Length-Length and Weight-Length Relationships of Seven Deep-Water Fishes in the Gulf of Mexico

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ABSTRACT

Regression coefficients for equations of the form Y = a + bX were estimated for total length (TL) and whole weight (W) as a function of standard length (SL) and fork length (FL) and vice versa for seven deep-water fishes. All lengths were measured in millimeters and all weights in grams. There was a significant correlation between weight and length and the types of length measurements for all species. However, the amount of variation explained by each regression varied among species. Weight-length regressions were less precise than length-length regression, as they generally are, because weights of small fish measured at sea are more inaccurate than those of large fish.

INTRODUCTION

A longline fishery has recently developed in the Gulf of Mexico to supplement the shrimp fishery (Prythrech 1983). The potential yield of the target species and impacts on the by-catch have not been examined, partly because of inadequate estimates of life history parameters (Matlock et al. 1988). However, recently collected length and weight data on deep-water (>200 m) fishes in the gulf afford the opportunity to develop conversion equations. This study develops equations for converting among total, standard and fork length (TL, SL and FL) and from length to weight for each of seven fishes.

MATERIALS AND METHODS

Fishes were collected on bottom longlines during the day in water 260-329 m deep about 160 km SE of Galveston, Texas during September 1984. Longlines were 366 m long with 100 circle hooks (no. 7) attached at equal intervals to 46-cm gangions (Matlock et al. 1988). They were baited with squid and fished about 2 h each. Additional fishing details are contained in Matlock et al. (1988). Each fish was identified to species (Robins et al. 1980), wet weighted (W) to the nearest 0.11 kg, and TL was measured (nearest mm) immediately after capture. SL of each fish, except Cuban dogfish (Squalus cubensis), was also measured (nearest mm). FL (nearest mm) was measured on each barrelfish (Hyperoglyphe perciformis) and tilefish (Lopholatilus chamaeleonticeps). Length definitions follow Hubbs and Lagler (1970). Sex was determined for tilefish. Data from female Cuban dogfish that could be identified were used to develop separate regressions for these fish.

Sufficient data for analysis were collected from Cuban dogfish, barrelfish, tilefish, southern hake (Urophycis floridana), gulf hake (U. cirrata), longspine scorpionfish (Pontinus longispinis) and yellowedge grouper (Epinephelus flavolimbatus). TL-frequency histograms were constructed using 10-mm intervals for all fishes to insure that measurements were evenly distributed over a wide size range. Weight-length regressions were estimated for each species using all fish. Separate regressions were estimated for each species by sex and water depth if data were available. W-SL and W-FL regressions were not estimated for Cuban dogfish, and W-FL regressions were estimated for barrelfish and tilefish only. Separate regressions were estimated for male and female tilefish and female Cuban dogfish. Separate regressions were also estimated for Southern hake caught in the 260-302 and 303-333 m depth zones. Each measurement used in all weight-length regressions was converted to common logarithm before analysis. Equations for converting one length measurement to another were estimated for each species as described above. Standard linear regression techniques for single y at each x were used (Sokal and Rohlf 1969). Separate regressions for each species were compared by inspecting 95% confidence intervals.

RESULTS

There was a significant correlation between weight and length and the types of length measurements for all species. However, the amount of variation explained by each regression varied. Weight-length regressions explained

about 70-90% (R^2) of the variation in weight; length-length regressions had R^2 of 95-100% (Tables 1-3).

The sizes of fish of each species appeared to be evenly distributed throughout the range to which regressions were fit (Appendix A).

Weight-length and length-length regressions for southern hake caught in water 260-302 and 303-333 m deep were similar. The estimated range (±1 SE) in slopes of each of the Log W-Log TL, Log W-Log SL, TL-SL or SL-TL regressions for fish from the two depth zones overlapped (Table 2).

Female Cuban dogfish had the same Log W-Log TL regression as all dogfish combined. The estimated range (±1 SE) in slopes of the two regressions overlapped (Table 1).

