Length-Weight Relationship of Gulf of Thailand Fishes

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Abstract

The length-weight relationship of 26 fish species belonging to 17 families obtained from the Gulf of Thailand was examined. As seven species were obtained from different survey periods and three were from two different locations, seasonal and geographic variations of the equation between body weight W and total length L, $W = aL^b$, were examined. The b values of the 27 species were tested for their significant differences from the value of 3; this confirmed that a few species showed significant differences of b value from 3. It is suggested that the 'cube law (b = 3)' can be applied to the length-weight relationship of most fishes in the Gulf of Thailand, with a few exceptions. This was confirmed by the analysis of b values from 72 additional species from the South China Sea area.

Introduction

The length-weight relationship of fish are important for biological studies and stock assessments. However, systematic biological data are not easily obtained; there are few reports concerning these subjects in the South China Sea Area. The status of biological information on fishes, squids and shrimps in the area has been reviewed, by FAO and SEAFDEC (1985), and Chullasorn and Martosubroto (1986), who have also compiled biological information on fishes, shrimps and squids in the area.

With the above in mind, the author seized the opportunity to join a project entitled 'Multidisciplinary Evaluation of the Artificial Reef Projects in Thailand' conducted by the Southeast Asian Fisheries Development Center (SEAFDEC)/Training Department, in collaboration with the Department of Fisheries, Thailand. Various types of biological information about fish were obtained by the survey project and were reported in the 'Stock Evaluation Survey' as a part of the report, by Fujisawa et al. (1989). However, some biological data on fish were still available and unpublished after the report on the artificial reef project had been issued. The author used this opportunity to examine the length and weight data on fish, and report them for future reference, not only for artificial reef projects, but also for general fisheries biological studies.

This study primarily examined the seasonal or geographic variations of the length-weight (L-W) relationship of seven species, obtained during different survey periods and locations. The observed b value of the equation $W = aL^b$ of 26 species was tested for any significant difference from the value of 3. In addition, the frequency distribution of the b value, from the available references, was discussed for 115 cases (72 species) in the South China Sea Area.

Materials and Methods

The specimens examined in this paper were obtained from surveys conducted during a 1988 project entitled 'Multidisciplinary Evaluation of the Artificial Reef Projects in Thailand' (Table 1), off Rayong and Phetchaburi (Fig. 1).

Table 1. Survey information in Rayong and Phetchaburi in the Gulf of Thailand.

Locality	Survey	Date
Rayong	1st survey (R-1)	25-29 January 1988
	2nd survey (R-2)	9-13 May 1988
	3rd survey (R-3)	13-17 June 1988
Phetchaburi	1st survey (P-1)	1-5 February 1988
	2nd survey (P-2)	23-27 May 1988

Specimens were collected by bottom gill nets, handlines and traps. Specimens were preserved in 10% formalin after being brought on board, and were then measured and examined at the laboratory. The effect on length and weight measurements of preserving the specimens in formalin can be considered as small, but its exact magnitude is unknown. Total length was taken from the anteriormost tip of the body with the mouth closed, to the farthest tip of the caudal fin, by calipers reading 0.1 mm. Body weight was measured to within 1 gram, after removing adhering water from the surface of the body.

Examination of linearity and test of the differences in regression coefficients and the adjusted means for log $W = \log a + b \log L$ were made using the 'REGRESSION' and 'ANOVA' routines of the SPSS/PC+ software (Norusis 1988). Calculation of the correlation coefficient was made using the 'PLOT' routine. In addition, the drawing of the frequency distribution of the b value with superimposed

