

LENGTH–WEIGHT RELATIONS OF 22 FISH SPECIES FROM THE LITTORAL ZONE OF THE EASTERN IONIAN SEA, GREECE

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Abstract. Length–weight relations are presented for 22 fish species caught in the littoral zone of the eastern Ionian Sea. Mean values of b ranged from 2.58 to 3.43. For Greek waters no information regarding the LWR existed for 2 of the recorded species. This is the first study on the LWR for species of the littoral zone of the eastern Ionian Sea which may be helpful in future fisheries studies in this area.

Keywords: Length–weight relation, littoral zone, eastern Ionian Sea

Length–weight relations (LWR) are of great importance for fisheries research as they allow the conversion of growth-in-length equations to growth-in-weight equations to be used in stock assessment models, the estimation of biomass from length observations, the estimation of the condition of the fish, and can be used to compare the life histories of certain species between regions and other aspects of fish population dynamics (Gonçalves et al. 1997, Moutopoulos and Stergiou 2002, Froese and Pauly 2011).

In Greek marine ecosystems length–weight relations for commercial fish species are available mostly for the Aegean Sea (Stergiou and Politou 1995, Petrakis and Stergiou 1995, Stergiou and Moutopoulos 2001, Moutopoulos and Stergiou 2002, Koutrakis and Tsikliras 2003, Karakulak et al. 2006). The length–weight relations of the fish species of the Ionian Sea are poorly known, however (Stergiou and Moutopoulos 2001, Froese and Pauly 2011) and such information for the littoral zone is absent altogether.

The aim of the presently reported study was to establish the length–weight relation of 22 fish species, either adult or juvenile, caught in the littoral zone of the eastern Ionian Sea. The results reported may be helpful in the fisheries management and will constitute a benchmark for future research in this area.

Samples were collected in two different estuarine habitats in the eastern Ionian Sea (Station I: Port of Igoumenitsa 39°31'04.63"N, 20°13'29.38"E, Station II Amvrakikos Gulf 39°00'10.92"N, 20°45'22.35"E). Station I

is exposed to wind and waves. It is a part of the Kalamas River estuarine ecosystem and its sea-grass habitat comprises predominantly of *Zostera* sp. providing a landscape of patchy sea grass amongst areas of bare sand. The Amvrakikos Gulf is a shallow semi-enclosed embayment in the Ionian Sea. The sea-grass habitat of the station comprises predominantly of dense *Posidonia oceanica* vegetation.

Fish species were collected at each station on a monthly basis from July of 2008 through March of 2010 using a beach seine (16-m long and 1.4-m high, mesh size of 2–4 mm) and were preserved in 4% neutralized formalin. In the laboratory, each specimen was identified to the species level and the standard length and weight were measured to the nearest cm and g, respectively.

The relations between the length (L) and weight (W) of a fish were expressed by the equation $W = aL^b$, where W is the total weight, L is the total length, a is a coefficient related to body form and b is an exponent indicating isometric growth when equal to 3 and allometric growth when different to 3 (positive if $b > 3$, negative if $b < 3$) (Beverton and Holt 1957, Froese 2006). The parameters a and b of the length–weight relations were estimated by the least-square method based on the predictive or Type I linear regression model (Sokal and Rohlf 1981), using W as the dependent variable and L as the independent variable, $\log(W) = \log(a) + b \log(L)$. The b -value for each species was tested by Student's t -test to verify that it was significantly different from the predictions for isometric growth ($b = 3$). Analysis of covariance (ANCOVA) was used to compare the regression lines between stations (Zar 1996)

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Table 1

Estimated parameters of the length–weight relation (LWR) of 22 fish species caught in the eastern Ionian Sea (When the regression lines were not statistically different between stations, LWRs were combined as eastern Ionian Sea; The species of the families: Mullidae, Mugilidae, and Sparidae were represented by juvenile specimens)

