

Length-weight relationships for the fifty littoral and coastal marine fish species from the Eastern Adriatic sea

Alen SOLDO

Department of Marine Studies, University of Split, Croatia

Corresponding autor, e-mail: soldo@unist.hr

*The length–weight relationship parameters are reported for the fifty littoral and coastal marine fish species from the Eastern Adriatic. Captures were made between the years 2004 and 2017 during sport fishing competitions. The parameters a and b of the equation $W = aL^b$ were estimated. The b values ranged from 2.1972 for *Spicara smaris* (Linnaeus, 1758) to 3.7044 for *Salaria pavo* (Risso, 1810). The L - W relation for *Scyliorhinus stellaris* (Linnaeus, 1758), *Gobius bucchichi* Steindachner 1870, *Gobius geniporus Valenciennes* 1837 and *Lipophrys trigloides* (Valenciennes, 1836) are not available in FishBase and presents new data for these species. For some other species, such as *Labrus mixtus* Linnaeus 1758, there are only two relationships, but none from the Mediterranean, for *Gobius paganellus* Linnaeus 1758 only four relationships and none from Central and Eastern Mediterranean, while for *Labrus merula* Linnaeus 1758, *Symphodus mediterraneus* (Linnaeus, 1758), *Symphodus roissali* (Risso, 1810), *Gobius cobitis* Pallas 1814, *Gobius cruentatus* Gmelin 1789, *Gobius niger* Linnaeus 1758, *Parablennius gatorugine* (Linnaeus, 1758), *Parablennius sanguinolentus* (Pallas, 1814), *Salaria pavo* (Risso, 1810), and *Bothus podas* (Delaroche, 1809) very low number of relationships are presented and none from the Adriatic Sea.*

Key words: length-weight relationship, parameters, fish, littoral and coastal, Adriatic

INTRODUCTION

The length–weight relationship (LWR) is useful in fishery assessments (ÇALIK & ERDOĞAN SAĞLAM, 2017) for predicting weights from the more easily measured lengths (RICKER, 1975), yield assessment (GARCIA *et al.*, 1998) and when calculating biomass (MARTIN-SMITH, 1996). During various sampling programs, it is usually easier to measure only length (e.g., because of the bobbing motion of the boat), or weight cannot be measured at all (e.g., underwater visual censuses). The LWR of a particular species allows the inter-conversion of these parameters. The relationship between the length (L)

and weight (W) of a fish is usually expressed by the equation $W = aL^b$. The exponent b provides information on growth (MOREY *et al.*, 2003); being isometric when $b = 3$ and allometric when this is not the case (positive if $b > 3$, negative if $b < 3$). The present study provides information on the length–weight relationships of fifty littoral and coastal marine fish species from the littoral and coastal waters of the Eastern Adriatic Sea.

MATERIAL AND METHODS

Data were collected between 2004 and 2017 from the Eastern Adriatic sea during the study of sport fishing competitions, using various fishing

gears, from the different hook lines to spear fishing. Competitions are held from the shore, and boats, while spear fishermen were fishing near shore or further offshore on underwater reefs. Thus, most of the fishes have been caught up to 40 m of depth. Due to the common period of the sport fishing competitions all fishes were collected from May until the end of October. Data on total length (TL, cm) to the nearest millimeter and total weight (TW, g) to the nearest gram were recorded for each fish. The length–weight relationship was calculated using the expression: $W = aL^b$, where the W is the weight (g), L the length (cm), a the intercept of the regression and b is the regression coefficient (HAYES *et al.*, 1995). Parameters a and b of the length–weight relationship were estimated by linear regression analysis based on logarithms: $\log(W) = \log(a) + b \log(L)$.

RESULTS AND DISCUSSION

A total of 16373 fish specimens representing 20 families and 50 different fish species were analyzed. For each species, the sample size, the minimum and maximum total length, the minimum and maximum weight measured, the LWR parameters a and b , and the coefficient of determination r^2 are presented in Table 1. The L-W relationship for *Scyliorhinus stellaris* (Linnaeus, 1758), *Gobius bucchichi* Steindachner 1870, *Gobius geniporus* Valenciennes 1837 and *Lipophrys trigloides* (Valenciennes, 1836) are not available in FishBase (FROESE & PAULY, 2019). For some other species, such as *Labrus mixtus* Linnaeus 1758, there are only 2 relationships, none from the Mediterranean, for *Gobius paganellus* Linnaeus 1758 only 4 relationships and none from Central and Eastern Mediterranean, while for *Labrus merula* Linnaeus 1758, *Symphodus mediterraneus* (Linnaeus, 1758), *Symphodus roissali* (Risso, 1810), *Gobius cobitis* Pallas 1814, *Gobius cruentatus* Gmelin 1789, *Gobius niger* Linnaeus 1758, *Parablennius gatorugine* (Linnaeus, 1758), *Parablennius sanguinolentus* (Pallas, 1814), *Salarias pavo* (Risso, 1810), *Trachinus radiatus* Cuvier 1829 and *Bothus podas* (Delaroche, 1809) very low num-