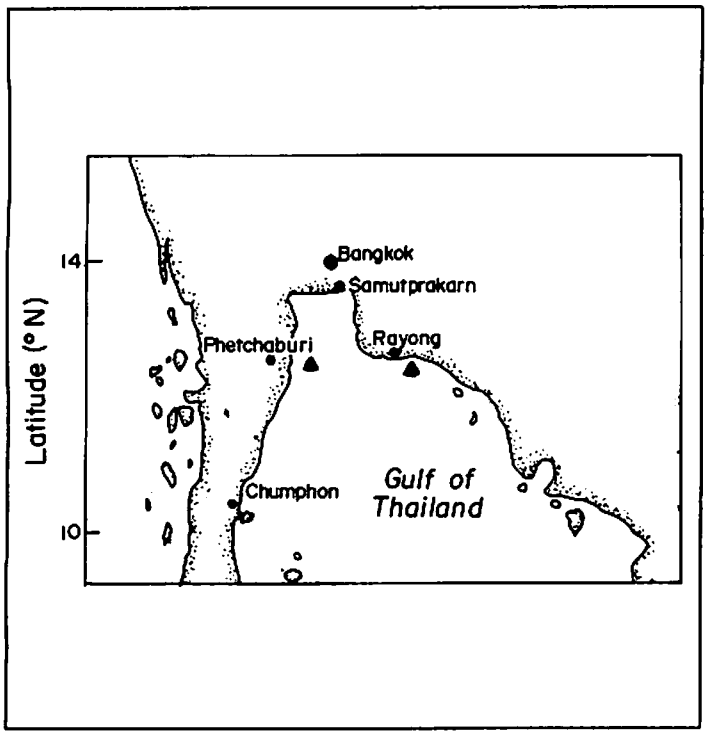

Fig. 1. *Inner Gulf of Thailand, showing the sampling area.*

normal curve, and calculation of kurtosis and skewness was done using the 'FREQUENCIES' routine.

Results and Discussion

The length-weight relationship of fishes obtained from the Gulf of Thailand was first examined for linearity; the tests of linearity were done at the 5% level for the regression coefficient (b value) and the adjusted mean ("a" value) of the linear regression equation. Twenty-six fish species belonging to 17 families were examined in this study.

Variations of the linear regression equation between seasons and locations

Seven of the 26 species, obtained from different survey periods at the same location, were tested for the regression coefficient and the adjusted mean of the linear regression equation (Table 2). Among them, only one species, *Lutjanus vitta*, showed significant differences between survey periods. There were significant differences of both the regression coefficient at the 5% level and the adjusted mean at the 0.5% level between survey period R-1 (late January) and R-2 (middle May) in Rayong. There was also a significant difference of the adjusted mean at the 0.5% level between survey period R-2 and R-3 (middle June) in Rayong. In Phetchaburi, however, there was no significant difference (b value, $0.50 > P > 0.25$; a value, $0.10 > P > 0.05$) of the linear regression equation of this species between survey period P-1 (early February) and P-2 (late May). Therefore, *Lutjanus vitta* in Rayong should be examined by separate periods when comparing the regression lines.

In the comparison of regression lines of three species between the two locations by species, *Monacanthus chinensis* showed a significant difference of the adjusted mean at the 1% level (Table 3). This may suggest different populations (Yanagawa 1981).

The comparison of b value of the other species, which showed no significant differences between seasons and locations, was done using the combined data.

Frequency distribution of b values

The values of a and b in the equation of $W = aL^b$, and the range of total length used for the estimation by species are shown in Table 4. All of the b values were tested for significant differences from the value of 3. There were seven cases (six species) which showed b values significantly different from 3: *Lutjanus russelli* in Phetchaburi, *Nemipterus hexodon* in Rayong, *Scolopsis ciliatus* in Rayong, *Chelmon rostratus* in Rayong and *Monacanthus chinensis* both in Rayong and Phetchaburi. After omitting the b values which differed significantly from 3, the statistical features of the b value in the length-weight relationship equation calculated from 23 cases (21 species) in the Gulf of Thailand, are shown in Table 5. The frequency distribution of b values with a superimposed normal curve is shown in Fig. 2; the mean value of b is estimated as 3.038, with a standard error of 0.038, i.e., the mean is very close to 3. The range of b value was from 2.658 to 3.388 and standard deviation 0.184. The kurtosis of b is -0.110, and the shape of frequency is a bit less peaked than the normal distribution. The skewness of the b value is small, -0.016.

