurements were converted to inches for the analyses, since sportsmen and commercial fishermen use inches and pounds. Four kinds of length measurements plus the girth and caudal spread were made by personnel of the Panama City Laboratory, except when conditions did not permit (e.g., broken bill or shark bites). Data from the cooperating scientists consisted of one or two kinds of length plus weight.

Measurements and their criteria are listed below. Criteria for body length, girth, and caudal spread are the same as those of Rivas (1956). All, except girth, consisted of horizontal, straight-line measurements.

(1) Total length: tip of bill to line joining tips of caudal lobes.

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.

(2) Fork length: tip of bill to tips of mid-caudal rays.
(3) Body length: tip of lower jaw (with jaws closed) to tips of mid-caudal rays.
(4) Eye-fork length: posterior margin of eye to tips of mid-caudal rays.
(5) Caudal spread: dorsal tip to ventral tip of lobes of caudal fin.
(6) Girth: twice the curved distance along one side of the body from the pelvic groove to the dorsal edge of the dorsal groove.

METHODS OF ANALYSIS

Three equations were used in the study. The relation between $\log_{10}$ (weight) and $\log_{10}$ (eye-fork length) is given by

$$Y = A + B_1 X_1 \qquad (1)$$

where

Y = $\log_{10}$ (weight),
A = intercept,
B_1 = coefficient,
X_1 = $\log_{10}$ (eye-fork length).

The equation can be transformed to the familiar form

$$\text{weight} = A' \text{ (eye-fork length)}^{B_1}$$

where

$$A' = 10^{A}$$

by taking antilogs of both sides of (1). The relation between $\log_{10}$ (weight), $\log_{10}$ (eye-fork length), and $\log_{10}$ (girth) is given by

$$Y = A + B_1 X_1 + B_2 X_2 \qquad (2)$$

where

Y = $\log_{10}$ (weight),
A = intercept,
B_1 and B_2 = coefficients,
X_1 = $\log_{10}$ (eye-fork length),
X_2 = $\log_{10}$ (girth).

The equation can be transformed to

$$\text{weight} = A' \text{ (eye-fork length)}^{B_1} \text{ (girth)}^{B_2}$$

by taking the antilogs of both sides. The relations between eye-fork length and other measures of length are given by

$$Y = A + B_1 X_1 \qquad (3)$$

where

Y = eye-fork length,
A = intercept,
B_1 = coefficient,
X_1 = other measure of length.

Equation (1) was not used for the relation between the various measures of length because estimates of B were very close to 1, indicating that linear relations among the variables were appropriate. Equation (3) was used instead.

The parameters of (1), (2), and (3) were estimated by use of linear regressions. Analysis of covariance was used to examine sexual differences. Multivariate analysis was used to determine if white marlin could be sexed or allocated to either Florida or Louisiana given measures of length and weight.

RESULTS AND DISCUSSION

Estimates of the parameters of (1), (2), and (3) are shown in Table 1. All estimates of the parameters are significantly different from 0 at the 0.01 level of significance.

Analyses of covariance revealed no significant differences between sexes in the relations between weight and eye-fork length, between eye-fork length and the three other measures of length, and between eye-fork length and caudal spread for blue marlin. However, sexual differences were found in the relations between weight and eye-fork length and between eye-fork length and caudal spread for white marlin (Fig. 1 and 2). Female white marlin tend to weigh more at a given length than male white marlin, but this difference tends to disappear at larger sizes. Further examination of the data indicates that the difference is partially the result of females tending to have deeper bodies than males. Male white marlin tend to have a wider caudal spread than females and the difference tends to increase with size. A sexual difference in caudal spread was also found for sailfish (Fig. 3), but the difference decreases with increased size. Sexual differences were not found in the length-weight relation for sailfish.

Deviations from the length-weight relation of the

Table 1.—Estimates of parameters of equations (1), (2), and (3).

Species	Y[1]	X^1_1	X^1_2	A	B_1	B_2	Sample size	Standard error	Range of X_1 (inches) Minimum	Maximum
Blue marlin	W	LL4	—	-3.84620	3.28222	—	78	0.0566	50.8	103.5
Blue marlin	W	LL4	G	-3.15120	1.80496	1.27853	78	0.0390	50.8	103.5
Blue marlin	L4	L1	—	1.68522	0.66670	—	80	1.9740	73.0	149.0
Blue marlin	L4	L2	—	3.07821	0.72374	—	80	1.6853	64.0	134.0
Blue marlin	L4	L3	—	-0.74597	0.88352	—	83	2.1451	58.0	117.0
Blue marlin	L4	TT	—	4.33691	1.93860	—	75	5.1410	24.0	48.0
White marlin	W	LL4	—	-2.41011	2.37515	—	182	0.0593	47.5	70.0
White marlin	W	LL4	G	-2.20239	1.24968	1.25290	177	0.0472	47.5	70.0
White marlin	L4	L1	—	-0.71780	0.66084	—	196	1.8680	72.5	99.0
White marlin	L4	L2	—	-0.59179	0.73942	—	193	1.5571	65.5	91.0
White marlin	L4	L3	—	1.17904	0.83010	—	192	1.1205	56.0	79.0
White marlin	L4	TT	—	40.38790	0.64258	—	185	3.0604	11.0	27.0
Sailfish	W	LL4	—	-3.89480	3.15757	—	244	0.0532	15.8	62.5
Sailfish	W	LL4	G	-3.36702	2.27782	0.73757	242	0.0480	15.8	62.5
Sailfish	L4	L1	—	-1.96822	0.68216	—	260	1.5403	26.0	93.0
Sailfish	L4	L2	—	-1.09314	0.75088	—	260	1.2235	23.0	85.0
Sailfish	L4	L3	—	-0.78628	0.87262	—	267	0.9175	19.2	72.5
Sailfish	L4	TT	—	11.66889	1.87509	—	256	4.0575	4.0	28.0