ber of relationships are presented and none from the Adriatic Sea, except for *T. radiates* (FROESE & PAULY, 2019). Comparing maximum lengths of fishes indicated in FishBase (FROESE & PAULY, 2019) with those obtained during this study, the new maximum lengths can be reported for a range of gobies, particularly *G. cobitis* (30.0 cm), *G. bucchichi* (12.1 cm), *G. geniporus* (17.8 cm), *G. paganellus* (16.0 cm) and for a blenny *S. pavo* (13.4 cm). The sample size ranged from 61 specimens for *Muraena helena* Linnaeus 1758 to 1472 for *Coris julis* (Linnaeus, 1758). The r^2 values ranged from 0.5644 for *Spicara smaris* (Linnaeus, 1758) to 0.9980 for *Chelidonichthys lastoviza* (Bonnaterre, 1788), 0.9953 for *T. radiatus* and 0.9917 for *Sarpa salpa* (Linnaeus, 1758). Twenty seven species, out of 50, showed r^2 values higher than 0.95, while only four of them had r^2 values less than 0.75. The b values ranged from 2.1972 for *S. smaris* to 3.7044 for *S. pavo*. Three species had b values less than 2.5 while only one had higher than 3.5. The mean value of b was 2.975, while the median was 2.9804. 50 % of the b values ranged between 2.8473 and 3.1434.

BAGENAL & TESCH (1978) reported that the parameters of weight–length relationships, particularly a , may vary daily, seasonally, and/or between habitats, unlike the parameter b , which does not vary significantly throughout the year. However, the comparison of b values for the same species appearing in different studies in the Mediterranean Sea suggested inter-regional differences (MOREY *et al.*, 2003). In order to test differences on a regional level, b values for similar habitat and species obtained previously from the Adriatic (DULČIĆ & KRALJEVIĆ, 1996) were compared to results of this study (Table 2). Comparison showed that for most of the species b values were indeed similar, but for *Mullus surmuletus* Linnaeus 1758 (3.512 vs 3,0901), *Pagellus acarne* (Risso, 1827) (3,499 vs 2,746) and *Scorpaena scrofa* Linnaeus 1758 (3,298 vs 2,8162) were significantly different. Therefore, it can be concluded that even b values, although less than a values, can vary due to a combination of different reasons, such as period of the year, spatial variation, influence of water qual-

ity, food availability, population differences and the ontogenetic stage of the individuals studied (SPARRE *et al.*, 1989, MOMMSEN, 1998, DULČIĆ & GLAMUZINA, 2006) or differences in sampling (the number of specimens and length ranges).

Thus, when LWR parameters are used for some species it would be appropriate, for obtaining more precise weight estimations, to use local/regional values calculated within suitable length ranges.

Table 1. Length – weight relationship parameters for the fifty species from the Eastern Adriatic