Sixteen cases (14 species, accounting for 70% of the total) of the b value fell into the range between 2.8 and 3.2. Those species which showed b values of less than 3 are *Lutjanus lutjanus, Upeneus tragula, Terapon jarbua, Lutjanus vitta* in Rayong (middle May), *Lethrinus lentjan*, and *Epinephelus tauvina*. Those with b>3 are *Cephalopholis boenack, Siganus canaliculatus, Plectorhinchus pictus, Myripristis hexagona, Pentapodus setosus, Scolopsis temporalis, Selaroides leptolepis, Lutjanus vitta* in Phetchaburi (early February and late May) and Rayong (late January and

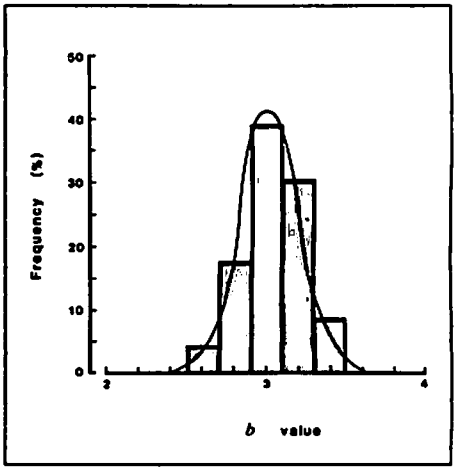

Fig. 2. *Frequency distribution of b value with superimposed normal curve from 23 cases (21 fish species in the Gulf of Thailand).*

Table 2. Comparison of the regression line between survey periods at Rayong and Phetchaburi in the Gulf of Thailand.

Species	Survey		N	Range of total length	Adjusted r^2	*a* value	*b* value	Test of slope			Test of adjusted mean		
								F_0	df	P	F_0	df	P
Cephalopholis boenak	Rayong	(R-1)	5	18.4 - 23.8	0.939	0.01048	3.126	0.235	1, 4	P>0.50	0.423	1, 5	P>0.50
	Rayong	(R-3)	3	15.6 - 21.8	0.997	0.01334	3.060						
Lutjanus russelli	Phetchaburi	(P-1)	14	11.4 - 33.8	0.994	0.00700	3.234	0.364	1,27	P>0.50	0.647	1,28	0.50>P>0.25
	Phetchaburi	(P-2)	17	13.0 - 30.0	0.982	0.00710	3.237						
Lutjanus vitta	Rayong	(R-1)	34	8.4 - 20.9	0.992	0.00837	3.173	5.017	1,71	0.05>P>0.01	9.106	1,72	P<0.005
	Rayong	(R-2)	41	13.2 - 21.9	0.946	0.01871	2.913						
Lutjanus vitta	Rayong	(R-1)	34	8.4 - 20.9	0.992	0.00837	3.173	3.376	1,91	0.10>P>0.05	0.453	1,92	P>0.50
	Rayong	(R-3)	61	11.9 - 20.4	0.894	0.01756	2.912						
Lutjanus vitta	Rayong	(R-2)	41	13.2 - 21.9	0.946	0.01871	2.913	0.279	1,98	P>0.50	11.751	1,99	P<0.005
	Rayong	(R-3)	61	11.9 - 20.4	0.894	0.01756	2.912						
Lutjanus vitta	Phetchaburi	(P-1)	18	10.2 - 14.1	0.875	0.01876	2.898	0.883	1,26	0.50>P>0.25	3.695	1,27	0.10>P>0.05
	Phetchaburi	(P-2)	12	11.4 - 16.1	0.965	0.01032	3.155						
Lutjanus lutjanus	Rayong	(R-2)	59	10.2 - 14.3	0.852	0.01482	2.989	1.252	1,86	0.50>P>0.25	1.018	1,87	0.50>P>0.25
	Rayong	(R-3)	31	12.1 - 16.4	0.875	0.02445	2.789						
Nemipterus hexodon	Rayong	(R-2)	5	17.3 - 20.4	0.826	0.02532	2.769	1.235	1, 7	0.50>P>0.25	0.094	1, 8	P>0.50
	Rayong	(R-3)	6	13.1 - 21.7	0.997	0.00492	3.337						
Pentapodus setosus	Rayong	(R-2)	10	12.8 - 21.4	0.975	0.01020	3.092	0.479	1,16	0.50>P>0.25	0.649	1,17	0.50>P>0.25
	Rayong	(R-3)	10	12.0 - 19.1	0.992	0.01137	3.044						
Lethrinus lentjan	Rayong	(R-1)	14	19.0 - 22.3	0.813	0.05119	2.607	1.088	1,30	0.50>P>0.25	2.979	1,31	0.10>P>0.05
	Rayong	(R-2)	20	14.3 - 22.7	0.990	0.01447	3.038						
Lethrinus lentjan	Rayong	(R-1)	14	19.0 - 22.3	0.813	0.05119	2.607	0.717	1,36	0.50>P>0.25	0.127	1,37	P>0.50
	Rayong	(R-3)	26	14.4 - 19.6	0.970	0.01619	2.992						
Lethrinus lentjan	Rayong	(R-2)	20	14.3 - 22.7	0.990	0.01447	3.038	0.697	1,42	0.50>P>0.25	1.763	1,43	0.25>P>0.10
	Rayong	(R-3)	26	14.4 - 19.6	0.970	0.01619	2.992						

