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Weight-length relationship of 53 species of fish associated to artisanal trawl fisheries in the southern Brazil

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Abstract. The weight-length relationships of 53 species of the southern region of Brazil are presented and contribute to the knowledge of the ichthyofauna of the South American coast. Monthly samplings were carried out, through experimental trawls, in areas of action of artisanal shrimp fishing. A total of 5699 specimens belonging to 26 families and 53 species were examined. Significant length-weight relationships for the species were found, most of them characterized as a positive allometric growth, followed by negative allometric and isometric. The species *Chirocentrodon bleekerianus*, *Urophycis brasiliensis* and *Stellifer brasiliensis* presented their maximum lengths higher than those currently recorded in FishBase. This study represents the first report of the length-weight relationships in trawl areas in Santa Catarina, southern Brazil

Key words: Monitoring, Shrimp, Growth, Allometry, Icthyofauna

Resumo. Relação peso-comprimento de 53 espécies de peixes associadas à pesca artesanal de arrasto no sul do Brasil. A relação peso-comprimento de 53 espécies da região sul do Brasil é apresentada e contribui para o conhecimento da ictiofauna da costa sul-americana. Amostragens mensais foram realizadas, através de arrastos experimentais, em áreas de atuação da pesca artesanal camaroeira. Um total de 5699 exemplares pertencendo a 26 famílias e 53 espécies foram examinados. Significativas relações de peso comprimento para as espécies foram encontradas, sendo em sua maioria caracterizadas como um crescimento alométrico positivo, seguido de alométrico negativo e isométrico. As espécies *Chirocentrodon bleekerianus*, *Urophycis brasiliensis* e *Stellifer brasiliensis* apresentaram seus comprimentos máximos superiores aqueles registrados atualmente no FishBase. Esse estudo representa o primeiro relato das relações peso comprimento em áreas de arrasto artesanal em Santa Catarina, região sul do Brasil

Palavras-chave: Monitoramento, Camarão, Crescimento, Alometria, Ictiofauna

Introduction

The length-weight relationship is an important tool in ichthioofaunistic studies, since it generates information about the biology of the species and their stocks in the environments (Abdurahiman *et al*. 2004, Ferraz & Giarrizzo 2015)

The metrics of this relationship are considered essential elements for fishing investigations and can be used as estimates of other information involving the life history of the fish, through empirical relations of conversion of structures of length in weight vice versa, which are fundamental in programs of fishing and environmental monitoring (Froese 2006, Albieri *et al*. 2014). In this context, the coastal environments are places favorable for the knowledge of these parameters, since these places present a high diversity of shapes and sizes, harboring important species for the future of the fishing (Lasta 1995, Solari *et al*. 2016).

However, the parameters of the weight-length relationship can vary temporally and spatially for the same species, requiring constant updates in the environments (Ismen *et al*. 2007, Ferraz & Giarrizo 2015). Thus, this study aimed to estimate the weight-length relationship of 53 most frequent fish species in a traditional shrimp fishing area in southern Brazil.

Material and Methods

The study area is located in the municipality of Penha - SC (Fig. 1), between the coordinates 26°46´0’’S , 48°37´0”W and 26°46´0’’S , 48°32´0” W, which is characterized by a traditional area of artisanal trawl fishing for the sea-bob shrimp, *Xiphopenaeus kroyeri* (Heller 1862). Due to the regularity and intensity with which this activity occurs, it presents great social and economic relevance in the Southeastern and south coast of the country (Branco 2005).

Monthly trawls lasting 30 minutes at depths of 10 to 30 meters, during the year 2016, were carried out using two trawls with doors, 3.0 cm mesh on the sleeve and body, 2.0 cm in the bagger, trailed by a vessel (whaling vessel) of the local fleet with an approximate velocity of two knots.

The product of each trawl was separated on board, labeled, stored in iceboxes and transported to the laboratory. The fish were identified through taxonomic keys of Figueiredo & Menezes (1978, 1980); Menezes & Figueiredo (1980, 1985) and the nomenclature of the taxa followed the international standard (FishBase 2017).

