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Length–weight relationships of forty-nine fish species from shallow waters of Gökçeada Island, northern Aegean Sea

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Abstract: Length–weight relationships (LWRs) of 49 fish species belonging to 18 families from the shallow waters (0–20 m) of Gökçeada Island were reported. Fish specimens were sampled monthly with a beach seine (0–2 m) and beam trawl (5–20 m) between June 2013 and June 2014. The b values estimates varied between 2.66 and 3.59. Five of the 49 species (*Arnoglossus kessleri*, *Scorpaena maderensis*, *Symphodus ocellatus*, *Symphodus rostratus*, and *Gobius geniporus*) presented maximum length values that exceeded their maximum lengths listed in FishBase.

Key words: Marine fish, near shore, coastal, Aegean Sea, Mediterranean

Length–weight relationships (LWRs) of fishes provide important information for many studies in a given geographic region, such as comparing the condition, fatness, estimation of weight-at-age from total reported catch weight, and length–frequency distributions (Tesch, 1968), as well as for interregional life-history comparisons (Petrakis and Stergiou, 1995). The relationships may change temporarily and/or spatially, and for this reason should be regularly updated (Ismen et al., 2007). The northern Aegean Sea is an important region for fisheries; fish stocks are heavily exploited by artisanal and industrial fishermen. Although length–weight relationships of many fish species have already been determined from the northern Aegean Sea (Koutrakis and Tsikliras, 2003; Karakulak et al., 2006; Ismen et al., 2007; Çakır et al., 2008; Karachle and Stergiou, 2008; Ismen et al., 2009; Ozekinci et al., 2009; Ozen et al., 2009; Yigin and Ismen, 2009; Cengiz, 2013), 9 species were reported for the first time in the present study. Furthermore, the maximum length of 5 species exceeded their previous records in FishBase.

Fish collection was carried out in the shallow waters (0–20 m) of Gökçeada Island, northern Aegean Sea (Figure). Samples were collected at 6 sites with a beach seine (0–2 m) and beam trawl (5–20 m). These 6 sites were sampled monthly between June 2013 and June 2014. The specimens were fixed immediately after capture in 4% formaldehyde. The samples were then taken to the laboratory and fish species were identified according to Whitehead et al. (1986). Thereafter, total lengths (L) of specimens were measured to the nearest 0.1 cm and specimens were weighed to the nearest 0.1 g. The maximum size records were compared with the information in FishBase (Froese and Pauly, 2014). Length–weight relationships were calculated from the log-transformed equation:

Log (W) = log (a) + b (×) log (L), where W is the total weight (g), L is the total length (cm), 'a' is the intercept, and 'b' is the slope of the linear regression. Log–log plots of the length–weight pairs were performed to remove outliers (Froese, 2006). The degree of association between L and W was measured through the coefficient of determination (r^2). Student's t-test (Zar, 1999) was used to test for differences of the parameter 'b' from the theoretical value of 3.

A total of 19,874 specimens representing 49 fish species belonging to 18 families were analyzed. The length–weight relationship parameters are presented with confidence intervals (95%) in Table 1. Maximum lengths of 5 species (*Arnoglossus kessleri*, *Gobius geniporus*, *Symphodus ocellatus*, *Symphodus rostratus*, and *Scorpaena maderensis*) were longer than the previously recorded maximum lengths in Fishbase (Froese and Pauly, 2014). Additionally,