[1] W = $\log_{10}$(weight)
LL4 = $\log_{10}$(eye-fork length)
L4 = eye-fork length
L1 = total length
L2 = fork length
L3 = body length
TT = caudal spread
G = girth

three species were plotted against month of capture to examine the possibility of seasonal patterns in the relations. None was found.

Multivariate analysis was used in an attempt to develop a method of sexing white marlin given weight, caudal spread, and the measures of length. Approximately 75% of the specimens could be properly sexed. Although this procedure produced better results than pure guesswork, the results are not satisfactory for scientific purposes.

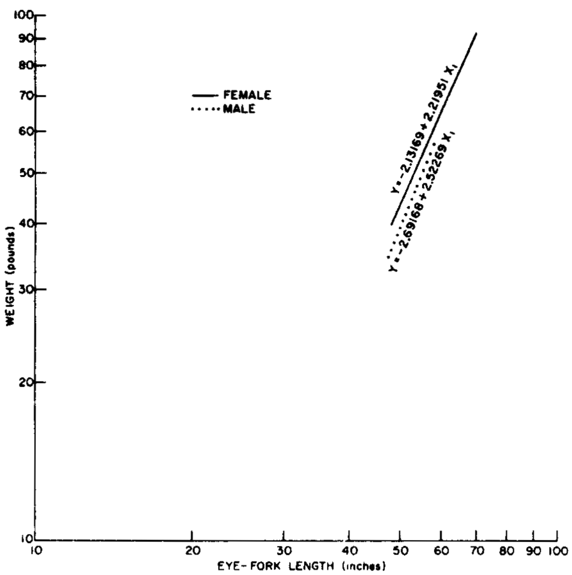

Figure 1.—Relationship of weight and eye-fork length of white marlin *(Tetrapturus albidus)* by sex.

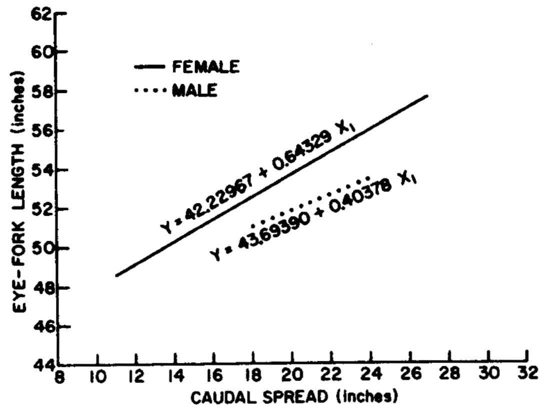

Figure 2.—Relationship of eye-fork length and caudal spread of white marlin *(Tetrapturus albidus)* by sex.

Multivariate analysis was also used to determine if white marlin could be allocated to Florida or Louisiana given weight, caudal spread, and the measures of length. White marlin could not be so allocated.

A review of the literature revealed that very little had been done on length-weight relations of billfishes in the western Atlantic Ocean. De Sylva and Davis (1963) estimated the relation between body length and weight for white marlin and noted the same sexual difference found in this study. De Sylva (1957) plotted weight and total lengths of sailfish but did not estimate the parameters of the relation.

The results of our analyses will permit conversions from one type of length to another and also will provide better estimates of weight from length plus girth measurements.

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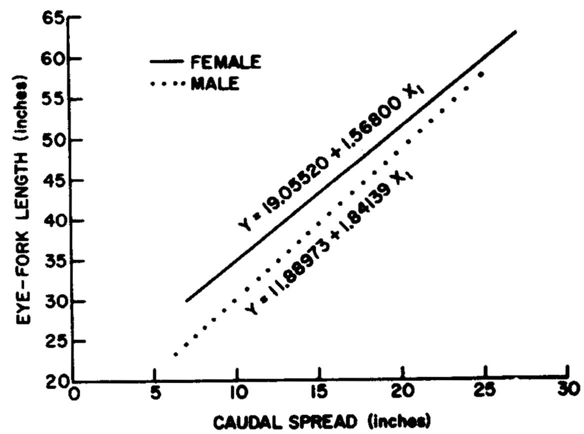

Figure 3.—Relationship of eye-fork length and caudal spread of sailfish *(Istiophorus platypterus)* by sex.

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