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Research Article

Length-weight relationship of 73 fish species caught in the southeastern inner continental shelf region of Brazil

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ABSTRACT. The *a* and *b* parameters of the length-weight relationship (LWR) of the form $W = aL^b$ were estimated for 71 species of Actinopterygii and 2 Elasmobranchii, caught in the coastal region and inner shelf of southeastern Brazil. Estimates of b varied from 2.151 to 3.882. For the first time LWR for eight fish species is reported. Significant differences were observed among *b* values obtained for the same species caught in different ecosystems. Moreover, significant different results for *b* were observed among species caught in different ecosystems and between sexes of 12 species. Therefore, in order to obtain a reliable biomass estimate it is necessary to choose LWR data close in time and region with estimates for each sex.

Keywords: length-weight relationship, Actinopterygii, Elasmobranchii, Santos Bay, Bertioga Channel, southwestern Atlantic.

Relación longitud-peso de 73 especies de peces capturadas en la plataforma continental interna del sudeste de Brasil

RESUMEN. Se estimaron los parámetros *a* y *b* de la relación longitud peso (LWR), de la forma $W = aL^b$, para 71 especies de Actinopterygii y 2 Elasmobranchii, capturados en la región costera y plataforma interior del sudeste de Brasil. Las estimaciones de *b* variaron de 2,151 a 3,882. Por primera vez se registra la LWR para ocho especies. Se observaron diferencias significativas entre los valores de *b* obtenidos para las mismas especies capturadas en diferentes ecosistemas. Además, se observaron resultados significativamente diferentes para *b* entre especies capturadas en diferentes ecosistemas y entre los sexos de 12 especies. Por lo tanto, a objeto de obtener una estimación confiable de la biomasa es necesario elegir datos LWR, cercanos en tiempo y región, con estimaciones para cada sexo.

Palabras clave: relación longitud-peso, Actinopterygii, Elasmobranchii, Bahía de Santos, Canal de Bertioga, Atlántico sudoccidental.

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INTRODUCTION

Fish population biomass estimates, or of an individual fish of the ichthyofauna, depends on the measurement of individual weight of these organisms. However, in most cases, weighing each organism individually under field conditions is a very difficult task and not always possible (Kimmerer *et al*., 2005).

The lenght-weight relationship (LWR) estimates are used to calculate the weight of the individual from length frequency data, allowing spatial and temporal comparisons among populations and species (Salles & Feitosa, 2000; Vianna *et al.*, 2004). Therefore, the LWR may be considered an essential tool in the studies of fish stock assessment and management of fisheries resources (Haimovici & Velasco, 2000a; Ilkyaz *et al.*, 2008; Rodriguez-Romero *et al*., 2009; Rojas-Herrera, 2009).

On the other hand, the historical review carried out by Froese (2006) shows that the intra-specific variance of LWR may be quite large and that users should follow some recommendations when using this relationship. Among the problems that may contribute to increase the variability of LWR, one can mention: the narrow range of body lengths in the sample, the use of non-random samples and of one specific size gear to select specimens and the LWR calculation with no regard of differences between the sexes.

Despite these recommendations, the application of LWR for individuals of the same size class for the same species still persists (Muto *et al.*, 2000). According to Kimmerer *et al.* (2005), it is highly recommended to use the LWR relationship with data collected in the same area and close to time of the study to minimize bias in the weight estimate.

LWR data are available in the literature for the majority of fish species from Europe and North America. Although publications regarding the LWR for marine tropical species and, in particular, in the Brazilian coast have increased (Araújo *et al.*, 1998; Bernardes & Rossi-Wongtschowski, 2000; Haimovici & Velasco, 2000a, 2000b; Muto *et al.*, 2000; Sales & Feitosa, 2000; Frota *et al.*, 2004; Santos *et al.*, 2004; Vianna *et al.*, 2004; Giarrizo *et al.*, 2006), these works are restricted to specific and isolated regions with no comparison among the data.

The Baixada Santista region, located in the central area of São Paulo state, southeastern Brazil, is characterized by intense industrial and port activity and human occupation, and is considered one of the most impacted areas of Brazil (Lamparelli *et al.*, 2001). This coastal region features a diversity of ecosystems such as the estuary, the Santos Bay, and three main channels, namely Santos, Bertioga and São Vicente, connecting the estuary with the bay (Fig.1). Two variables are mainly responsible for the changes in the ichthyofauna of the region: the shrimp fishing with artisanal fishing trawlers (Paiva Filho & Schmiegelow, 1986; Ávila da Silva *et al.*, 2005), with by-catch composed mainly of young sciaenids; and the temporal variability of the occurrence of water mass in the inner continental shelf (Rossi-Wongtschowski & Paes, 1993; Castro & Miranda, 1998).

This work aims at describing the LWR of 73 fish species collected in three different coastal ecosystems of southern Brazil, that is, one bay, one channel and the inner continental shelf. Moreover, for the specimens observed in two or three ecosystems, a comparison of the LWR parameter estimates will be carried out following some of the recommendations proposed by Froese (2006).

MATERIALS AND METHODS

The specimens were sampled monthly in six oceanographic stations of the Santos Bay (23°59'S; 46°21'W) between November 2004 and December 2005. Samplings were carried out in Bertioga Channel (23°51'S; 46°09'W) between September and December 2005 in two oceanographic stations. The inner shelf off shore Santos (24°24'S; 46°16'W) was sampled in two campaigns: August 2005 and February 2006, in sixteen oceanographic stations (Fig. 1). A trawl-net as described by Rossi-Wongtschowski & Paes (1993) was used.

Although samplings in the bay as well as in the channel were carried out only with one fishing gear, the size classes were found to be representative according to the frequency of distribution of the length classes. Larvae or juveniles were not considered in the analysis as to minimize errors in the estimate. No subsamples were carried out and all specimens were examined.