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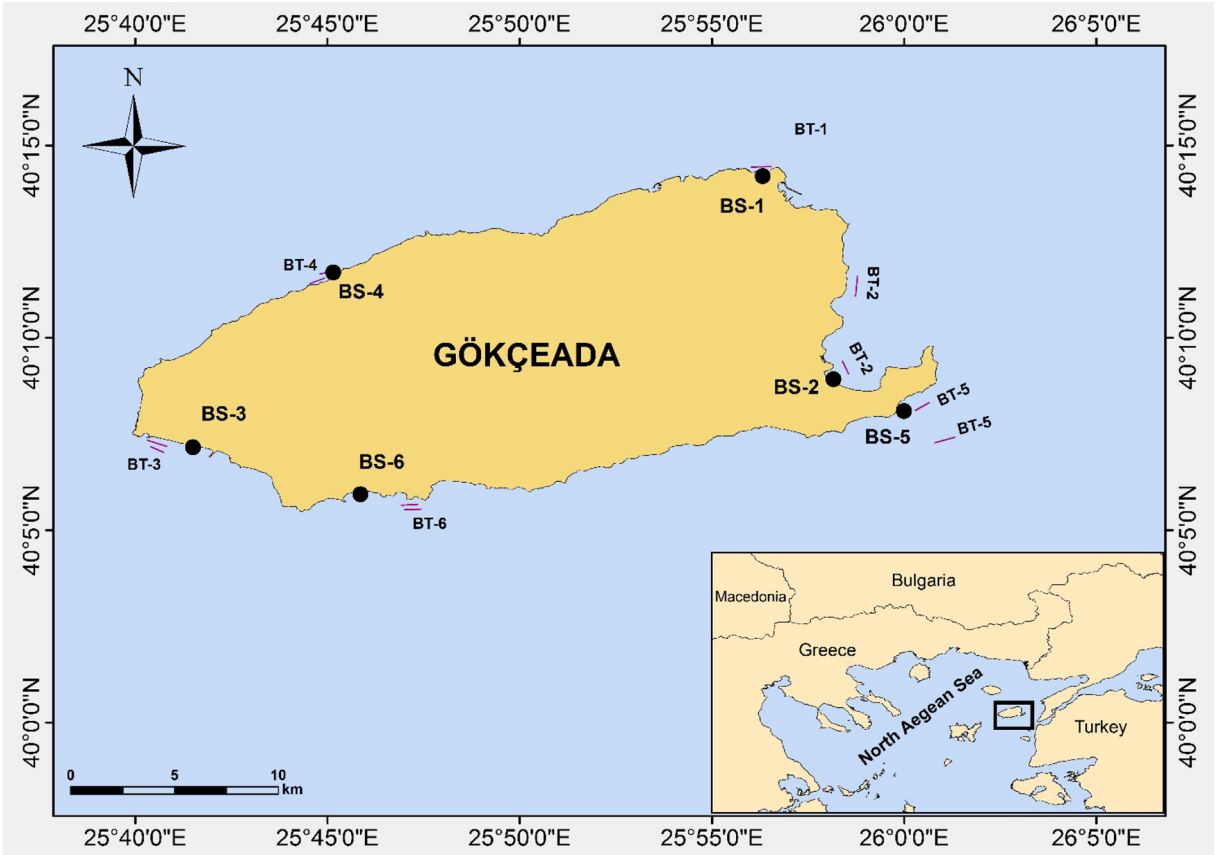

Figure. Sampling stations (BS: beach seine, BT: beam trawl).

Table 1. Sample sizes, minimum and maximum lengths and weights for each species, and length–weight relationship parameters with confidence intervals (95%).

