WEIGHT-TOTAL LENGTH AND LENGTH-LENGTH RELATIONSHIPS FOR FOUR SALTWATER FISHES

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ABSTRACT

Weight-total length relationships were developed for red snapper (Lutjanus campechanus), vermilion snapper (Rhombolites aurorubens), Spanish mackerel (Scomberomorus maculatus) and dolphin (Coryphaena hippurus) caught in the Gulf of Mexico off the Texas coast. Total length-standard length relationships were developed for red snapper and vermilion snapper. Total length-fork length relationships were developed for Spanish mackerel and dolphin.

Regression coefficients for equations in the form of $Y = a + bX$ were estimated for $\log_{10}$ transformed weight (W) as a function of $\log_{10}$ transformed total length (TL), TL as a function of standard length (SL), and TL as a function of fork-length (FL).

The equations developed for the species in this study were generally different from those reported in other studies.

INTRODUCTION

Conversions from length to weight (W) or weight to length can be calculated if regression analysis is used to establish the relationship between weight and length. These conversions allow for estimates of harvest by weight by utilizing fish measured but not weighed.

Three different methods are commonly used to measure fish lengths in fisheries surveys: total length (TL), standard length (SL) and fork length (FL). A particular species' length is often recorded using only one method, however, many weight-length relationships have been developed utilizing a combination of these measurements. In addition, total lengths and even fork lengths cannot be obtained in some cases because of caudal fin damage. Conversions among these methods of measurement allow the inclusion of length data formerly excluded as well as comparisons of length data from other studies or sources. Conversions also provide the mechanism by which a single standard measure of length can be made for regulatory and enforcement purposes.

Weight-length relationships have been developed for red snapper (Lutjanus campechanus) in isolated areas of the Gulf of Mexico (Camber 1955, Dawson 1963, Futch and Bruger 1976) and the Atlantic Ocean (Nelson and Manooch 1982). Grimes (1978) provided W-TL regressions for vermilion snapper (Rhombolites aurorubens) from Atlantic waters off North and South Carolina. Spanish mackerel (Scomberomorus maculatus) regressions have been calculated for fish caught off Florida (Powell 1975) and off Veracruz, Mexico (Doi and Mendizabal 1978). Weight-length relationships have been reported for dolphin (Coryphaena hippurus) caught in the Straits of Florida (Beardsley 1967), in the Atlantic Ocean off North Carolina (Schuck 1951, Rose and Hassler 1968), and in the Mediterranean Sea (Bannister 1976).

General weight-length relationships for red snapper, vermilion snapper, Spanish mackerel and dolphin caught in the Gulf of Mexico off the Texas coast have not been previously reported. No TL-SL regressions for red snapper or vermilion snapper or TL-FL regressions for Spanish mackerel or dolphin have been previously reported from Texas coastal waters.

The objectives of this paper were to:

1) develop W-TL equations for red snapper, vermilion snapper, Spanish mackerel and dolphin;

2) develop TL-SL conversions for red snapper and vermilion snapper; and

3) develop TL-FL conversions for Spanish mackerel and dolphin.

MATERIALS AND METHODS

Individual weight-length and length-length data were collected on selected Gulf of Mexico fish during routine Texas Parks and Wildlife Department (TPWD) creel surveys (McEachron 1984) and during routine surveys of Texas commercial fish houses (McEachron 1980) from September 1978 through November 1980. Fish were also collected during routine Gulf sampling (Cody and Avent 1980). Fish for this study were identified and TL (from the tip of snout to the tip of the caudal fin), SL (from the tip of the snout to the posterior end of the vertebral column), and/or FL (from the tip of the snout to the fork of the caudal fin) were recorded to the nearest mm (Hoese and Moore 1977). Fish $\leq$10.0 lbs (4.54 kg) were weighed to the nearest 1.0 oz (0.03 kg) on an Accu-weigh model SM40 scale; fish >10.0 lbs (4.54 kg) were weighed to the nearest 0.5 lb (0.23 kg) using a Hanson hanging scale. All weights were converted to grams before analysis.

Least squares linear regressions ($P = 0.05$) were performed on the log transformed model of $W = aTL^b$ (LeCren 1951) thus resulting in the computational equation $\log W = \log a + b \log TL$, where a = W axis intercept and b = the slope of the regression line (Sokal and Rohlf 1969). Weights were regressed on TL for red snapper, vermilion snapper, Spanish mackerel and dolphin.

TL-SL and TL-FL were plotted and inspected to determine linearity. TL was regressed on SL for red snapper and vermilion snapper using TL = a + bSL. TL was regressed on FL for Spanish mackerel and dolphin using TL = a + bFL.

Coefficients of determination (r^2) were calculated for all equations and 95% confidence intervals were calculated for each slope. Ninety-five percent confidence intervals were also calculated for the y-intercept (a) of each weight-length regression. Slopes for W-TL regressions were tested against $b = 3$ using a two tailed t-test ($P \leq 0.05$) to determine if growth was isometric (Everhart et al. 1975).