Each specimen of the ichthyofauna was identified, measured (total length-TL in cm) and weighed (total weight-TW in g). The specimens TL and TW pairs that had at least 14 individuals were plotted to identify and exclude possible outliers. The LWR was calculated using power regression $W = aL^b$ (Haimovici & Velasco, 2000a, 2000b), where *a* is the intercept and *b* the slope, W the weight and L the length. The degree of association between W and L was measured through the coefficient of determination (R^2). A Student's t-test (H_0: $b = 3$) with ± 95% ($\alpha = 0.05$) confidence level was carried out in order to verify if *b* values estimates are significantly different from the isometric value ($b = 3$) (Zar, 1998). The estimated values of the same species from different ecosystems were tested in order to check if there were significant differences among them.

RESULTS

The number of individuals captured according to species varied from 14 to 20,123. The LWR of 73 species belonging to 32 families, totaling 47,373 individuals, were estimated (Table 1). The families, the species and their descriptors, the sampling locations, the sample sizes (*n*), the length and weight variations, length median (Md), the *a* and *b* parameters of LWR, the lower and upper confidence limit (LCL-UCL) of the intercepts and slopes, and the coefficient of determination (R^2) are also shown in the Table 1.

Out of a total of 73 species that were analyzed, eight species, namely *Chilomycterus spinosus*, *Nebris microps*, *Ogcocephalus vespertilio*, *Rypticus randalli*, *Sphoeroides greeleyi*, *Sphyraena guachancho*, *Stellifer* sp. and *Trinectes paulistanus* have no data published so far.

The median lengths values of the species that have occurred in more than one environment were bigger in the inner continental shelf and smaller in Bertioga Channel or in Santos Bay. On the other hand,

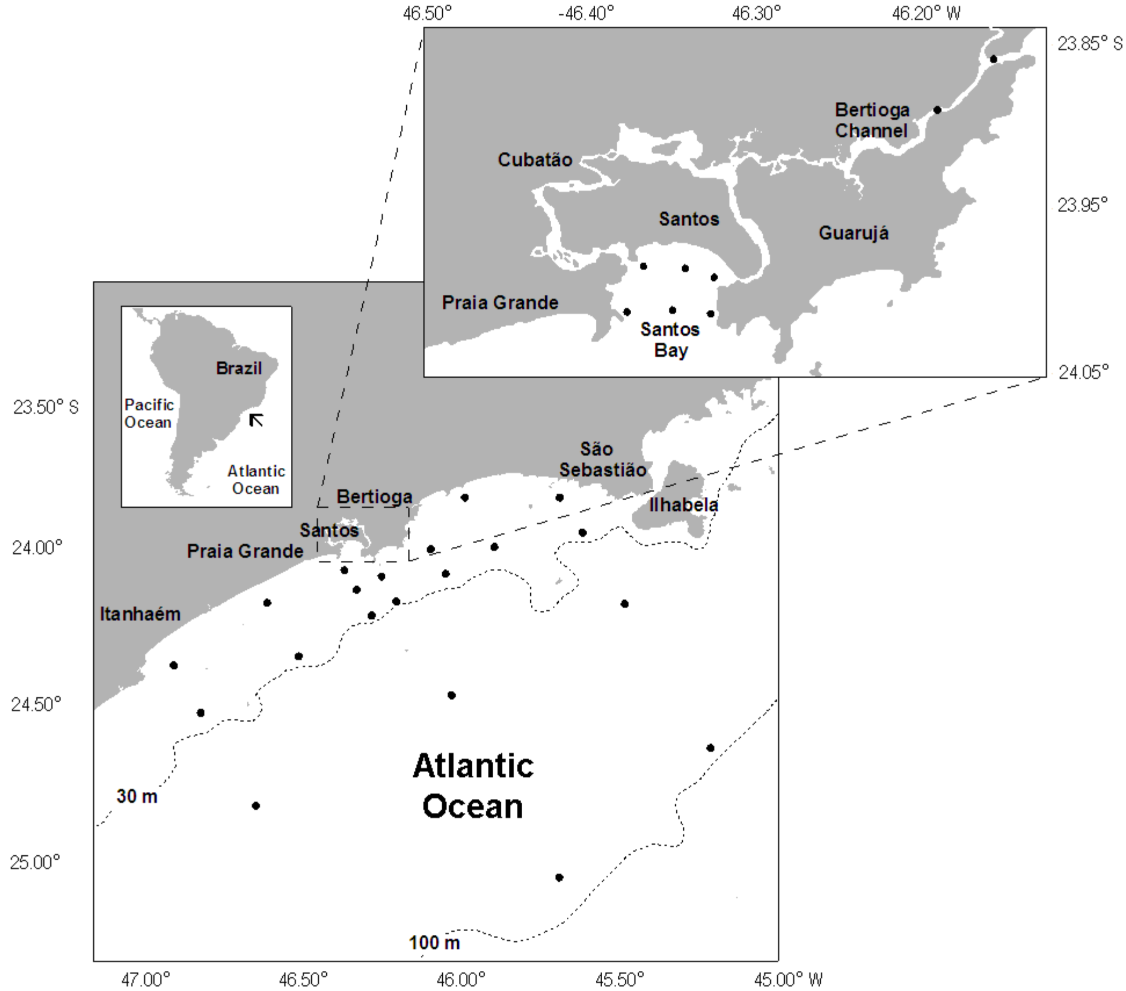

Figure 1. Map of the southwestern Atlantic showing sampling areas of Brazil: Santos Bay, Bertioga Channel and inner shelf. Black dots indicate sampling stations.

specimens were found to be smaller in the channel when the median length values of the species were compared with those captured in the bay.

All LWR were highly significant with the coefficient of determination (R^2) varying from 0.747 to 0.999 ($P < 0.01$). The *b* values estimates varied from 2.151 for *Chilomycterus spinosus* to 3.882 for *Anchoviella lepidentostole*, both captured in the inner continental shelf, but most of the *b* values estimated ranged from 2.6 and 3.5. The LWR *b* coefficient distribution exhibited symmetry (0.418) and kurtosis (0.781) (Fig. 2).