Measurements of standard length and total length (cm) were obtained, in addition to the weight (g) of each specimen. In the species *Symphurus tesselatus*, *S. plagusia*, *Gymnothorax ocellatus*, *Ophicthus gomesii and Trichiurus lepturus*, only weight and total length were used. The weight-length relation was adjusted by the equation $W = a.L^b$ (Le Cren, 1951), where W corresponds to weight, a curve intercept, L standard length and b, angular coefficient or allometric coefficient.

The values of the coefficient b of the weight-length relation are references for the type of growth, being it isometric type (= 3), allometric positive (> 3) or negative allometric (<3). The confidence intervals (95%) for this parameter were recorded and, through the student t test, we tested the null hypothesis for isometry (hypothetical mean = 3) through the statistical package PAST v3.15 (Hammer *et al*. 2001).

Results

A total of 5699 specimens of the accompanying ichthyofauna were analyzed in the sea-bob shrimp fishery, distributed among 53 species and 26 families. Information on the breadth, length and weight-length parameters are given in Table I.

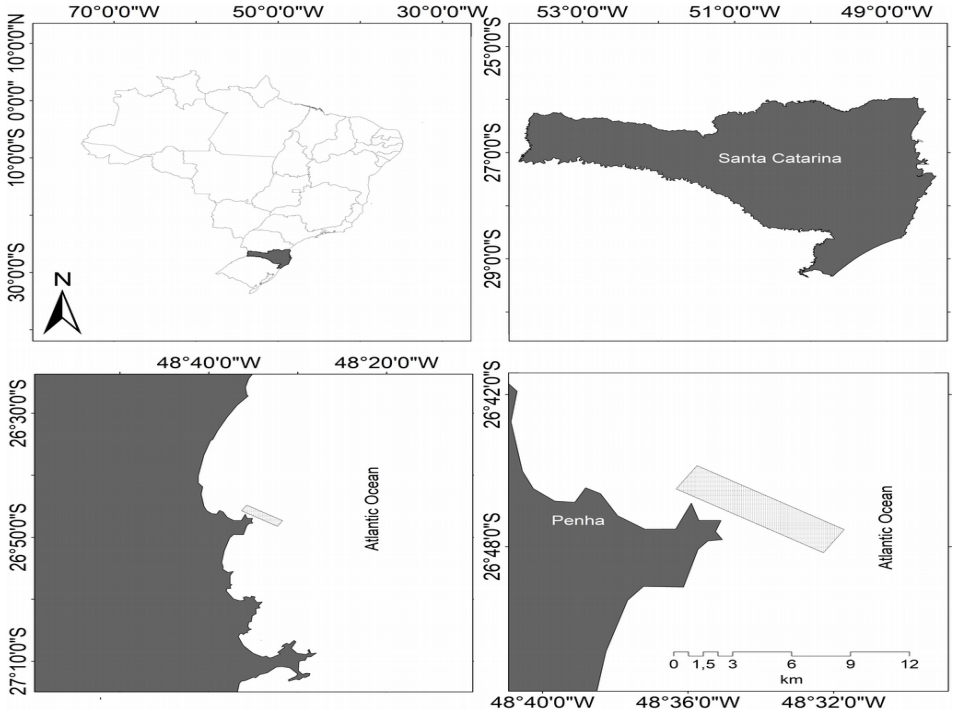

Figure 1. Location of the study area in Penha, Santa Catarina state – southern Brazil. Gray rectangle: Sampling area.

Table I - Lenght- Weight relationship for 53 species species of fish associated with trawling on the southern coast of Brazil. Legend: **SL** – Standard Lenght, **TL** – Total Lenght, **A+** – Positive allometry, **A-** – Negative allometry and I – Isometric, t – student t test and * – significant ($p < 0.05$). Bold numbers - New maximum size when compared to FishBase data (2017).