RESULTS

The W-TL regressions for red snapper, vermilion snapper, Spanish mackerel and dolphin explained from 74% to 99% of the variation of weight as a function of TL (Table 1). Slopes of the W-TL equations for red snapper ($t = 9.93$, $df = 510$) and vermilion snapper ($t = 2.44$, $df = 190$) were significantly different from the hypothesized value of 3. However, for Spanish mackerel ($t = 1.12$, $df = 73$) and dolphin ($t = 1.30$, $df = 65$), slopes were not significantly different from 3.

The TL-SL regressions for red snapper and vermilion snapper explained from 89% to 97% of the variation of TL as a function of SL (Table 2). The TL's were 10% and 17.7% greater than SL's for red snapper and vermilion snapper, respectively.

The TL-FL regressions for Spanish mackerel and dolphin explained from 99% to 100% of the variation of TL as a function of FL (Table 3). The TL's were 12.3% and 20.5% greater than SL's for Spanish mackerel and dolphin, respectively.

DISCUSSION

The weight-total length relationships developed for the species reported in this study differ from the relationships reported elsewhere. The W-TL relationships calculated for red snapper by Dawson (1963) (log W = 3.93125 + 2.60513 log TL) and by Nelson and Manooch (1982) (log W = -4.690 + 2.953 log TL) indicate that their slopes (b) do not fall within the confidence intervals calculated in this study. The W-TL relationship developed for vermilion snapper by Grimes (1978) (log W = 4.764 + 2.946 log TL) indicates b does not fall within the confidence intervals calculated in this study. The b for Spanish mackerel reported by Doi and Mendizabal (1978) (log W = 2.1367 + 3 log TL) does not fall within the confidence interval of b calculated in this stdy.

Weight differences for identical lengths may occur between sexes for Spanish mackerel (Powell 1975) and dolphin (Rose and Hassler 1968, Beardsley 1967). Because there was no differentiation between sexes for these two species in this study, these relationships will under or overestimate weights of fish, depending on sex. However, the relationships developed here are useful for estimating total harvest (by weight) when only lengths are obtained. The estimates will probably be less precise than if the catch is separated by sex and the appropriate regression for each sex is applied.

Differences in the published relationships and the one's developed for this study could be attributed to the use of different ranges and distributions of fish lengths, and different times and locations of data collection. For example, Dawson (1963) used a narrower range (37-354 mm) of red snapper total lengths than did the present study (175-940 mm).

Weight-length relationships for a species may vary over time due to such factors as metamorphosis or the onset of maturity (Le Cren 1951). Variations in condition may occur among spatially separate fish populations. Nelson and Manooch (1982) compared red snapper weight-length data from the east and west coasts of Florida and from the coast of the Carolinas and found significant differences for the weight-length regressions among these areas. Fisheries managers should utilize, when possible, W-L relationships calculated from fish collected in the geographic area where management occurs.

Many weight-length and length-length relationships for fishes used in this study were not directly comparable due to differences in measuring techniques. For example, regressions for red snapper were calculated as W-FL (Futch and Bruger 1976) and FL-SL (Bradley and Bryan 1975). Similarly, Schuck (1951), Camber (1955), and Bannister (1976) calculated W-FL for dolphin and Powell (1975) calculated W-SL for Spanish mackerel.

In addition, the slopes associated with the weight-length regression for Spanish mackerel and dolphin indicate isometric growth. Future regressions for these two species should be derived by separating the sexes during data collection which may result in an indication of allometric growth.

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Table 1. Weight-total length (TL) relationships for four species caught in Gulf waters off the Texas coast during September 1978–November 1980.

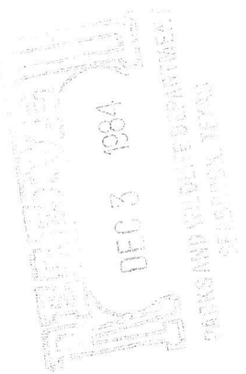
Species	TL range (mm)	N	a (95% confidence interval)	b (95% confidence interval)	r^2
Red snapper	175–940	512	-5.242 (-5.248 to -5.236)	3.145 (3.117 to 3.174)	0.99
Vermilion snapper	185–350	192	-5.766 (-5.782 to -5.770)	3.324 (3.063 to 3.584)	0.74
Spanish mackerel	320–720	75	-4.878 (-5.034 to -4.721)	2.866 (2.569 to 3.163)	0.84
Dolphin	333–920	67	-4.925 (-5.203 to -4.017)	2.888 (2.716 to 3.061)	0.94

Table 2. Total length-standard length (SL) relationships for two species caught in Gulf waters off the Texas coast during September 1978-November 1980.

Species	SL range (mm)	N	a	b	95% confidence interval of b	r^2
Red snapper	117-837	1821	19.319	1.177	1.168 to 1.186	0.97
Vermilion snapper	112-303	393	36.859	1.100	1.061 to 1.138	0.89

Table 3. Total length-fork length (FL) relationships for two species caught in Gulf waters off the Texas coast during September 1978-November 1980.

Species	FL range (mm)	N	a	b	95% confidence interval of b	r^2
Spanish mackerel	235-594	148	21.599	1.123	1.108 to 1.138	0.99
Dolphin	285-755	68	-2.648	1.205	1.186 to 1.224	1.00



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