Regressions for male and female tilefish were similar. The estimated range (±1 SE) in slopes of the two regressions overlapped (Table 3).

DISCUSSION

Weighing fish at sea results in reduced precision of weight-length regressions. However, the reduction is probably dependent on the size of the fish weighed. As size increases, precision of weight measurements increases (SEAMAP Subcommittee 1985). Cuban dogfish, gulf hake, longspine scorpionfish and southern hake were generally less than 600 mm TL, and their weight-length regressions R^2 were less than 0.9. Barrelfish, tilefish and yellowedge grouper were generally larger than 500 mm, and their weight-length regressions R^2 were greater than 0.9.

Length-length and weight-length regressions for tilefish in the gulf were similar to those for fish of a similar size range in the Atlantic off Georgia. The y-intercepts and slopes for the TL-SL, TL-FL and FL-SL regressions for both sexes pooled were 5.533 and 1.211; -16.036 and 1.083; and 22.541 and 1.112, respectively for Atlantic fish (Harris and Grossman 1985). Corresponding values for gulf fish were 17.4 and 1.18; -10.5 and 1.08; and 34.2 and 1.08. The y-intercepts and slopes for standard weight-length regressions for Atlantic fish were -5.110 and 3.141 for males; -4.650 and 2.974 for females; and -5.007 and 3.104 for both sexes combined, respectively (Harris and Grossman 1985). Corresponding values for Gulf fish were -5.26 and 3.19 for males; -4.63 and 2.95 for females; and -5.00 and 3.09 for both sexes combined. Low et al. (1983) estimated the W-TL regression for fish off South Carolina and Georgia as Log W = -5.9590 + 3.3353 Log TL; Texas W-TL was Log W = -5.51 + 3.18 Log TL. Low et al. (1983) did not present separate equations for each sex, nor did they indicate sex composition of fish used. However, the two regressions yield similar results for fish 400 to 900 mm TL. At these sizes, Atlantic fish weighed 524 and 7839 g, respectively, and gulf fish weighed 582 and 7664 g, respectively.

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Table 1. Equations for converting total or standard length (TL or SL) to weight (g) and between length types for four deep-water fishes caught in the Gulf of Mexico during September 1984. Sex was determined for female (F) Cuban dogfish only.

Species	Sex	TL range (mm)	N	Log Weight-Log TL Y-intercept	Log Weight-Log TL Slope (±1 SE)	Log Weight-Log TL R^2	Log Weight-Log SL Y-intercept	Log Weight-Log SL Slope (±1 SE)	Log Weight-Log SL R^2	TL-SL Y-intercept	TL-SL Slope (±1 SE)	TL-SL R^2	SL-TL Y-intercept	SL-TL Slope (±1 SE)	SL-TL R^2
Cuban dogfish	F	471-1035	86	-5.51	3.05±0.20	0.74									
	Combined	471-1035	104	-6.33	3.34±0.18	0.78									
Gulf hake		284- 655	52	-7.41	3.83±0.25	0.82	-6.98	3.75±0.23	0.84	16.30	1.08±0.01	0.99	-12.50	0.92±0.01	0.99
Longspine scorpionfish		205- 353	48	-7.16	3.93±0.20	0.89	-6.51	3.81±0.22	0.86	4.95	1.21±0.02	0.99	-1.43	0.82±0.01	0.99
Yellowedge grouper		510- 966	28	-4.13	2.74±0.16	0.91	-4.37	2.92±0.16	0.93	-18.23	1.28±0.05	0.96	38.41	0.75±0.03	0.96

Table 2. Equations for coverting total or standard length (TL or SL) to weight (g) and between length types for southern hake caught in the Gulf of Mexico in two depth zones during September 1984.