Family/ Species		Weight(g)	SL(cm)	TL(cm)	Relationship Parameters					
	N	min – max	min - max	min - max	a	b	b (CI 95%)	r^2	t (≠ 3)	Growth
Achiridae										
Achirus declivis Chabanaud, 1940	15	8.65 - 28.76	6.1 - 8.5	8.1 - 11.0	0.034	3.11	3.06 - 3.12	0.90	5.86 *	A+
Achirus lineatus (Linnaeus, 1758)	15	8.65 - 28.76	6.1 - 8.5	8.1 - 11.0	0.034	3.11	3.06 - 3.15	0.90	5.44 *	A+
Ariidae										
Genidens genidens (Cuvier, 1829)	15	17.65 - 398.6	10.5 - 28.0	13.7 - 34.2	0.0133	3.10	3.08 - 3.12	0.98	11.33 *	A+
Batrachoididae										
Porichthys porosissimus (Cuvier, 1829)	20	1.54 - 8.31	5.0 - 8.4	6.20 - 9.6	0.018	2.79	2.77 - 2.82	0.95	-19.15 *	A-
Carangidae										
Chloroscombrus chrysurus (Linnaeus, 1766)	15	4.92 - 19.15	6.5 - 9.9	8.3 - 12.8	0.016	3.09	3.06 - 3.11	0.96	7.34 *	A+
Selene setapinnis (Mitchill, 1815)	15	0.72 - 17.93	2.3 - 8.8	3.5 - 11.2	0.046	2.73	2.63 - 2.86	0.96	4.79 *	A-
Clupeidae										
Chirocentrodon bleekerianus (Poey, 1867)	157	0.68 - 11.22	4.4 - 10.4	5.4 - 12.1	0.0044	3.39	3.38 - 3.40	0.92	102.9 *	A+
Cynoglossidae										
Symphurus tesselatus (Quoy & Gaimard, 1824)	40	2.83 - 76.83	-	7.7 - 21.4	0.0046	3.19	3.18 - 3.20	0.99	36.84 *	A+
Symphurus plagusia (Bloch & Schneider, 1801)	25	2.90 - 77.90	-	7.8 - 22.0	0.0041	3.23	3.22 - 3.24	0.98	39.00 *	A+
Dactylopteridae										
Dactylopterus volitans (Linnaeus, 1758)	495	2.70 - 53.48	4.4 - 14.2	5.90 - 17.7	0.0167	3.08	3.07 - 3.08	0.94	33.43 *	A+
Diodontidae										
Chilomycterus spinosus spinosus (Linnaeus, 1758)	220	11.39 - 383.0	4.0 - 18.0	5.0 - 20.0	0.3203	2.44	2.42 - 2.45	0.90	-76.53 *	A-
Engraulidae										
Lycengraulis grossidens (Spix & Agassiz, 1829)	20	1.35 - 23.4	5.0 - 12.5	6.0 - 14.8	0.0103	3.09	3.07 - 3.11	0.99	8.99 *	A+
Gerreidae										
Diapterus rhombeus (Cuvier, 1829)	12	45.0 - 135.12	10.7 - 15.4	14.8 - 20.5	0.049	2.89	2.88 - 2.91	0.97	-18.29 *	A+
Eucinostomus melanopterus (Bleeker, 1863)	10	28.95 - 134.59	10.0 - 16.2	13.2 - 20.5	0.016	3.24	3.20 - 3.28	0.96	15.63 *	A+
Haemulidae										
Orthopristis ruber (Cuvier, 1830)	31	13.70 - 208.92	7.9 - 21.5	10.0 - 25.5	0.0448	2.82	2.81 - 2.84	0.98	-22.98 *	A-
Monocanthidae										
Stephanolepis hispidus (Linnaeus, 1766)	257	0.66 - 70.91	2.5 - 13.0	3.2 - 16.2	0.0542	2.83	2.82 - 2.84	0.98	-52.08 *	A-
Mullidae										
Upeneus parvus (Poey, 1852)	77	0.73 - 20.70	3.3 - 9.3	4.3 - 11.6	0.0153	3.26	3.25 - 3.28	0.94	36.56 *	A+
Muraenidae										
Gymnothorax ocellatus Agassiz, 1831	15	60.04 - 220.87	-	34.0 - 49.0	0.0003	3.44	3.42 - 3.45	0.97	67.24 *	A+
Ophichthidae										
Ophichthus gomesii (Castelnau, 1855)	15	60.27 - 124.52	-	39.7 - 60.5	0.0698	1.83	1.82 - 1.84	0.91	-295.7 *	A-