Family/Species	N	Weight range (g)	Length range (cm)	a	b	r ²
Scyliorhinidae						
<i>Scyliorhinus stellaris</i>	86	998-3820	58,1-96,2	0,0705	2,3769	0,8161
Sparidae						
<i>Boops boops</i>	1144	12-236	11,0-27,5	0,0147	2,8608	0,9515
<i>Dentex dentex</i>	92	442-6695	32,7-82,1	0,0095	3,0855	0,9884
<i>Diplodus annularis</i>	1325	8-195	8,3-22,5	0,017	2,9796	0,9511
<i>Diplodus puntazzo</i>	101	61-795	15,6-39,0	0,0243	2,8477	0,9772
<i>Diplodus sargus</i>	415	58-1525	15,3-42,0	0,0251	2,9003	0,9322
<i>Diplodus vulgaris</i>	740	8-570	8,5-32,0	0,0118	3,0926	0,9789
<i>Lithognathus mormyrus</i>	74	41-488	15,0-32,7	0,008	3,1393	0,9849
<i>Pagellus erythrinus</i>	1235	12-744	10,0-39,2	0,0163	2,8942	0,9786
<i>Pagellus acarne</i>	288	12-110	10,0-21,1	0,0253	2,746	0,8847
<i>Sarpa salpa</i>	171	16-885	10,7-39,0	0,015	2,9636	0,9917
<i>Sparus aurata</i>	202	124-1460	21,0-49,1	0,0106	3,064	0,9542
Labridae						
<i>Coris julis</i>	1472	4-116	8,5-23,0	0,0035	3,3611	0,967
<i>Labrus merula</i>	299	59-1102	16,6-42,0	0,0183	2,947	0,9457
<i>Labrus mixtus</i>	63	60-536	18,1-34,6	0,0042	3,3251	0,9786
<i>Symphodus mediterraneus</i>	301	10-64	8,0-16,1	0,0247	2,7591	0,8226
<i>Symphodus roissali</i>	93	10-41	8,4-13,4	0,0109	3,1801	0,867
<i>Symphodus tinca</i>	876	14-565	9,6-34,8	0,0212	2,8351	0,9636
Gobiidae						
<i>Gobius bucchichi</i>	62	8-18	9,1-12,1	0,0071	3,1548	0,7205
<i>Gobius cobitis</i>	141	12-332	10,3-30,0	0,0134	2,9844	0,9609
<i>Gobius cruentatus</i>	504	8-78	9,6-17,8	0,0078	3,1435	0,9002
<i>Gobius geniporus</i>	472	4-58	7,2-17,2	0,0546	2,36	0,7784
<i>Gobius niger</i>	91	5-31	7,8-14,0	0,0092	3,0831	0,8622
<i>Gobius paganellus</i>	277	8-38	9,8-16,0	0,028	2,6675	0,7496
Serranidae						
<i>Serranus cabrilla</i>	457	12-226	10,8-26,2	0,0123	2,9636	0,9561
<i>Serranus hepatus</i>	169	3-32	5,3-12,0	0,0364	2,6475	0,8977
<i>Serranus scriba</i>	923	10-154	9,8-22,1	0,0092	3,1433	0,9621
Centracanthidae						

<i>Spicara flexuosa</i>	504	17-92	12,0-19,8	0,0093	3,0367	0,8639
<i>Spicara maena</i>	182	32-340	14,2-27,1	0,0052	3,2846	0,9526
<i>Spicara smaris</i>	179	22-52	12,3-19,2	0,0716	2,1972	0,5644
Scorpaenidae						
<i>Scorpaena porcus</i>	173	21-770	10,5-32,7	0,0099	3,2133	0,9841
<i>Scorpaena scrofa</i>	225	20-2060	10,6-50,2	0,034	2,8162	0,9542
Carangidae						
<i>Trachurus trachurus</i>	377	20-564	13,4-44,5	0,0115	2,8637	0,9746
Blenniidae						
<i>Lipophrys trigloides</i>	77	9-26	8,9-13,0	0,0341	2,5688	0,7557
<i>Parablennius gatorugine</i>	155	6-198	7,4-22,0	0,0064	3,2741	0,9667
<i>Parablennius sanguinolentus</i>	316	9-89	9,7-19,4	0,0051	3,343	0,9261
<i>Salaria pavo</i>	83	4-16	8,3-13,4	0,0015	3,7044	0,9215
Mugilidae						
<i>Chelon auratus</i>	83	205-875	27,6-47,5	0,0158	2,8472	0,9029
<i>Chelon ramada</i>	65	278-1311	35,5-56,8	0,0243	2,7089	0,9707
Triglidae						
<i>Chelidonichthys lastoviza</i>	64	40-214	15,8-27,7	0,0133	2,9109	0,998
Trachinidae						
<i>Trachinus draco</i>	447	7-192	10,4-32,2	0,0082	2,9063	0,9784
<i>Trachinus radiatus</i>	85	24-399	13,8-33,5	0,0085	3,0285	0,9953
Congridae						
<i>Conger conger</i>	391	735-11775	70,9-165,4	0,0006	3,2754	0,9057
Phycidae						
<i>Phycis phycis</i>	127	210-2720	26,6-58,3	0,0048	3,2499	0,9594
Mullidae						
<i>Mullus surmuletus</i>	157	14-330	9,9-30,3	0,0099	3,0901	0,9797
Sciaenidae						
<i>Sciaena umbra</i>	118	328-1995	29,0-52,2	0,0095	3,1053	0,9664
Pomacentridae						
<i>Chromis chromis</i>	235	11-48	9,2-13,2	0,0181	2,979	0,6425
Moronidae						
<i>Dicentrarchus labrax</i>	119	230-2963	27,8-64,1	0,0104	2,9812	0,9095
Muraenidae						
<i>Muraena helena</i>	61	1115-4310	79,0-120,2	0,0116	2,6477	0,8212
Bothidae						
<i>Bothus podas</i>	77	16-58	12,6-18,1	0,0058	3,2125	0,8998

n – sample size, weight range, total length range, *a* and *b* parameters, *r*² – coefficient of determination