FAM	Species	STN	n	Length [cm]				Mean weight [g]				Parameters of LWR				Allometry	
				Mean	Min	Max		Mean	Min	Max		a	P value of a	b	95% CI of b	P value of b	r ²
AT	<i>Atherina boyeri</i>	I	1304	5.60	2.7	8	2.08	0.00842	$F_{1,2113} = 0.13$	3.06	3.03–3.10	$F_{1,2373} = 8.31$	0.95	+	<0.001		
		II	1471	4.71	1.6	8.3	1.39	0.01173	$P > 0.05$	2.99	2.99–3.02	$P < 0.05$	0.97	+	>0.5		
B	<i>Belone belone</i>	I	47	13.13	3.4	35.7	8.97	0.00532		3.18	3.09–3.27		0.99	+	<0.001		
		II	80	6.10	3.2	11.8	7.06	0.02172		3.01	2.94–3.08		0.99	+	>0.5		
Blennidae	<i>Parablennius gattorugine</i>	I	37	4.45	3.6	7.7	2.41	0.05551	$F_{1,60} = 0.048$	2.78	2.62–2.94	$F_{1,60} = 18.073$	0.97	–	<0.005		
		II	25	4.17	1.8	8	1.66	0.00714	$P < 0.05$	3.21	3.09–3.33	$P < 0.05$	0.99	+	<0.001		
Blennidae	<i>Parablennius sanguinolentus</i>	I	40	4.01	1.8	10.8	1.81	0.00790	$F_{1,117} = 0.222$	3.17	3.07–3.28	$F_{1,117} = 0.074$	0.99	+	<0.001		
		II	79	4.36	1.5	10.4	2.44	0.00911	$P > 0.05$	3.15	3.05–3.25	$P > 0.05$	0.98	+	<0.005		
Blennidae	<i>Salarias pavo</i>	I	119	4.25	1.5	10.8	2.23	0.01233		3.16	3.09–3.23		0.98	+	<0.005		
		II	87	4.14	1.8	6.7	0.91	0.05222		2.58	2.48–2.68		0.97	–	<0.001		
Clupeidae	<i>Sardina pilchardus</i>	I	59	2.74	1.5	4.8	0.65	0.01401		3.16	2.99–3.33		0.96	+	>0.1		
		II	96	4.39	1.8	7	0.87	0.00513		3.13	3.02–3.25		0.97	+	<0.05		
Engraulidae	<i>Engraulis encrasicolus</i>	I	263	4.89	2.2	8.7	3.04	0.01334	$F_{1,302} = 1.071$	3.12	3.06–3.19	$F_{1,302} = 0.897$	0.97	+	<0.001		
		II	41	5.29	4.0	8.3	3.87	0.00883	$P > 0.05$	3.22	3.05–3.39	$P > 0.05$	0.97	+	<0.005		
Gobiidae	<i>Gobius niger</i>	I	304	4.95	2.2	8.70	3.15	0.01752		3.13	3.07–3.19		0.97	+	<0.001		
		II	276	5.23	2.1	8	3.84	0.00671	$F_{1,330} = 5.33$	3.31	3.26–3.36	$F_{1,330} = 4.718$	0.98	+	<0.001		
1	<i>Symphodus cithereus</i>	I	65	5.44	3.5	8	4.68	0.01250	$P > 0.05$	3.17	3.09–3.26	$P < 0.05$	0.99	+	<0.001		
		II	44	4.37	2.7	9	2.30	0.01224	$F_{1,100} = 0.001$	3.16	3.04–3.28	$F_{1,100} = 0.038$	0.99	+	<0.005		
1	<i>Symphodus ocellatus</i>	I	59	4.38	2.9	10.6	2.82	0.01234	$P > 0.05$	3.17	3.08–3.27	$P > 0.05$	0.99	+	<0.001		
		II	103	4.37	2.7	10.60	2.60	0.01801		3.17	3.09–3.24		0.99	+	<0.005		
1	<i>Syngnathus abaster</i>	I	184	9.35	4.1	20.5	0.57	0.00012	$F_{1,105} = 2.076$	3.32	3.20–3.43	$F_{1,105} = 1.991$	0.95	+	<0.005		
		II	235	7.50	2.2	22.1	0.29	0.00024	$P > 0.05$	3.19	3.09–3.29	$P > 0.05$	0.95	+	<0.001		
1	<i>Syngnathus acus</i>	I	419	8.31	2.2	22.10	0.47	0.00031		3.22	3.15–3.29		0.95	+	<0.001		
		II	237	9.84	2.6	24.8	1.10	0.00023	$F_{1,382} = 2.646$	3.35	3.27–3.41	$F_{1,382} = 2.255$	0.98	+	<0.005		
1	<i>Syngnathus typhle</i>	I	153	8.07	2.7	23	0.57	0.00022	$P > 0.05$	3.27	3.17–3.36	$P > 0.05$	0.97	+	<0.001		
		II	390	9.14	2.6	24.80	0.91	0.00032		3.30	3.25–3.36		0.97	+	<0.001		
1	<i>Chelon labrosus</i>	I	236	11.65	3.2	23.6	1.28	0.00013	$F_{1,790} = 3.321$	3.32	3.27–3.38	$F_{1,790} = 3.393$	0.98	+	<0.001		
		II	556	9.97	2.4	18.6	0.69	0.00030	$P > 0.05$	3.25	3.21–3.30	$P > 0.05$	0.97	+	<0.001		
1	<i>Liza aurata</i>	I	792	10.47	2.4	23.60	0.85	0.00023		3.28	3.24–3.31		0.98	+	<0.001		
		II	45	6.46	4.8	17.1	7.05	0.01461		3.06	2.94–3.19		0.98	+	>0.5		
1	<i>Liza saliens</i>	I	958	3.21	1.5	11	1.03	0.00750	$F_{1,1400} = 15.334$	3.20	3.17–3.23	$F_{1,1400} = 9.920$	0.98	+	<0.001		
		II	444	3.69	1.5	13	1.66	0.01012	$P > 0.05$	3.13	3.10–3.16	$P < 0.005$	0.99	+	<0.001		
1	<i>Mullus surmuletus</i>	I	39	4.49	1.2	12.2	4.10	0.00651	$F_{1,1219} = 43.913$	3.22	3.13–3.31	$F_{1,1220} = 39.869$	0.99	+	<0.001		
		II	182	4.42	1.1	15.5	2.56	0.02881	$P < 0.001$	2.85	2.78–2.92	$P < 0.001$	0.97	–	<0.001		
1	<i>Diplodus annularis</i>	I	198	6.12	3.5	11.5	5.40	0.00624	$F_{1,1225} = 0.845$	3.28	3.21–3.35	$F_{1,1225} = 1.076$	0.98	+	<0.001		
		II	29	8.68	4.3	13	15.55	0.00902	$P > 0.05$	3.18	3.11–3.26	$P > 0.05$	0.99	+	<0.001		
1	<i>Diplodus puntazzo</i>	I	227	6.45	3.5	13.00	6.70	0.01251		3.24	3.18–3.29		0.98	+	<0.001		
		II	44	4.86	2.0	10.3	5.49	0.00674		3.36	3.19–3.52		0.97	+	<0.001		
1	<i>Diplodus vulgaris</i>	I	96	2.88	1.6	7.4	0.97	0.01854		3.12	3.03–3.21		0.98	+	<0.005		
		II	30	3.59	2.3	6.6	1.99	0.00563		3.43	3.25–3.61		0.98	+	<0.005		
1	<i>Sarpa salpa</i>	I	119	4.75	3.0	12.7	3.40	0.01291	$F_{1,1103} = 0.293$	3.14	3.07–3.21	$F_{1,1103} = 0.678$	0.99	+	<0.001		
		II	46	9.09	6.6	12	22.96	0.01050	$P > 0.05$	3.21	3.11–3.32	$P > 0.05$	0.99	+	<0.001		
1		I	165	5.98	3.0	12.70	8.96	0.01542		3.25	3.21–3.29		0.99	+	<0.001		