Family/ Species	N	Weight(g) min – max	SL(cm) min - max	TL(cm) min - max	Relationship Parameters a	b	b (CI 95%)	r^2	t (≠ 3)	Growth
Paralichthyidae										
Citharichthys arenaceus Evermann & Marsh, 1900	58	1.65 - 48.9	4.8 - 14.4	5.9 - 17.7	0.0156	3.04	3.02 - 3.05	0.96	5.54 *	A+
Citharichthys macrops Dresel, 1885	30	3.01 - 42.1	3.5 - 13.5	5.0 - 16.7	0.0153	3.07	3.06 - 3.09	0.99	11.40 *	A+
Citharichthys spilopterus Günther, 1862	12	3.31 - 20.28	6.0 - 10.5	7.0 - 12.8	0.0092	3.24	3.21 - 3.28	0.96	15.59 *	A+
Etropus crossotus (Jordan & Gilbert, 1882)	65	2.77 - 50.69	5.8 - 13.7	7.0 - 16.7	0.0090	3.33	3.32 - 3.34	0.97	60.58 *	A+
Etropus longimanus Norman, 1933	145	0.66 - 18.71	3.7 - 10.9	4.6 - 13.6	0.0108	3.14	3.13 - 3.15	0.97	27.39 *	A+
Paralichthys patagonicus Jordan, 1889	53	1.28 - 382.80	4.4 - 27.6	5.5 - 33.3	0.0134	3.07	3.05 - 3.08	0.99	11.26 *	A+
Syacium papillosum (Linnaeus, 1758)	67	12.57 - 204.56	9.0 - 22.5	11.0 - 26.5	0.0144	3.08	3.07 - 3.09	0.98	20.77 *	A+
Syacium micrurum Ranzani, 1842	175	0.82 - 152.28	2.0 - 22.0	3.7 - 23.0	0.0140	3.08	3.07 - 3.09	0.99	20.77 *	A+
Phyceiidae										
Urophycis brasiliensis (Kaup, 1858)	314	0.18 - 1790.0	1.9 - 49.0	2.5 - 57.0	0.0078	3.14	3.13 - 3.16	0.98	21.20 *	A+
Pristigasteridae										
Pellona harroweri (Fowler, 1917)	38	0.23 - 8.35	2.7 - 8.0	3.1 - 10.5	0.0169	2.89	2.85 - 2.93	0.94	-5.56 *	A-
Sciaenidae										
Ctenosciaena gracilicirrhus (Metzelaar, 1919)	338	0.83 - 56.66	1.5 - 13.5	3.3 - 16.1	0.0245	3	2.99 - 3.01	0.96	1.14	I
Cynoscion guatacupa (Cuvier, 1830)	428	0.57 - 116.28	2.8 - 21.0	3.5 - 23.0	0.0358	2.64	2.62 - 2.64	0.93	-76.90 *	A-
Isopisthus parvipinnis (Cuvier,1830)	269	0.31 - 96.13	2.7 - 17.8	3.4 - 19.0	0.0124	3.18	3.16 - 3.19	0.95	25.52 *	A+
Larimus breviceps Cuvier, 1830	109	0.48 - 126.39	2.9 - 15.9	3.7 - 20.5	0.0156	3.25	3.23 - 3.26	0.99	33.23 *	A+
Macrodon ancylodon (Bloch & Schneider, 1801)	119	1.25 - 94.02	4.2 - 17.4	5.4 - 22.1	0.0195	2.91	2.90 - 2.92	0.98	-16.58 *	A-
Menticirrhus americanus (Linnaeus, 1758)	50	3.00 - 58.10	5.5 - 14.0	7.2 - 17.7	0.0182	3.01	3.00 - 3.02	0.98	2.34 *	A+
Menticirrhus litorallis (Holbrook, 1847)	46	2.90 - 139.65	5.5 - 21.2	7.2 - 26.3	0.0281	2.95	2.93 - 2.96	0.98	-8.41 *	A-
Micropogonias furnieri (Desmarest, 1823)	95	0.61 - 81.55	2.6 - 16.2	3.8 - 20.0	0.0371	2.7	2.67 - 2.74	0.96	-17.16 *	A-
Paralonchurus brasiliensis (Steindachner, 1875)	666	0.08 - 130.00	1.5 - 18.8	1.9 - 23.5	0.0187	2.98	2.97 - 2.99	0.97	-3.48 *	A-
Stellifer brasiliensis (Schultz, 1945)	82	2.93 - 66.63	5.0 - 14.3	6.8 - **17.5**	0.0220	3.06	3.06 - 3.07	0.99	17.16 *	A+
Stellifer rastrifer (Jordan, 1889)	341	0.78 - 150.0	1.5 - 17.5	3.5 - 21.2	0.0129	3.31	3.30 - 3.32	0.99	110.14 *	A+
Stellifer stellifer (Bloch, 1790)	60	12.09 - 58.42	8.1 - 12.6	10.3 - 16.1	0.0153	3.19	3.19 - 3.20	0.97	55.29 *	A+
Scorpaenidae										
Scorpaena brasiliensis Cuvier, 1829	10	3.5 - 24.0	4.7 - 8.3	5.8 - 10.9	0.0373	3.02	2.98 - 3.05	0.97	1.17	I
Serranidae										
Diplectrum formosum (Linnaeus, 1766)	25	6.06 - 190.31	6.5 – 19	8.4 - 23.2	0.0137	3.23	3.21 - 3.24	0.99	41.34 *	A+
Diplectrum radiale (Quoy & Gaimard, 1824)	10	5.30 - 30.11	5.5 - 9.8	7.1 - 12.2	0.0452	2.82	2.76 - 2.87	0.97	-8.02 *	A-
Dules auriga (Cuvier, 1829)	39	5.0 - 44.81	5.0 - 11.0	6.6 - 13.7	0.0219	3.17	3.16 - 3.19	0.97	23.23 *	A+
Stromateidae										
Peprilus paru (Linnaeus, 1758)	16	0.15 - 29.35	1.5 - 9.0	1.8 - 12.8	0.0527	2.90	2.74 - 3.06	0.97	-1.25	I
Synodontidae										
Saurida brasilisensis Norman, 1935	51	1.23 - 9.27	5.1 - 10.2	6.1 - 12.2	0.0168	2.70	2.69 - 2.71	0.96	-56.38 *	A-