Regarding the types of growth (positive/negative allometry or isometry), it was observed that the members of the same family presented similar patterns. For instance, Carangidae exhibited a higher number of species with negative-allometric growth ($b < 3$), while Achiridae, Ariidae, Haemulidae, Paralichthyidae, Sciaenidae and Serranidae were characterized with more species with positive-allometric growth ($b > 3$). Two species of Pristigasteridae, although captured in different environments with different abundance values, exhibited an isometric growth ($b = 3$), that is, the individuals keep the same body form and proportional growth in all size classes.

The estimated *b* values were found to be significantly different from $b = 3$ in 16 out of 30 species observed in the continental shelf. For two species that were exclusively observed in Bertioga channel, *b* was found to be significantly different in one of the species. In addition, *b* was found to be significantly different from $b = 3$ in eight out of 12 species exclusively observed in Santos Bay. The LWR *b* values estimates for *Lagocephalus laevigatus*, *Micropogonias furnieri* and *Pellona harroweri* were not significantly different from 3. Nevertheless, the *b*

Table 1. Sample characteristics (local, number, minimum, maximum and median length, minimum and maximum weight) and estimated parameters of the length-weight relationship (a, b, lower confidence limit, upper confidence limit and coefficient of determination) for 73 fish species caught in the tropical southeastern inner continental shelf and estuarine region of Brazil. Bold numbers indicate significant differences from b = 3. LCL: lower confidence limit, UCL: upper confidence limit, B: Bay, C: Channel, S: Shelf.

Family	Species	Local	n	Length (cm)			Weight (g)		Parameters of the relationship				
				Min.	Max.	Median	Min.	Max.	*a*	LCL – UCL	*b*	LCL - UCL	R^2
Engraulidae	*Anchoviella lepidentostole* (Fowler, 1941)	B	17	5.2	16.3	7.7	0.80	30.30	0.00812	0.00555 - 0.01068	2.935	2.817 - 3.052	0.995
		C	20	7.0	18.0	13.7	2.20	48.54	0.00241	0.00067 - 0.00415	**3.416**	3.154 - 3.678	0.989
		S	65	6.1	12.9	9.2	1.58	17.71	0.00089	0.00019 - 0.00158	**3.882**	3.552 - 4.211	0.873
Pristigasteridae	*Pellona harroweri* (Fowler, 1919)	B	4938	2.4	14.2	5.0	0.07	29.45	0.00732	0.00706 - 0.00757	**3.105**	3.089 - 3.120	0.958
		C	26	5.4	13.4	7.8	1.67	22.47	0.00994	0.00629 - 0.01358	2.996	2.845 - 3.146	0.990
		S	547	3.4	15.2	6.3	0.38	29.01	0.00846	0.00776 - 0.00915	2.999	2.965 - 3.033	0.982
Carangidae	*Chloroscombrus chrysurus* (Linnaeus, 1766)	B	318	4.0	10.5	6.1	0.77	9.60	0.01829	0.01573 - 0.02085	**2.694**	2.622 - 2.765	0.924
		C	99	4.9	10.0	6.4	1.31	10.67	0.01103	0.00870 - 0.01336	2.962	2.855 - 3.068	0.954
		S	384	4.1	20.6	12.7	0.88	62.60	0.01815	0.01469 - 0.02160	**2.710**	2.637 - 2.783	0.933