FAM = family, AT = Atherinidae, B = Belonidae, C1 = Clupeidae, C2 = Cyprinodontidae, E = Engraulidae, L = Labridae, EIS = eastern Ionian Sea, STN = sampling site.

and when no different, stations were combined. The coefficient of determination r^2 was calculated.

A total of 7905 specimens collected and studied represented 12 families and 22 species. The sample size ranged from 25 individuals for *Parablennius sanguinolentus* (Pallas, 1814) to 1471 for *Atherina boyeri* Risso, 1810. All of the regressions were highly significant ($P < 0.005$) and the values of r^2 ranged from 0.95 for *Syngnathus abaster* Risso, 1827 and *Atherina boyeri* (Station I) to 0.99 for *Mullus surmuletus* L. The high values of correlation coefficient r^2 indicate a high degree of positive correlation between standard length and total weight of all 22 fish species. For 8 species the regression lines were not statistically different between stations and LWRs were combined and referred to as eastern Ionian Sea (Table 1).

The mean values of b ranged from 2.58 for *Sardina pilchardus* (Walbaum, 1792) (Station I) to 3.43 for *Diplodus vulgaris* (Geoffroy Saint-Hilaire, 1817). For the majority of the species the slopes of b were significantly ($P < 0.05$) higher than 3.0, exhibiting a positive allometric growth. The estimated values of b were close to 3.0 ($P > 0.05$) showing isometric growth for three species while only for one species the mean values of b showed a significant difference ($P < 0.05$) lower than 3.0 reflecting a negative allometric growth (Table 1). At this point, it has to be stated that the species of the families of Mulidae, Mugilidae, and Sparidae are represented by juvenile specimens. Also the species of the remaining families were represented by small- and medium sized specimens compared to the published maximum lengths recorded for the species and available mean lengths at maturity. Hence the use of the length–weight relation parameters should be limited to the observed length ranges (Petrakis and Stergiou 1995, Gonçalves et al. 1997). Extrapolation of these parameters to different length ranges (higher or lower) should be avoided (Bagenal and Tesch 1978).

As shown in Table 1 there is a significant statistical between stations difference in the LWRs for five species: *Atherina boyeri*; *Liza aurata* (Risso, 1810); *Liza saliens* (Risso, 1810); *Parablennius sanguinolentus*; and *Symphodus cinereus* (Bonnaterre, 1788). Even though the change of b values depends primarily on the shape and well-being of the species, various factors may be responsible for that difference. According to Bagenal and Tesch (1978), Gonçalves et al. (1997), Taskavak and Bilecenoglu (2001), and Özaydin and Taskavak (2006), the parameter b , unlike the parameter a , may vary seasonally, daily, and between habitats. Also gonad maturity, sex, diet, stomach fullness, health, and preservation techniques, as well as season could attribute to that difference. However none of these factors were taken into consideration in the presently reported study (Tesch 1971, Wootton 1998).

For Greek waters no information regarding the length–weight relations existed for 2 of the recorded adult species (*Syngnathus typhle* L. and *Gobius niger* L.), while apart from *Mullus surmuletus* no length–weight relations information were available in FishBase for the littoral zone of the eastern Ionian Sea (Froese and Pauly 2011).

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