Depth range (m)	TL range (mm)	N	Log Weight-Log TL			Log Weight-Log SL			TL-SL			SL-TL		
			Y-intercept	Slope (±1 SE)	R^2	Y-intercept	Slope (±1 SE)	R^2	Y-intercept	Slope (±1 SE)	R^2	Y-intercept	Slope (±1 SE)	R^2
260-302	292-527	71	-7.43	3.87 ± 0.21	0.83	-7.02	3.78 ± 0.21	0.85	10.2	1.10 ± 0.02	0.98	-3.0	0.90 ± 0.01	0.98
303-333	322-573	66	-6.64	3.55 ± 0.29	0.69	-6.47	3.55 ± 0.25	0.75	18.1	1.07 ± 0.02	0.98	-7.9	0.91 ± 0.02	0.98
Combined	292-573	137	-7.13	3.75 ± 0.18	0.76	-6.84	3.71 ± 0.17	0.78	14.1	1.09 ± 0.01	0.98	-5.2	0.90 ± 0.01	0.98

Table 3. Equations for converting total, standard, or fork length (TL, SL, or FL) to weight (g) and among length types for barrelfish and tilefish caught on longlines in the Gulf of Mexico during September 1984. Numbers in parentheses represent number of fish examined.

Regression	Item	Barrelfish (51)	Tilefish		
			Males (20)	Females (60)	All fish (111)
Log Weight on Log TL	TL range (mm)	475-867	467-983	460-946	382-983
	Y-intercept	-5.65	-5.45	-5.43	-5.51
	Slope (±1 SE)	3.29 ± 0.09	3.16 ± 0.12	3.15 ± 0.12	3.18 ± 0.06
	R^2	0.96	0.98	0.93	0.96
Log Weight on Log SL	SL range (mm)	372-702	385-807	373-773	316-807
	Y-intercept	-4.75	-5.26	-4.63	-5.00
	Slope (±1 SE)	3.08 ± 0.11	3.19 ± 0.12	2.95 ± 0.12	3.09 ± 0.07
	R^2	0.95	0.97	0.91	0.94
Log Weight on Log FL	FL range (mm)	422-790	444-917	435-880	362-917
	Y-intercept	-5.23	-5.72	-5.42	-5.61
	Slope (±1 SE)	3.19 ± 0.10	3.29 ± 0.17	3.17 ± 0.11	3.24 ± 0.07
	R^2	0.95	0.95	0.93	0.95
TL on SL	Y-intercept	42.1	4.2	35.6	17.4
	Slope (±1 SE)	1.18 ± 0.02	1.22 ± 0.03	1.15 ± 0.02	1.18 ± 0.01
	R^2	0.99	0.99	0.98	0.98
TL on FL	Y-intercept	20.4	-14.5	-4.6	-10.6
	Slope (±1 SE)	1.08 ± 0.01	1.10 ± 0.05	1.07 ± 0.01	1.08 ± 0.01
	R^2	1.00	0.96	0.99	0.98
SL on TL	Y-intercept	-30.8	2.3	-20.7	-5.7
	Slope (±1 SE)	0.84 ± 0.01	0.81 ± 0.02	0.85 ± 0.02	0.83 ± 0.01
	R^2	0.99	0.99	0.98	0.98
SL on FL	Y-intercept	-15.8	-7.5	-26.0	-14.8
	Slope (±1 SE)	0.92 ± 0.01	0.89 ± 0.05	0.92 ± 0.02	0.90 ± 0.02
	R^2	1.00	.95	0.98	0.97
FL on TL	Y-intercept	-16.3	34.2	8.1	18.7
	Slope (±1 SE)	0.92 ± 0.01	0.88 ± 0.04	0.93 ± 0.01	0.91 ± 0.01
	R^2	1.00	0.96	0.99	0.98
FL on SL	Y-intercept	20.1	39.9	39.7	34.2
	Slope (±1 SE)	1.09 ± 0.01	1.07 ± 0.06	1.07 ± 0.02	1.08 ± 0.02
	R^2	1.00	0.95	0.98	0.97

Appendix A. Total length frequencies of seven deep-water fishes.

Table A.1. Number of fish in each 10-mm TL class used in weight-length and length-length regressions. Numbers in parentheses represent number of fish measured.