Family	Species	N	TL (cm)		W (g)		Length–weight relationship parameters and statistics							P	Growth type
			Min.	Max.	Min.	Max.	a	95% Cl of a		b	95% Cl of b		r^2		
Atherinidae	*Atherina boyeri*	4490	1	13.5	0.01	18.25	0.003	0.003	0.003	3.398	3.383	3.413	0.978	0.000	A+
Belonidae	*Belone belone*	49	11.8	32.5	0.94	22.8	0.000	0.000	0.000	3.280	3.100	3.461	0.966	0.003	A+
Bothidae	*Arnoglossus kessleri**	393	1.3	11.2	0.01	15.76	0.005	0.004	0.005	3.292	3.205	3.380	0.933	0.000	A+
	Arnoglossus laterna	11	4.3	10.7	0.49	11.21	0.005	0.003	0.010	3.238	2.896	3.580	0.981	0.146	I
	Arnoglossus thori	71	3.9	12.4	0.45	18.15	0.006	0.005	0.009	3.149	2.993	3.306	0.959	0.061	I
	Bothus podas	194	2.5	20.1	0.07	79.66	0.004	0.003	0.004	3.367	3.304	3.429	0.983	0.000	A+
Carangidae	*Trachinotus ovatus*	79	2.9	15.2	0.24	26.25	0.016	0.013	0.020	2.660	2.527	2.793	0.953	0.000	A–
Centracanthidae	*Spicara maena*	77	3.2	16.8	0.86	55.31	0.017	0.013	0.024	2.817	2.684	2.950	0.960	0.008	A–
	Spicara smaris	651	1	13.7	0.01	31	0.007	0.006	0.007	3.142	3.102	3.182	0.973	0.000	A+
Clupeidae	*Sardina pilchardus*	96	5.4	8.9	0.82	4.23	0.007	0.005	0.010	2.949	2.762	3.136	0.913	0.593	I
	Sprattus sprattus	134	4.3	7.9	0.37	3.18	0.004	0.003	0.005	3.351	3.158	3.544	0.900	0.000	A+
Engraulidae	*Engraulis encrasicolus*	18	2.1	3.6	0.02	0.13	0.002	0.001	0.004	3.229	2.633	3.825	0.892	0.426	I
Gobiidae	*Gobius geniporus**	63	3.6	16.5	0.33	44.23	0.005	0.004	0.007	3.255	3.124	3.386	0.976	0.000	A+
	Pomatoschistus marmoratus	1678	1.2	6.7	0.01	2.64	0.005	0.004	0.005	3.168	3.114	3.222	0.888	0.000	A+
Labridae	*Coris julis*	131	2.6	17.5	0.08	51.68	0.005	0.004	0.006	3.215	3.139	3.291	0.982	0.000	A+
	Symphodus cinereus	536	1.5	15.8	0.02	56.32	0.008	0.007	0.008	3.180	3.132	3.228	0.969	0.000	A+
	Symphodus mediterraneus	72	2	12.2	0.06	26.6	0.010	0.008	0.011	3.157	3.068	3.246	0.986	0.001	A+

Table 1. (Continued).