Sciaenidae	*Menticirrhus americanus* (Linnaeus, 1758)	B	56	6.3	41.0	12.4	2.39	850.10	0.00528	0.00457 - 0.00599	**3.230**	3.192 - 3.267	0.999
		C	22	7.0	19.3	10.5	2.38	75.10	0.00452	0.00197 - 0.00707	**3.258**	3.059 - 3.456	0.989
		S	231	5.6	29.2	18.5	1.54	289.99	0.00366	0.00285 - 0.00447	**3.348**	3.278 - 3.418	0.981
	Micropogonias furnieri (Desmarest, 1823)	B	264	4.0	47.8	19.0	0.53	1174.20	0.00845	0.00742 - 0.00949	**3.063**	3.027 - 3.098	0.979
		C	75	7.0	24.3	12.7	3.27	138.76	0.00688	0.00519 - 0.00857	**3.109**	3.025 - 3.191	0.992
		S	14	18.9	52.3	23.2	68.66	1725.90	0.00755	0.00645 - 0.00866	**3.118**	3.080 - 3.156	1.000
Trichiuridae	*Trichiurus lepturus* Linnaeus, 1758	B	702	7.6	92.9	26.5	0.07	531.10	0.00016	0.00013 - 0.00019	**3.287**	3.244 - 3.329	0.965
		C	116	11.6	57.7	21.5	1.32	127.14	0.00003	0.00001 - 0.00005	**3.356**	3.584 - 3.883	0.885
		S	130	16.8	91.0	30.4	1.32	401.75	0.00043	0.00008 - 0.00077	3.048	2.862 - 3.233	0.973
Tetraodontidae	*Lagocephalus laevigatus* (Linnaeus, 1766)	B	70	3.4	11.5	5.3	1.08	25.38	0.03052	0.01948 - 0.04156	**2.763**	2.602 - 2.924	0.953
		C	27	3.8	11.2	5.6	1.48	22.86	0.02528	0.01956 - 0.03101	**2.818**	2.715 - 2.921	0.990
		S	21	3.9	16.8	7.2	1.43	72.91	0.0212	0.01224 - 0.03016	2.881	2.724 - 3.037	0.991
Ariidae	*Cathorops spixii* (Agassiz, 1829)	B	2851	4.1	27.5	14.8	0.59	206.61	0.01701	0.01482 - 0.0192	**2.800**	2.755 - 2.845	0.957
		C	238	8.0	24.0	11.3	4.34	139.15	0.00663	0.00518 - 0.00808	**3.147**	3.071 - 3.221	0.976
	Genidens barbus (Lacepède, 1803)	B	55	5.5	25.5	7.5	1.24	152.86	0.00774	0.00365 - 0.01183	3.049	2.879 - 3.217	0.992
		C	27	11.3	28.9	13.9	10.31	214.30	0.00502	0.00249 - 0.00754	**3.163**	3.007 - 3.319	0.994
	Aspistor luniscutis (Valenciennes, 1840)	B	85	6.0	33.5	11.4	1.53	424.04	0.00280	0.00161 - 0.00398	**3.384**	3.256 - 3.511	0.984
		C	63	10.9	37.0	18.8	10.55	646.70	0.00102	0.00021 - 0.00182	**3.680**	3.451 - 3.909	0.974
Sciaenidae	*Bairdiella ronchus* (Cuvier, 1830)	B	38	6.1	26.1	15.3	2.71	203.37	0.00693	0.00411- 0.00975	**3.141**	3.011 - 3.271	0.992
		C	29	13.8	21.6	17.4	26.21	135.48	0.00616	0.00152 - 0.01079	3.235	2.978 - 3.491	0.964
	Stellifer rastrifer (Jordan, 1889)	B	20123	3.3	22.0	8.3	0.18	160.63	0.00571	0.00563 - 0.00579	**3.318**	3.313 - 3.323	0.987
	Stellifer stellifer (Bloch, 1790)	B	649	4.2	20.1	8.4	0.81	100.70	0.0058	0.00543 - 0.00618	**3.264**	3.238 - 3.290	0.973
		C	38	7.7	14.3	10.2	4.77	35.33	0.00365	0.00241 - 0.00489	**3.443**	3.308 - 3.577	0.989
Ephippidae	*Chaetodipterus faber* (Broussonet, 1782)	B	27	5.2	23.3	14.7	5.31	461.80	0.0753	0.02100 - 0.12959	**2.752**	2.509 - 2.994	0.973
		C	28	7.7	49.0	11.6	15.16	3041.90	0.07368	0.04318 - 0.10417	**2.731**	2.623 - 2.838	0.997
Achiridae	*Achirus lineatus* (Linnaeus, 1758)	B	187	4.0	13.9	10.9	1.78	59.82	0.02249	0.01286 - 0.03211	2.939	2.764 - 3.113	0.873
		C	82	6.8	13.5	9.6	2.21	51.36	0.00323	0.00013 - 0.00633	**3.698**	3.304 - 4.091	0.833