Table 3. Comparison of the regression line between locations, Rayong and Phetchaburi, in the Gulf of Thailand.

Species	Location	N	Range of total length	Adjusted r^2	a value	b value	Test of slope			Test of adjusted mean		
							F_0	df	P	F_0	df	P
Epinephelus bleekeri	Rayong	7	20.5 - 26.9	0.840	0.00713	3.199	0.026	1, 7	P>0.50	0.306	1, 8	P>0.50
	Phetchaburi	4	12.4 - 23.8	0.997	0.01229	3.009						
Plectorhinchus pictus	Rayong	7	15.5 - 39.6	0.996	0.01275	3.012	2.965	1, 7	0.25>P>0.10	2.434	1, 8	0.25>P>0.10
	Phetchaburi	4	25.3 - 56.6	0.967	0.02142	2.898						
Monacanthus chinensis	Rayong	4	6.9 - 20.0	0.999	0.07038	2.447	0.089	1, 7	P>0.50	12.653	1, 8	0.01>P>0.005
	Phetchaburi	7	15.2 - 24.5	0.900	0.07978	2.506						

Table 4. Summarized length-weight relationships of fish obtained from the Gulf of Thailand.

Species	N	Range of total length	Adjusted r^2	a	b	Survey
Holocentridae						
Sargocentron rubrum	8	12.4 - 18.4	0.871	0.05710	2.658	R-2
Myripristis hexagona	11	14.2 - 18.9	0.872	0.01869	3.040	R-1
Serranidae						
Epinephelus bleekeri	11	14.2 - 26.9	0.976	0.00889	3.126	R-3 & P-2
Epinephelus tauvina	9	12.7 - 37.8	0.996	0.01563	2.957	P-2
Cephalopholis boenak	3	10.9 - 17.4	0.991	0.00990	3.207	P-2
Cephalopholis boenak	8	15.6 - 23.8	0.982	0.01554	3.002	R-1, 3
Apogonidae						
Archamia lineolata	63	7.0 - 10.3	0.907	0.01066	3.207	R-3
Sillaginidae						
Sillago sihama	8	17.1 - 20.8	0.905	0.00285	3.362	P-1
Carangidae						
Selaroides leptolepis	25	9.9 - 16.4	0.983	0.00745	3.101	R-2
Lutjanidae						
Lutjanus russelli	31	11.4 - 33.8	0.991	0.00708	3.234*	P-1, 2
Lutjanus vitta	95	8.4 - 20.9	0.970	0.00999	3.110	R-1, 3
Lutjanus vitta	41	13.2 - 21.9	0.946	0.01871	2.913	R-2
Lutjanus vitta	30	10.2 - 16.1	0.919	0.01142	3.103	P-1, 2
Lutjanus lutjanus	90	10.2 - 16.4	0.892	0.02351	2.807	R-2, 3
Nemipteridae						
Nemipterus hexodon	11	13.1 - 21.7	0.990	0.00576	3.277*	R-2, 3
Scolopsis ciliatus	9	16.0 - 26.1	0.964	0.06405	2.480*	R-1
Scolopsis taeniopterus	4	21.9 - 24.8	0.995	0.00542	3.280	R-3
Scolopsis temporalis	5	15.3 - 23.1	0.967	0.01129	3.090	R-2
Pentapodidae						
Pentapodus setosus	20	12.0 - 21.4	0.984	0.01062	3.073	R-2, 3
Pomadasyidae						
Plectorhinchus pictus	11	15.5 - 56.6	0.983	0.01302	3.019	R-3 & P-2