	Symphodus melanocercus	57	2	7.8	0.07	4.78	0.008	0.006	0.009	3.181	3.065	3.297	0.982	0.003	A+
	*Symphodus ocellatus**	1922	1.4	18.5	0.01	81.69	0.007	0.007	0.007	3.229	3.209	3.248	0.982	0.000	A+
	*Symphodus rostratus**	1016	1.2	17.7	0.01	73.88	0.007	0.006	0.007	3.193	3.168	3.217	0.985	0.000	A+
	Symphodus tinca	27	3	18.5	0.23	77.22	0.007	0.005	0.008	3.269	3.169	3.368	0.995	0.000	A+
Mugilidae	*Chelon labrosus*	286	1.9	19.1	0.07	52.46	0.011	0.010	0.012	2.862	2.815	2.909	0.981	0.000	A–
	Liza aurata	50	5.8	14.6	1.7	23.92	0.013	0.010	0.016	2.770	2.674	2.866	0.986	0.000	A–
Mullidae	*Mullus barbatus barbatus*	61	4.7	24	0.34	100	0.004	0.002	0.005	3.436	3.215	3.657	0.943	0.000	A+
	Mullus surmuletus	691	4.5	14.8	0.53	40.16	0.005	0.004	0.005	3.342	3.278	3.407	0.938	0.000	A+
Pomacentridae	*Chromis chromis*	166	1.9	12.5	0.09	28.8	0.012	0.011	0.014	3.058	3.006	3.110	0.988	0.030	A+
Scorpaenidae	*Scorpaena maderensis**	47	3.1	17.8	0.41	107.72	0.017	0.013	0.023	2.980	2.845	3.114	0.978	0.760	I
	Scorpaena notata	20	7.2	13.2	7.32	42.01	0.022	0.008	0.065	2.876	2.419	3.333	0.907	0.575	I
	Scorpaena porcus	78	3	23.2	0.56	242.75	0.014	0.011	0.018	3.080	2.970	3.190	0.976	0.151	I
	Scorpaena scrofa	16	6.3	13.2	3.46	37.82	0.012	0.007	0.021	3.135	2.897	3.372	0.983	0.243	I
Serranidae	*Serranus cabrilla*	88	2.7	14	0.19	29.84	0.012	0.011	0.014	2.908	2.853	2.964	0.992	0.002	A–
	Serranus hepatus	131	1.7	12.6	0.04	23.65	0.013	0.011	0.014	2.903	2.837	2.969	0.983	0.004	A–
	Serranus scriba	636	1.5	21.4	0.04	121.7	0.010	0.009	0.011	3.066	3.022	3.110	0.967	0.003	A+
Sparidae	*Diplodus annularis*	923	1.1	14	0.01	48.33	0.011	0.010	0.011	3.103	3.071	3.135	0.976	0.000	A+
	Diplodus puntazzo	87	1.2	24.5	0.01	209.78	0.006	0.005	0.007	3.564	3.395	3.732	0.954	0.000	A+
	Diplodus sargus sargus	530	1.4	23.1	0.01	222	0.011	0.010	0.011	3.121	3.061	3.182	0.951	0.000	A+
	Diplodus vulgaris	334	1.4	22.6	0.01	160.56	0.010	0.009	0.010	3.134	3.072	3.196	0.968	0.000	A+
	Lithognathus mormyrus	2015	1.4	16.5	0.01	46.69	0.011	0.010	0.011	2.907	2.865	2.949	0.901	0.000	A–
	Pagellus acarne	908	1.7	8	0.01	5.28	0.004	0.003	0.004	3.594	3.520	3.667	0.911	0.000	A+
	Pagellus bogaraveo	471	1.4	5.7	0.01	1.68	0.008	0.007	0.009	3.034	2.932	3.136	0.880	0.511	I
	Pagellus erythrinus	259	1.2	16.3	0.01	47.59	0.009	0.009	0.010	3.218	3.162	3.273	0.981	0.000	A+
	Sarpa salpa	37	4.4	32.6	0.7	260.8	0.010	0.006	0.014	3.074	2.873	3.276	0.965	0.458	I
	Spondyliosoma cantharus	29	5.5	13.7	2.14	33.58	0.009	0.006	0.012	3.176	3.022	3.329	0.985	0.026	A+
Syngnathidae	*Nerophis ophidion*	35	12.3	23.1	0.09	1.04	0.000	0.000	0.000	3.124	2.696	3.552	0.870	0.560	I
	Syngnathus abaster	10	11.3	17	0.49	1.72	0.000	0.000	0.001	3.359	2.480	4.238	0.907	0.370	I
	Syngnathus acus	12	11.4	25.5	0.04	6.75	0.000	0.000	0.000	3.592	3.049	4.134	0.956	0.000	A+
	Syngnathus typhle	70	5.4	28.6	0.05	8.95	0.000	0.000	0.000	2.985	2.864	3.106	0.973	0.801	I
Trachinidae	*Trachinus draco*	106	2.4	29.3	0.08	200	0.009	0.008	0.011	2.847	2.756	2.938	0.974	0.001	A–
Uranoscopidae	*Uranoscopus scaber*	13	18.1	27.3	92.4	401.76	0.013	0.002	0.072	3.084	2.541	3.626	0.934	0.741	I

* The maximum length values exceeded their maximum length in Fish Base.