Continuation

Family	Species	Local	n	Length (cm)			Weight (g)		Parameters of the relationship				
				Min.	Max.	Median	Min.	Max.	*a*	LCL – UCL	*b*	LCL - UCL	R^2
Batrachoididae	*Porichthys porosissimus*	B	17	3.2	23.7	6.4	0.25	169.88	0.00411	-0.01079 - 0.01901	3.365	2.199 - 4.529	0.958
	(Valenciennes, 1837)	S	59	6.1	33.2	16.3	1.19	388.24	0.00556	0.0035 - 0.00762	**3.203**	3.090 - 3.316	0.982
Carangidae	*Selene setapinnis* (Mitchill, 1815)	B	106	3.1	23.5	5.7	0.41	156.75	0.0134	0.01109 - 0.01571	2.955	2.897 - 3.012	0.996
		S	46	3.6	26.3	17.4	0.65	234.20	0.00267	0.00061 - 0.00473	**3.465**	3.210 - 3.720	0.953
Gerreidae	*Diapterus rhombeus* (Valenciennes, 1830)	B	14	10.0	19.8	14.2	12.01	91.86	0.06242	-0.0197 - 0.14455	**2.476**	2.006 - 2.945	0.920
		S	17	11.5	20.7	17.1	19.29	155.92	0.00849	0.00034 - 0.01664	3.228	2.898 - 3.558	0.976
Sciaenidae	*Cynoscion virescens* (Cuvier, 1830)	B	71	6.6	33.1	20.6	1.87	295.20	0.00133	0.00073 - 0.00192	**3.508**	3.374 - 3.641	0.988
		S	17	7.0	43.5	18.8	3.02	505.80	0.02172	-0.01124 - 0.05467	2.689	2.271 - 3.106	0.960
	Isopisthus parvipinnis (Cuvier, 1830)	B	2201	2.0	18.5	7.0	0.04	60.15	0.00987	0.0093 - 0.01045	**2.973**	2.950 - 2.995	0.970
		S	355	4.0	16.0	7.5	0.57	40.04	0.00858	0.00757 - 0.00959	3.020	2.972 - 3.067	0.976
	Larimus breviceps Cuvier, 1830	B	116	4.7	25.5	11.2	0.85	237.98	0.00742	0.00600 - 0.00884	**3.206**	3.142 - 3.269	0.991
		S	161	4.9	21.5	9.9	0.99	146.02	0.00563	0.00503 - 0.00624	**3.318**	3.279 - 3.357	0.991
	Macrodon ancylodon (Bloch & Schneider, 1801)	B	1078	2.2	35.5	8.5	0.08	393.28	0.0036	0.00332 - 0.00387	**3.251**	3.227 - 3.273	0.987
		S	152	5.0	31.1	8.6	1.09	269.73	0.01316	0.01143 - 0.0149	**2.887**	2.846 - 2.927	0.992
	Paralonchurus brasiliensis (Steindachner, 1875)	B	1607	4.4	23.1	11.6	0.43	135.41	0.00191	0.00177 - 0.00205	**3.533**	3.507 - 3.558	0.985
		S	189	5.0	22.7	17.6	0.74	114.52	0.00483	0.00301 - 0.00664	**3.220**	3.092 - 3.346	0.960
	Stellifer brasiliensis (Schultz, 1945)	B	1625	3.6	22.2	9.9	0.43	159.98	0.00393	0.00371 - 0.00414	**3.428**	3.407 - 3.447	0.986
		S	91	5.0	15.3	11.2	1.08	49.09	0.00751	0.00469 - 0.01032	**3.193**	3.046 - 3.339	0.974
Stromateidae	*Peprilus paru* Linnaeus, 1758	B	47	2.9	12.5	5.5	0.58	33.68	0.04876	0.03452 - 0.06301	**2.549**	2.423 - 2.674	0.975
		S	34	3.4	16.0	4.9	0.93	70.08	0.03261	0.02771 - 0.0375	**2.769**	2.712 - 2.825	0.998
Diodontidae	*Chilomycterus spinosus* (Linnaeus, 1758)	B	14	5.6	16.2	8.0	21.69	230.26	0.23161	0.13855 - 0.32466	**2.484**	2.330 - 2.636	0.993
		S	104	3.5	22.1	11.3	0.92	363.00	0.50378	0.22078 - 0.78677	**2.151**	1.947 - 2.354	0.874
Clupeidae	*Harengula clupeola* (Cuvier, 1829)	C	21	5.6	18.7	10.6	1.47	67.12	0.00977	0.00225 - 0.0173	3.035	2.762 - 3.307	0.990
		S	26	9.1	18.6	14.2	8.35	60.67	0.0143	-0.00093 - 0.02953	2.895	2.510 - 3.280	0.945
Triglidae	*Prionotus punctatus* (Bloch, 1793)	C	18	4.3	14.1	7.5	0.98	33.22	0.01287	0.0066 - 0.01914	2.972	2.779 - 3.163	0.993
		S	470	4.5	38.0	17.0	1.07	639.90	0.0096	0.00852 - 0.01067	**3.078**	3.043 - 3.112	0.979
Haemulidae	*Pomadasys corvinaeformis* (Steindachner, 1868)	C	32	9.0	15.9	12.3	10.32	53.87	0.00951	0.00345 - 0.01557	3.152	2.905 - 3.398	0.958
		S	125	7.7	21.4	12.5	6.26	153.10	0.01006	0.00831 - 0.01181	**3.137**	3.071 - 3.202	0.975
Paralichthyidae	*Etropus crossotus* Jordan & Gilbert, 1882	C	33	7.0	12.1	9.6	2.23	20.05	0.00308	0.00061 - 0.00554	**3.485**	3.142 - 3.826	0.943
		S	42	10.4	16.4	12.7	10.64	48.43	0.00601	-0.00014 - 0.01217	3.198	2.814 - 3.581	0.892
Engraulidae	*Anchoa filifera* (Fowler, 1915)	B	93	7.2	10.5	9.5	1.93	10.10	0.00514	0.00045- 0.00983	3.133	2.730 - 3.535	0.747
Ariidae	*Bagre bagre* (Linnaeus, 1758)	B	61	6.5	24.6	14.7	1.65	101.31	0.00399	0.00284 - 0.00514	**3.176**	3.078 - 3.273	0.986
Centropomidae	*Centropomus parallelus* Poey, 1860	B	26	24.3	54.0	29.3	121.98	1459.20	0.00704	0.00325 - 0.01084	3.084	2.943 - 3.224	0.989
Serranidae	*Rypticus randalli* Courtenay, 1967	B	17	10.3	20.4	12.7	15.83	143.89	0.00486	0.00174 - 0.00798	**3.411**	3.189 - 3.632	0.989
Carangidae	*Selene vomer* (Linnaeus, 1758)	B	28	2.7	15.2	4.8	0.27	44.41	0.02009	0.01745 - 0.02274	**2.830**	2.780 - 2.879	0.999
Haemulidae	*Conodon nobilis* (Linnaeus, 1758)	B	53	7.0	18.2	13.7	4.13	106.53	0.00687	0.00423 - 0.00950	**3.288**	3.150 - 3.425	0.989
Sciaenidae	*Cynoscion jamaicensis* (Vaillant & Bocourt, 1883)	B	33	3.9	16.4	7.4	0.53	25.33	0.05212	0.01315 - 0.09109	**2.172**	1.871 - 2.472	0.860
	Nebris microps Cuvier, 1830	B	455	3.5	29.9	10.5	0.46	274.68	0.00584	0.00493 - 0.00675	**3.157**	3.108 - 3.205	0.987
	Stellifer sp.	B	227	4.0	13.7	7.5	0.53	30.95	0.00466	0.00393 - 0.00538	**3.370**	3.302 - 3.436	0.976