Family/ Species	N	Weight(g) min – max	SL(cm) min - max	TL(cm) min - max	Relationship Parameters a	b	b (CI 95%)	r^2	t (≠ 3)	Growth
Synodus foetens (Linnaeus, 1766)	56	7.50 - 96.20	12.2 - 27.2	13.7 - 31.0	0.0025	3.22	3.21 - 3.23	0.97	55.60 *	A+
Synodus intermedius (Spix & Agassiz, 1829)	27	47.09 - 262.53	7.0 - 17.7	8.30 - 20.50	0.0133	2.81	2.79 - 2.83	0.95	-16.22 *	A-
Tetraodontidae										
Lagocephalus laevigatus (Linnaeus, 1766)	10	1.88 - 25.73	3.5 - 10.0	4.5 - 12.0	0.0948	2.41	2.40 - 2.42	0.99	-93.03 *	A-
Sphoeroids splengeri (Bloch, 1785*)*	98	1.00 - 45.40	2.0 - 10.0	2.90 - 12.30	0.1152	2.44	2.40 - 2.50	0.90	-21.59 *	A-
Trichiuridae										
Trichiurus lepturus Linnaeus, 1758	10	0.59 - 59.12	-	12.5 - 47.5	0.0001	3.34	3.39 - 3.43	0.99	46.82 *	A+
Triglidae										
Prionotus punctatus (Bloch, 1793)	318	0.67 - 140.71	3.0 - 17.2	3.70 - 21.40	0.0192	3.06	3.05 - 3.07	0.98	15.01 *	A+