Table 2. Number of specimens (*n*), total length ranges (TL range) and *b* values for species compared between previous study from the Adriatic (DULČIĆ & KRALJEVIĆ, 1996) and present study

species	DULČIĆ & KRALJEVIĆ, 1996			present study		
	n	TL range (cm)	b	n	TL range (cm)	b
<i>Chromis chromis</i>	1230	5,9-13,9	3,102	235	9,2-13,2	2,979
<i>Coris julis</i>	94	4,3-15,3	3,238	1472	8,5-23,0	3,3611
<i>Dentex dentex</i>	250	18,3-85,9	3,172	92	32,7-82,1	3,0855
<i>Dicentrarchus labrax</i>	417	24,5-88,0	3,146	119	27,8-64,1	2,9812
<i>Diplodus annularis</i>	100	8,9-23,5	2,928	1325	8,3-22,5	2,9796
<i>Diplodus puntazzo</i>	289	5,9-45,0	2,951	101	15,6-39,0	2,8477
<i>Diplodus sargus</i>	214	14,3-39,9	3,038	415	15,3-42,0	2,9003
<i>Diplodus vulgaris</i>	601	14,3-39,9	3,028	740	8,5-32,0	3,0926
<i>Mullus surmuletus</i>	127	15,4-30,9	3,512	157	9,9-30,3	3,0901
<i>Pagellus acarne</i>	74	10,0-23,7	3,499	288	10,0-21,1	2,746
<i>Pagellus erythrinus</i>	193	10,9-46,0	2,944	1235	10,0-39,2	2,8942
<i>Phycis phycis</i>	58	26,2-56,4	3,502	127	26,6-58,3	3,2499
<i>Sciaena umbra</i>	26	18,1-41,2	3,048	118	29,0-52,2	3,1053
<i>Scorpaena porcus</i>	351	9,7-26,6	3,243	173	10,5-32,7	3,2133
<i>Scorpaena scrofa</i>	125	19,7-53,6	3,298	225	10,6-50,2	2,8162
<i>Spicara maena</i>	220	14,2-27,5	3,037	182	14,2-27,1	3,2846
<i>Symphodus tinca</i>	100	12,7-30,2	2,726	876	9,6-34,8	2,8351
<i>Trachinus draco</i>	22	9,2-26,8	2,934	447	10,4-32,2	2,9063
<i>Trigloporus lastoviza</i>	52	7,4-35,0	3,003	64	15,8-27,7	2,9109

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Dužinsko-maseni odnos pedeset litoralnih i obalnih riba u istočnom Jadranu

Alen SOLDÓ

Kontakt e-pošta: soldo@unist.hr

SAŽETAK

Parametri dužinsko-masenog odnosa su prijavljeni za 50 litoralnih i obalnih rba iz istočnog Jadrana. Svi primjerci su ulovljeni u periodu 2004–2017 za vrijeme natjecanja u sportskom ribolovu.

Parametri a i b od jednadžbe $W = aL^b$ su prezentirani. Vrijednosti b parametra su varirale od 2.1972 za *Spicara smaris* (Linnaeus, 1758) do 3.7044 za *Salaria pavo* (Risso, 1810). Dužinsko-maseni odnosi za *Scyliorhinus stellaris* (Linnaeus, 1758), *Gobius bucchichi* Steindachner 1870, *Gobius geniporus Valenciennes 1837* i *Lipophrys trigloides Valenciennes, 1836* dosad nisu bili dostupni u *FishBase*.

Za neke druge vrste, primjerice *Labrus mixtus* Linnaeus 1758, postoje samo dva prijavljena odnosa, pri čemu niti jedan nije iz Mediterana, za *Gobius paganellus* Linnaeus 1758 postoje samo 4 odnosa i nijedan iz središnjeg i istočnog Mediterana, dok za *Labrus merula* Linnaeus 1758, *Symphodus mediterraneus* (Linnaeus, 1758), *Symphodus roissali* (Risso, 1810), *Gobius cobitis* Pallas 1814, *Gobius cruentatus* Gmelin 1789, *Gobius niger* Linnaeus 1758, *Parablennius gatorugine* (Linnaeus, 1758), *Parablennius sanguinolentus* (Pallas, 1814), *Salaria pavo* (Risso, 1810) i *Bothus podas* (Delaroche, 1809) postoji veoma mali broj dužinsko-masениh odnosa, pri čemu niti jedan nije prijavljen za Jadransko more, osim za *T. radiates*.

Ključne riječi: dužinsko-maseni odnos, parametri, riba, primorje i priobalje, Jadran