Lower end of total length interval (mm)	Barrelfish		Gulf hake		Longspine scorpionfish		Yellowedge grouper	
	No. (51)	Cumulative %	No. (52)	Cumulative %	No. (48)	Cumulative %	No. (28)	Cumulative %
965							1	100
955							1	96
945							0	93
935							0	93
925							0	93
915							1	93
905							0	89
895							1	89
885							0	86
875							0	86
865	1	100					1	86
855	0	98					0	82
845	1	98					1	82
835	1	96					0	79
825	2	94					0	79
815	1	90					1	79
805	1	88					4	75
795	4	86					0	61
785	2	78					0	61
775	3	74					0	61
765	2	69					0	61
755	4	65					3	61
745	2	57					0	50
735	2	53					1	50
725	2	49					0	46
715	1	45					0	46
705	0	43					1	46
695	0	43					1	43
685	3	43					1	39
675	3	37					0	36
665	1	31					0	36
655	1	29	1	100			2	36
645	1	27	0	98			0	28
635	2	25	0	98			0	28
625	1	22	0	98			0	28
615	0	20	0	98			1	28
605	0	20	1	98			1	25
595	1	20	1	96			0	21
585	0	18	0	94			2	21
575	3	18	0	94			0	14
565	2	12	1	94			1	14
555	0	8	0	92			2	11
545	1	8	0	92			0	4
535	0	6	0	92			0	4
525	0	6	2	92			0	4
515	0	6	0	88			0	4
505	0	6	0	88			1	4
495	0	6	2	88				
485	2	6	1	85				
475	1	2	3	83				
465			4	77				
455			3	69				

Table A.1. (Cont'd.)

Lower end of total length interval (mm)	Barrelfish		Gulf hake		Longspine scorpionfish		Yellowedge grouper	
	No. (51)	Cumulative %	No. (52)	Cumulative %	No. (48)	Cumulative %	No. (28)	Cumulative %
445			5	63				
435			2	54				
425			1	50				
415			1	48				
405			1	46				
395			3	44				
385			3	38				
375			6	33				
365			2	21				
355			4	17				
345			1	10	1	100		
335			1	8	0	98		
325			1	6	8	98		
315			1	4	3	81		
305			0	2	3	75		
295			0	2	8	69		
285			0	2	4	52		
275			1	2	4	44		
265					3	35		
255					3	29		
245					0	23		
235					1	23		
225					0	21		
215					6	21		
205					4	8		

Table A.2. Number of fishes in each 10-mm TL interval used in weight-length and length-length regressions. Numbers in parentheses represent number of fish measured.

Lower end of total length (mm) interval	Tilefish						Cuban dogfish				Southern hake					
	Males		Females		All fish		Females		All fish		260-302 m		303-333 m		All depths	
	No. (20)	Cumulative %	No. (60)	Cumulative %	No. (111)	Cumulative %	No. (86)	Cumulative %	No. (104)	Cumulative %	No. (71)	Cumulative %	No. (66)	Cumulative %	No. (137)	Cumulative %
1035							1	100	1	100						
1025							0	99	0	99						
1015							0	99	0	99						
1005							0	99	0	99						
995							0	99	0	99						
985							0	99	0	99						
975	1	100			1	100	0	99	0	99						
965	0	95			0	99	0	99	0	99						
955	1	95			1	99	0	99	0	99						
945	0	90	1	100	1	98	0	99	0	99						
935	0	90	0	99	0	97	0	99	0	99						
925	0	90	0	99	1	97	0	99	0	99						
915	0	90	0	99	0	96	0	99	0	99						
905	0	90	0	99	0	96	0	99	0	99						
895	0	90	0	99	0	96	0	99	0	99						
885	0	90	0	99	0	96	0	99	0	99						
875	0	90	0	99	0	96	0	99	0	99						
865	0	90	0	99	0	96	0	99	0	99						
855	0	90	0	99	0	96	0	99	0	99						
845	0	90	0	99	0	96	0	99	0	99						
835	0	90	0	99	0	96	0	99	0	99						
825	0	90	0	99	0	96	0	99	0	99						
815	0	90	0	99	0	96	0	99	0	99						
805	0	90	0	99	1	96	0	99	0	99						
795	0	90	0	99	0	96	0	99	0	99						
785	0	90	0	99	0	96	1	99	1	99						
775	0	90	0	99	0	96	2	98	2	98						
765	1	90	0	99	1	96	8	97	8	96						
755	0	85	0	99	0	95	12	87	12	89						
745	0	85	0	99	0	95	13	73	13	77						
735	0	85	1	99	1	95	9	58	9	64						
725	0	85	1	98	1	94	8	48	8	56						
715	0	85	1	97	2	93	11	38	11	48						
705	0	85	2	95	4	91	1	26	1	38						
695	1	85	3	92	4	87	1	24	1	36						
685	0	80	5	87	5	84	1	23	1	36						