Among the species sampled, 62.3% presented positive allometric growth, 32.1% allometric negative and 5.6% Isometric (Table I), where the lowest and highest value recorded for the allometric coefficient occurred, respectively, in *Ophicthus gomesii* (b = 1.83) and *Gymnothorax ocellatus* (b = 3.44)

The parameters described for all species were significant ($p < 0.05$) and with the coefficient of determination (r^2) ranging from 0.90 to 0.99. With the exception of the species *Chilomycterus spinosus*, *Lagocephalus laevigatus*, *Sphoeroids splengeri* and *Ophicthus gomesii*, all others presented values of the allometric constant (b) ranging from 2.64 (*Cynoscion guatacupa*) to 3.44 (*Gymnothorax ocellatus*), showing low variability in the interspecific allometric coefficient (3.06 ± 0.19; CV = 3.65%).

Discussion

The richness of fish species caught in seven-beard shrimp fisheries is a consequence of low trawl selectivity (Kelleher 2005). Thus, in order to benefit from this low selectivity, the accompanying fauna or captured bycatch can be used, at first, for studies that provide information on the species that live in the fishing sites.

The allometric constants recorded for most species are in agreement with the thresholds found by Froese (2006) ranging from 2.5 to 3.5, and any value that is outside this range can be considered atypical (Ricker 1975). However, the species *Chilomycterus spinosus*, *Lagocephalus laevigatus* and *Sphoeroids splengeri* are outside this threshold, but with values close to 2.5 (2.44, 2.41 and 2.44 respectively). *Ophicthus gomesii* presented the lowest value of b among all species (b = 1.83), which is probably explained by its elongated and longilineous shape.

The relationships of allometry was discussed by Le Cren (1951) as the organism's ability to maintain the same form throughout the ontogenetic growth, being the isometry (b = 3) characteristic of a proportional and, theoretically, ideal growth fish. In this sense, lower or higher values the 3.0 is characteristic of individuals who, over the growth, become more longilíneos or round, respectively (Araújo & Vicentini 2001). This same author also states that ‘b” constant variation is possible between the thresholds of 2.0 to 4.0, and is a greater amplitude than those stated by Froese (2006).

However, any comparison involving weight and / or length relationships should be cautious, since many factors, such as growth phase, stomach weight, gonads, maturity, sexual dimorphism, length frequency, health and conservation techniques can contribute to the great variability of recorded values (Tesch 1971, Ferraz & Giarrizzo 2015).

In coastal environments, it is expected that most species present positive isometric or allometric growth, since these environments are used by most of them as feeding and development areas (Ferraz & Giarrizzo 2015). This information corroborates our results, since 67.9% of the species presented these two types of growth.

The parameters collected in this study add the information obtained by several authors in Brazil, in the states of Pará (Giarrizzo et al., 2006; Ferraz & Giarrizzo 2015); Rio de Janeiro and São Paulo (Vianna *et al*. 2004, Franco et al. 2014, Albieri *et al.* 2014), Rio Grande do Sul (Haimovici & Velasco 2000), Argentina (Solari *et al.* 2016) and Uruguay (Segura *et al*. 2012, Gurdek & Acuña-Plavan 2013).

This work is the first to involve 53 species in the state of Santa Catarina and contributes to the knowledge of the ichthyofauna on the South American coast. In addition, the studied area is of environmental, social and economic interest, since it involves fishing exploration through trawling shrimp and can contribute to future work aimed at local fisheries management.

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