Theraponidae						
Terapon jarbua	6	9.6 - 26.8	0.999	0.02215	2.884	R-3
Sciaenidae						
Johnius belangerii	13	15.1 - 19.4	0.918	0.00385	3.388	P-1
Lethrinidae						
Lethrinus lentjan	60	14.3 - 22.7	0.984	0.01894	2.938	R-1, 2, 3
Mullidae						
Upeneus tragula	8	15.3 - 21.7	0.976	0.01438	2.845	R-1
Chaetodontidae						
Chelmon rostratus	10	13.6 - 17.0	0.811	0.12803	2.289*	R-1
Siganidae						
Siganus canaliculatus	4	6.7 - 25.1	0.991	0.01201	3.011	R-3
Siganus javus	35	8.9 - 16.3	0.984	0.00912	3.208*	R-2
Scombridae						
Rastrelliger kanagurta	18	10.7 - 13.8	0.867	0.01634	2.755	R-2
Aluteridae						
Monacanthus chinensis	4	6.9 - 20.0	0.999	0.07038	2.447*	R-3
Monacanthus chinensis	7	15.2 - 24.5	0.900	0.07978	2.506*	P-2

*Significant difference from b = 3 at the 5% level.

Table 5. Statistical features of b value in the equation of length-weight relationship of fishes in the Gulf of Thailand.

Statistical features	Mean	Kurtosis	Skewness
	3.038	-0.110	-0.016
Standard error	0.038	0.935	0.481
Standard deviation	0.184	-	-
Minimum 2.658		Maximum	3.388

(late January and middle June) and *Epinephelus bleekeri*.

These results show that the method for conversion of length and weight, and calculation of the condition factor can be applied simply using b = 3 for most fishes in the Gulf of Thailand. In the case of exceptions (b≠3), the species' own b value should be obtained from a reasonable number of specimens with a wide range of length, and careful examination of seasonal and geographic variations and sexual dimorphism.

In general, b values of fish are close to 3, despite the many variations of fish forms (Nose et al. 1962). The results in this study showed only a few exceptions to this. The possible reasons for the b value of some species showing a significant difference from 3 may be the small number of specimens and the smaller ranges of length. In the case of *Chelmon rostratus* and *Monacanthus chinensis*, however, the lower values of b can be considered to be the result of biological features of the species. These species feature a high, strongly compressed body, and the b value of these species showed lower values than those of other ordinary-shaped fishes.