Continuation

Family	Species	Local	n	Length (cm)			Weight (g)		Parameters of the relationship				
				Min.	Max.	Median	Min.	Max.	*a*	LCL – UCL	*b*	LCL - UCL	R^2
Achiridae	*Trinectes paulistanus* (Miranda Ribeiro, 1915)	B	120	5.8	20.5	11.4	3.95	177.96	0.01485	0.01031 - 0.01938	**3.136**	3.028 - 3.242	0.985
Cynoglossidae	*Symphurus tessellatus* (Quoy & Gaimard, 1824)	B	59	6.1	17.8	11.7	2.15	41.82	0.00558	0.0017 - 0.00946	3.084	2.822 - 3.345	0.895
Tetraodontidae	*Sphoeroides testudineus* (Linnaeus, 1758)	B	44	4.3	26.0	17.4	1.51	383.93	0.01553	-0.00032 - 0.03137	3.113	2.784 - 3.440	0.957
Paralichthyidae	*Citharichthys spilopterus* Günther, 1862	C	29	7.3	15.7	9.8	2.65	38.65	0.0038	0.00159 - 0.00601	**3.333**	3.109 - 3.556	0.974
Tetraodontidae	*Sphoeroides greeleyi* Gilbert, 1900	C	14	5.8	11.4	8.4	4.68	33.85	0.01991	-0.00146 - 0.04127	3.048	2.574 - 3.520	0.944
Rajidae	*Atlantoraja cyclophora* (Regan, 1903)	S	30	12.2	59.1	30.9	8.35	1150.00	0.06175	-0.01381 - 0.13731	**2.408**	2.096 - 2.719	0.968
	Psammobatis extenta (Garman, 1913)	S	14	8.7	27.6	24.5	3.65	116.08	0.00622	-0.00695 - 0.01940	2.946	2.294 - 3.598	0.958
Pristigasteridae	*Chirocentrodon bleekerianus* (Poey, 1867)	S	161	6.0	11.3	9.3	0.83	8.20	0.00635	0.00332 - 0.00938	2.929	2.719 - 3.138	0.852
Synodontidae	*Saurida brasiliensis* Norman, 1935	S	66	4.8	14.0	8.9	0.57	18.31	0.00264	0.0016 - 0.00368	**3.343**	3.173 - 3.512	0.920
	Synodus foetens (Linnaeus, 1766)	S	65	8.5	53.8	32.0	3.10	707.10	0.02431	-0.00242 - 0.0462	**2.607**	2.364 - 2.848	0.925
Merlucciidae	*Merluccius hubbsi* Marini, 1933	S	52	8.2	34.0	12.2	2.87	377.21	0.00142	0.00014 - 0.0027	**3.503**	3.239 - 3.766	0.962
Phycidae	*Urophycis brasiliensis* (Kaup, 1858)	S	16	8.5	39.5	27.6	2.57	618.90	0.00092	-0.00043 - 0.00227	**3.638**	3.223 - 4.051	0.979
Ogcocephalidae	*Ogcocephalus vespertilio* (Linnaeus, 1758)	S	17	5.4	14.2	6.6	2.45	48.59	0.02076	0.0023 - 0.03923	2.926	2.580 - 3.271	0.982
Fistularidae	*Fistularia petimba* Lacepède, 1803	S	24	29.5	97.0	35.9	7.50	466.01	0.00007	-0.00021 - 0.00034	3.432	2.516 - 4.346	0.905
Dactylopteridae	*Dactylopterus volitans* (Linnaeus, 1758)	S	1156	6.3	31.0	13.0	2.71	316.27	0.00725	0.00667 - 0.00783	**3.121**	3.094 - 3.147	0.981
Triglidae	*Prionotus nudigula* Ginsburg, 1950	S	60	4.0	21.2	6.0	0.92	89.72	0.02606	0.01957 - 0.03254	**2.681**	2.594 - 2.768	0.993
Serranidae	*Diplectrum radiale* (Quoy & Gaimard, 1824)	S	38	8.2	24.0	17.9	6.03	186.53	0.01928	0.00205 - 0.03652	2.881	2.585 - 3.176	0.971
	Serranus auriga Cuvier, 1829	S	41	5.9	16.3	12.9	3.59	77.92	0.00972	0.0039 - 0.01554	3.219	2.995 - 3.442	0.975
Carangidae	*Trachurus lathami* Nichols, 1920	S	199	4.6	15.8	10.8	0.78	35.18	0.00473	0.00322 - 0.00624	**3.206**	3.076 - 3.335	0.936
Gerreidae	*Eucinostomus argenteus* Baird & Girard, 1855	S	47	12.5	21.2	17.5	23.72	119.66	0.01637	-0.00067 - 0.03341	2.917	2.559 - 3.275	0.875
Haemulidae	*Orthopristis ruber* (Cuvier, 1830)	S	86	13.6	13.8	21.7	38.49	347.67	0.04376	0.02192 - 0.06559	**2.643**	2.488 - 2.798	0.944
Sparidae	*Pagrus pagrus* (Linnaeus, 1758)	S	199	4.0	21.8	9.8	0.75	153.11	0.02187	0.01912 - 0.02462	**2.876**	2.832 - 2.919	0.994
Sciaenidae	*Ctenosciaena gracilicirrhus* (Metzelaar, 1919)	S	696	5.1	18.0	13.3	1.46	91.01	0.00674	0.00545 - 0.00803	**3.264**	3.192 - 3.334	0.958
	Umbrina canosai Berg, 1895	S	14	11.5	15.6	13.5	19.35	48.98	0.02423	-0.01367 - 0.06214	2.794	2.200 - 3.388	0.908
	Umbrina coroides Cuvier, 1830	S	14	19.1	26.9	23.6	86.11	252.90	0.01200	-0.00839 - 0.03239	3.028	2.49 - 3.558	0.944
Mullidae	*Mullus argentinae* Hubbs & Marini, 1933	S	25	6.2	22.5	14.0	3.22	170.63	0.0052	0.00141 - 0.00899	**3.340**	3.090 - 3.590	0.968
	Upeneus parvus Poey, 1852	S	312	5.4	23.2	8.5	1.87	186.58	0.00282	0.00241 - 0.00323	**3.513**	3.463 - 3.563	0.988
Percophidae	*Bembrops heterurus* (Miranda-Ribeiro, 1903)	S	29	8.8	18.2	12.6	3.51	36.18	0.00311	0.00113 - 0.00509	3.237	3.004 - 3.470	0.966
Sphyraenidae	*Sphyraena guachancho* Cuvier, 1829	S	15	9.8	22.8	16.3	4.99	86.03	0.00500	-0.00043 - 0.01043	3.129	2.765 - 3.492	0.969
Paralichthyidae	*Citharichthys macrops* Dresel, 1885	S	34	7.4	17.7	12.4	3.94	64.15	0.00624	0.00239 - 0.01009	3.189	2.962 - 3.415	0.976
	Etropus longimanus Norman, 1933	S	128	5.8	12.6	9.5	1.48	15.24	0.01288	0.00697 - 0.01879	**2.769**	2.574 - 2.962	0.897
	Paralichthys isosceles Jordan, 1891	S	30	8.8	34.5	22.6	3.67	456.14	0.00075	-0.00001 - 0.00151	**3.742**	3.448 - 4.036	0.980
	Syacium papillosum (Linnaeus, 1758)	S	206	7.0	24.6	17.5	2.30	152.53	0.00885	0.00551 - 0.01219	3.040	2.915 - 3.164	0.954
	Xystreurys rasile Jordan, 1891	S	19	8.0	26.5	14.2	3.52	169.77	0.00175	0.00060 - 0.00289	**3.510**	3.301 - 3.718	0.993
Monacanthidae	*Stephanolepis hispidus* (Linnaeus, 1766)	S	549	4.0	22.6	11.7	1.66	219.79	0.01647	0.01445 - 0.01849	3.026	2.980 - 3.071	0.959

Table 2. Estimated parameters of the length-weight relationship (*a*, *b*, lower confidence limit, upper confidence limit and coefficient of determination) for 21 fish species, collected in the tropical southeastern inner continental shelf and estuarine region of Brazil.