Table A.2. (Cont'd.)

Lower end of total length (mm) interval	Tilefish						Cuban dogfish				Southern hake					
	Males		Females		All fish		Females		All fish		260-302 m		303-333 m		All depths	
	No. (20)	Cumulative %	No. (60)	Cumulative %	No. (111)	Cumulative %	No. (86)	Cumulative %	No. (104)	Cumulative %	No. (71)	Cumulative %	No. (66)	Cumulative %	No. (137)	Cumulative %
675	1	80	4	78	8	79	1	22	1	35						
665	0	75	7	72	7	72	2	21	3	34						
655	0	75	3	60	5	66	1	19	1	31						
645	0	75	3	55	4	61	1	17	3	30						
635	2	75	3	50	6	58	2	16	6	27						
625	2	65	0	45	7	52	0	14	3	21						
615	1	55	1	45	3	46	0	14	3	18						
605	1	50	2	43	6	43	1	14	4	15						
595	2	45	2	40	4	38	1	13	1	12						
585	0	35	3	37	3	34	0	12	0	11						
575	0	35	3	32	4	32	1	12	1	11			0	100	0	100
565	2	35	3	27	6	28	0	10	0	10			1	100	1	100
555	0	25	3	22	4	23	1	10	1	10			1	98	1	99
545	0	25	2	17	3	19	2	9	2	9			0	97	0	98
535	0	25	1	12	2	16	0	7	0	7			0	97	0	98
525	1	25	0	10	1	14	3	7	4	7	1	100	0	97	1	98
515	1	20	1	10	2	14	0	3	0	3	0	98	1	97	1	98
505	0	15	3	8	3	12	1	3	1	3	2	98	0	95	2	97
495	1	15	1	3	2	9	1	2	1	2	2	96	0	95	2	96
485	0	10	0	2	2	7	0	1	0	1	0	93	0	95	0	94
475	1	10	0	2	1	5	0	1	0	1	1	93	1	95	2	94
465	1	5	0	2	1	4	1	1	1	1	5	92	5	94	10	93
455			1	2	2	4					2	84	3	86	5	85
445					0	0					7	82	3	82	10	82
435					1	2					10	72	7	77	17	74
425					0	1					10	58	4	67	14	62
415					0	1					1	44	4	61	5	52
405					0	1					5	42	1	54	6	48
395					0	1					4	35	5	53	9	44
385					0	1					3	30	3	45	6	37
375					1	1					8	25	5	41	13	33
365											2	14	6	33	8	23
355											2	11	7	24	9	18
345											0	8	3	14	3	11
335											1	8	2	9	3	9
325											1	7	3	6	4	6

Table A.2. (Cont'd.)

Lower end of total length (mm) interval	Tilefish						Cuban dogfish				Southern hake					
	Males		Females		All fish		Females		All fish		260-302 m		303-333 m		All depths	
	No. (20)	Cumulative %	No. (60)	Cumulative %	No. (111)	Cumulative %	No. (86)	Cumulative %	No. (104)	Cumulative %	No. (71)	Cumulative %	No. (66)	Cumulative %	No. (137)	Cumulative %
315											3	6	1	2	4	4
305											0	1			0	1
295											0	1			0	1
285											1	1			1	1