Cinco (1982) examined the length-weight relationships of 26 species of fish from San Miguel Bay in the Philippines, and he stated that "the mean value of b for all 26 species studied was 3.03, suggesting that the 'cube law' (b = 3) can be used, as an approximation, for the length-weight relationship of most San Miguel Bay fishes". To examine whether the 'cube law' could be generally applied to most fishes obtained from the whole of the South China Sea Area, the b values from the present study, from Cinco (1982), Chullasorn and Martosubroto (1986), Navaluna (1982), Mohan and Kunhikoya (1985), Pokapunt and Sawasdivorn (1988), Saikliang (1990) - were jointly analyzed (115 cases, and 72 species belonging to 23 families).

The frequency distribution of these b values, with a superimposed normal curve, is shown in Fig. 3. This result

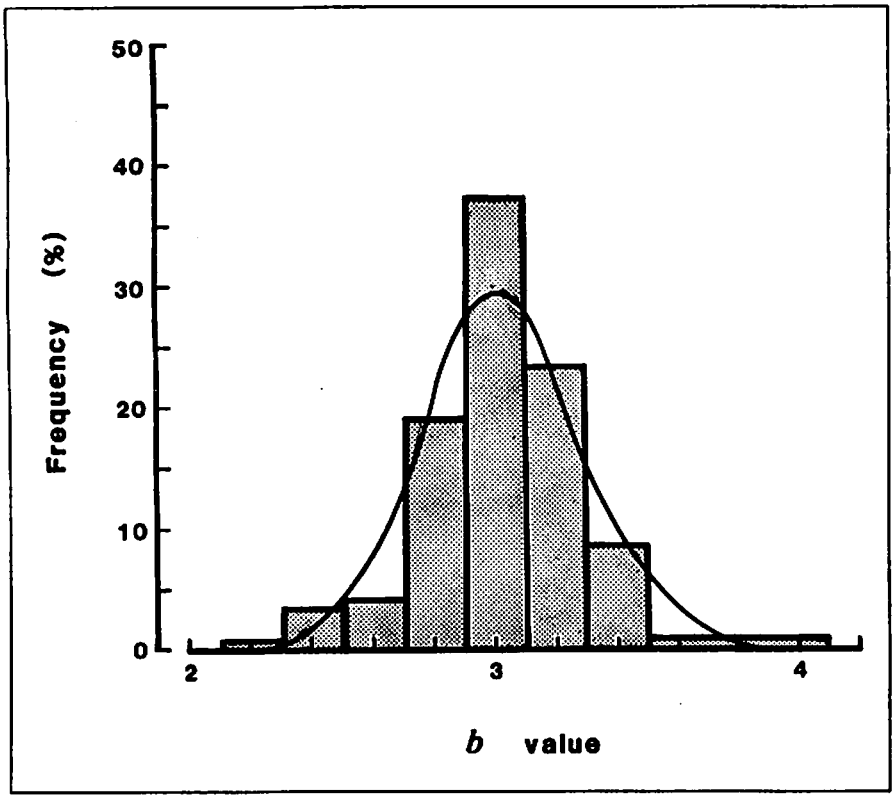

Fig. 3. Frequency distribution of b value with superimposed normal curve from 115 cases (72 fish species) in the South China Area.

shows that the mean value of b (3.017) is closer to 3 than the present study and Cinco (1982). The value of skewness is 0.331 and this means that the shape of frequency distribution of the b value is a bit skewed toward higher values. The kurtosis is 2.129, suggesting that the shape of b value frequency distribution is not only more peaked than the normal distribution, more so than for the results of the present study and of Cinco (1982). A comparison of two frequency distributions clearly shows that the range of b value is far larger than in Fig. 3 than Fig. 2. This resulted in a large kurtosis in Fig. 3 and suggests that many of the b values larger than 3.5 or smaller than 2.5 are significantly different from 3. Morever, the examinations of these 115 cases showed that the b value concentrated at a peak around 3 (80% of the b values fell into the range from 2.7 to 3.3), with both sides of the frequency distribution displaying very similar shapes (47% of the b value were less than 3, and 53% more than 3). This implies that the 'cube law' for the length-weight relationship of fish can be applied to most species from the South China Sea Area, though detailed studies may be needed for some species.

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