Family	Species	Sex	Parameters of the relationship				
			a	LCL – UCL	*b*	LCL – UCL	R^2
Ariidae	*Cathorops spixii* (Agassiz, 1829)	Female	0.01443	0.01268 - 0.01618	2.868	2.827 - 2.908	0.928
		Male	0.01701	0.01482 - 0.01920	2.801	2.755 - 2.845	0.936
Pristigasteridae	*Pellona harroweri* (Fowler, 1919)	Female	0.01072	0.00370 - 0.01775	2.949	2.687 - 3.211	0.869
		Male	0.01038	0.00476 - 0.01601	2.931	2.715 - 3.149	0.960
Gerreidae	*Diapterus rhombeus* (Valenciennes, 1830)	Female	0.00692	0.00560 - 0.00823	3.135	3.073 - 3.198	0.975
		Male	0.00720	0.00553 - 0.00887	3.112	3.038 - 3.186	0.987
Triglidae	*Prionotus punctatus* (Bloch, 1793)	Female	0.00525	0.00424 - 0.00625	3.280	3.220 - 3.341	0.985
		Male	0.00536	-0.000002 - 0.01072	3.275	2.943 - 3.606	0.851
Haemulidae	*Orthopristis ruber* (Cuvier, 1830)	Female	0.04516	-0.00458 - 0.0949	2.627	2.277 - 2.976	0.928
		Male	0.00590	-0.00300 - 0.01479	3.300	2.807 - 3.793	0.915
	Pomadasys corvinaeformis (Steindachner, 1868)	Female	0.00855	0.00645 - 0.01066	3.194	3.105 - 3.283	0.985
		Male	0.02348	0.00199 - 0.04497	2.810	2.456 - 3.165	0.910
Sciaenidae	*Ctenosciaena gracilicirrhus* (Metzelaar, 1919)	Female	0.00704	0.00411 - 0.00998	3.253	3.099 - 3.406	0.915
		Male	0.00968	0.00600 - 0.01337	3.132	2.991 - 3.273	0.889
	Menticirrhus americanus (Linnaeus, 1758)	Female	0.00489	0.00329 - 0.00648	3.253	3.157 - 3.349	0.970
		Male	0.00352	0.00134 - 0.0057	3.368	3.165 - 3.571	0.926
	Isopisthus parvipinnis (Cuvier, 1830)	Female	0.00994	0.00832 - 0.01155	2.984	2.922 - 3.046	0.957
		Male	0.01579	0.00983 - 0.02174	2.797	2.650 - 2.942	0.950
	Larimus breviceps Cuvier, 1830	Female	0.00831	0.00658 - 0.01004	3.167	3.097 - 3.235	0.988
		Male	0.00657	0.00518 - 0.00796	3.256	3.184 - 3.328	0.994
	Macrodon ancylodon (Bloch & Schneider, 1801)	Female	0.00901	0.00407 - 0.01395	2.978	2.812 - 3.142	0.984
		Male	0.00555	0.00291 - 0.00818	3.128	2.986 - 3.269	0.982
	Micropogonias furnieri (Desmarest, 1823)	Female	0.01059	0.00788 - 0.01329	3.003	2.932 - 3.074	0.973
		Male	0.0069	0.00537 - 0.00844	3.141	3.082 - 3.199	0.996
	Paralonchurus brasiliensis (Steindachner, 1875)	Female	0.00389	0.00304 - 0.00473	3.287	3.213 - 3.361	0.950
		Male	0.00224	0.00133 - 0.00315	3.483	3.343 - 3.622	0.966
	Stellifer brasiliensis (Schultz, 1945)	Female	0.00398	0.00362 - 0.00435	3.424	3.391 - 3.457	0.984
		Male	0.00661	0.00527 - 0.00795	3.234	3.159 - 3.310	0.977
	Stellifer rastrifer (Jordan, 1889)	Female	0.00625	0.00596 - 0.00654	3.283	3.266 - 3.300	0.975
		Male	0.00611	0.00589 - 0.00632	3.295	3.281 - 3.308	0.984
	Stellifer stellifer (Bloch, 1790)	Female	0.00605	0.00539 - 0.0067	3.245	3.204 - 3.287	0.981
		Male	0.00282	0.00204 - 0.00359	3.594	3.478 - 3.710	0.970
	Stellifer sp.	Female	0.00556	0.00403 - 0.00709	3.291	3.173 - 3.408	0.969
		Male	0.00339	0.00053 - 0.00624	3.514	3.149 - 3.879	0.957
Trichiuridae	*Trichiurus lepturus* Linnaeus, 1758	Female	0.00040	-0.00022 - 0.00102	3.059	2.710 - 3.408	0.965
		Male	0.00021	-0.00023 - 0.00065	3.241	2.767 - 3.714	0.947
Paralichthyidae	*Syacium papillosum* (Linnaeus, 1758)	Female	0.00654	0.00028 - 0.01279	3.148	2.829 - 3.468	0.895
		Male	0.03614	-0.01292 - 0.0852	2.565	2.115 - 3.015	0.935
Monacanthidae	*Stephanolepis hispidus* (Linnaeus, 1766)	Female	0.05071	0.02930 - 0.07212	2.590	2.423 - 2.757	0.872
		Male	0.00906	0.00729 - 0.01083	3.230	3.161 - 3.299	0.976
Tetraodontidae	*Sphoeroides testudineus* (Linnaeus, 1758)	Female	0.01529	-0.01491 - 0.04549	3.119	2.484 - 3.755	0.875
		Male	0.01410	-0.00103 - 0.02923	3.134	2.786 - 3.480	0.967

values for three different coastal systems were found to be significantly different for *Trichiurus lepturus*. On the other hand, intra-specific variations for the majority of 23 species (with significant differences in *b* values), were observed for the specimens of both areas. These variations could be responses to natural phenomena such as food availability and abiotic variables that may lead to different growth rates in time and in different regions.

No significant differences in *b* values were observed for 35% of the species: *Genidens barbus*, *Notarius luniscutis*, *Bairdiella ronchus* and *Chaetodipterus faber*

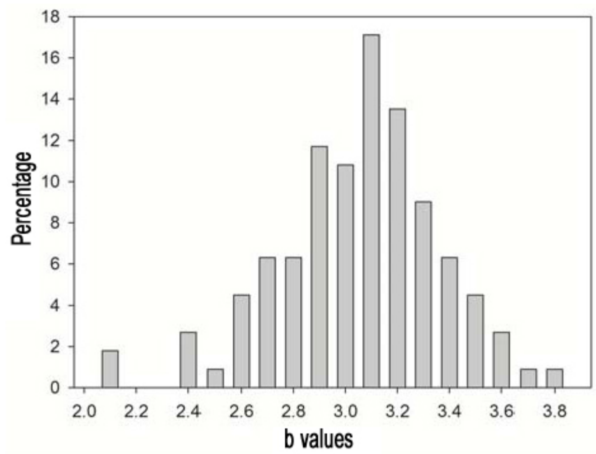

Figure 2. Distribution of b values estimated for 73 species collected in the tropical southeastern inner continental.

from Bertioga Channnel and Santos Bay, *Diapterus rhombeus*, *Isopisthus parvipinnis* and *Chilomycterus spinosus* from the bay and inner continental shelf, and for *Harengula clupeola*, *Prionotus punctatus*, *Pomadasys corvinaeformis* and *Etropus crossotus* from Bertioga Channel and the continental shelf.

Out of the total number of species with a representative number of males and females (21), significantly differences in the *b* values discriminated by sex were observed for five species (Table 2). Among five species, four belonged to the Sciaenidae family (*Micropogonias furnieri*, *Stellifer brasiliensis*, *Stellifer stellifer* and *Stellifer* sp.) and *Stephanolepis hispidus*. For these species the LWR estimates were obtained for each sex.

DISCUSSION

General data of LWR of 73 actinopterygian species were estimated for a tropical region of southwestern Atlantic according to recommendations of Froese (2006). From these 73 species, information about the LWR parameters for 23 species is not available in the FishBase data base (Froese & Pauly, 2004).

Smaller median lengths values of the species occurred in Bertioga Channel or in Santos Bay in comparison to the occurrences in the inner shelf. This result may be related to the fact that many fish species use the estuarine regions as a spawning and growth areas, remaining in these regions in the early stage of their life cycle (Fuiman & Werner, 2002).

Those extreme *b* values estimated for *Chilomycterus spinosus* (2.151) and for *Anchoviella lepidentostole* (3.882) account for the species body form, that is, species with height bigger or equal for a given length and species with low height relative to length. In this study no species presented long caudal fins that could interfere in the b values, as shown by Ilkyaz *et al*. (2008).

Carangidae exhibited a higher number of species with negative-allometric growth (b < 3), while Achiridae, Ariidae, Haemulidae, Paralichthyidae, Sciaenidae and Serranidae were characterized with more species with positive-allometric growth (b > 3). Two species of Pristigasteridae, although captured in different environments with different abundance values, exhibited an isometric growth (b = 3), that is, the individuals keep the same body form and proportional growth in all size classes. Similar growth patterns for Carangidae and Ariidae species were obtained by Giarrizzo *et al*. (2006) in the northeastern Brazilian estuary.

The observed intra-specific variations found in *b* values justify the use of LWR obtained in the same area and close to the time of sampling (Kimmerer *et al*., 2005). Differences in *b* values for some species when compared to other studies from other locations (Haimovici & Velasco, 2000b; Muto *et al*., 2000; Gomes & Araújo, 2004; Giarrizzo *et al.,* 2006) can be explained by several factors, such as variations in the parameters of hydrographic properties (*e.g.*, temperature, salinity), food availability, number of specimens and variation in the length of the individuals collected from the sampled populations, or to procedural and statistical reasons (Pauly, 1984; Weatherley & Gill, 1987; Kimmerer *et al*., 2005), or any other variable that can affect the body weight and indicates a difference in growth or condition.

The hydrographic pattern of the southeastern continental shelf region of Brazil comprises three water masses: the Tropical Water (TW) (T > 24, S), the Coastal Water (CW) and South Atlantic Central Water (SACW) (T < 18, S > 36.4) (Castro & Miranda, 1998). The SACW is the water mass responsible for carrying nutrients to the pelagic system mainly in summer (Gaeta & Brandini, 2006). Therefore, the penetration intensity of the SACW and the deep thermal front location may be responsible for the occurrence of higher *b* values in this period. As the *b* exponent corresponds to the allometric condition factor, the bigger the value the better the conditions of the individuals. Moreover, these values are also influenced by the degree of repletion of the digestive tracts of the specimens.

The intercept estimates may also be affected by individual features or processes such as reproduction, sex, size, and even the sample size (Haimovici &

Velasco, 2000b; Frota *et al*., 2004; Vianna *et al*., 2004).

This study reinforces data presented by Froese (2006), in that variations among sex, size classes, seasons and sites should be considered in the studies where weight data are needed to provide fish biomass estimates.

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