length–weight relationships of 9 species were recorded for the first time from the northern Aegean Sea (Table 2). All length–weight relationships were highly significant, with the coefficient of determination (r^2) varying from 0.870 to 0.997 ($P < 0.01$). The parameter 'b' of length–weight relationships of 35 species was significantly different from 3 ($P < 0.05$). The 'b' values estimates varied between 2.65 (*Labrus viridis*) and 3.59 (*Syngnathus acus*). The values of b for all species were within the expected ranges of 2.5–3.5 (Froese, 2006). Differences of the 'b' values between previous studies conducted in the northern Aegean Sea and the present study are shown in Table 2. The length–weight relationship is affected by many factors such as season, habitat, maturity, sex, feeding habits and stomach fullness, health, preservation techniques (Tesch, 1968), and annual differences in environmental conditions (Froese, 2006). The northern Aegean Sea is mainly affected by upwellings. The upwellings occur in the Aegean Sea (Metaxas, 1973) due to summer's (August–September) strong northerly winds. Due to the subsurface cool water upwellings, surface temperature differences create a thermal front between the eastern and western regions of the northern Aegean Sea (Zodiatis and Balopoulos, 1993). Moreover, the less saline and nutrient-rich Black Sea inflow is possibly an important factor in changes in environmental conditions. The Black Sea water causes strong stratification, which allows free

Table 2. Comparison of b values between the present study and previous studies in the northern Aegean Sea.

Family	Species	Studies conducted in the northern Aegean Sea								
		Koutrakis 2003	Karakulak, 2006	İsmen, 2007	Karachle, 2008	Ozen, 2008	Çakır, 2008	Özekinci, 2009	Cengiz, 2013	Present study
Atherinidae	*Atherina boyeri*	3.023								3.398
Belonidae	*Belone belone*	3.04			2.972				3.19	3.280
Bothidae	*Arnoglossus kessleri*					3.15	3.124			3.292
	Arnoglossus laterna		2.747	3.006			3.242	3.183		3.238
	Arnoglossus thori		3.123				2.945	3.564		3.149
	Bothus podas				3.034					3.367
Carangidae	*Trachinotus ovatus**									2.660
Centracanthidae	*Spicara maena*		3.505	3.01	3.18					2.817
	Spicara smaris		2.877	2.917	2.991		2.855		3.01	3.142
Clupeidae	*Sardina pilchardus*	3.46			3.144		2.76		3.12	2.949
	*Sprattus sprattus**									3.351
Engraulidae	*Engraulis encrasicolus*	2.728		2.972	3.822		2.77			3.229
Gobiidae	*Gobius geniporus*					3.21				3.255
	Pomatoschistus marmoratus	3.308								3.168
Labridae	*Coris julis*		3.054	3.157	3.036				3.18	3.215
	*Symphodus cinereus**									3.180
	Symphodus mediterraneus		2.902		2.14					3.157
	*Symphodus melanocercus**									3.181
	*Symphodus ocellatus**									3.229
	Symphodus rostratus		2.836							3.193
	Symphodus tinca		3.046		2.799					3.269
Mugilidae	*Chelon labrosus*	2.948								2.862
	Liza aurata	2.993								2.770
Mullidae	*Mullus barbatus barbatus*		3.273	3.094			3.348		3.22	3.436
	Mullus surmuletus	3.51	3.192		3.492					3.342
Pomacentridae	*Chromis chromis*		2.703		2.895					3.058
Scorpaenidae	*Scorpaena maderensis**									2.980
	Scorpaena notata		3.023	2.748	3.25					2.876
	Scorpaena porcus		2.915	2.877	3.182					3.080
	Scorpaena scrofa		3.005						2.96	3.135
Serranidae	*Serranus cabrilla*		2.997	3.061	2.935		2.626		3.03	2.908
	Serranus hepatus				3.258		2.801			2.903
	Serranus scriba		3.244		3.09				3.16	3.066
Sparidae	*Diplodus annularis*	3.142	3.315	3.019	3.192		2.82		3.05	3.103
	Diplodus puntazzo		2.662							3.564
	*Diplodus sargus sargus**									3.121
	Diplodus vulgaris		2.431	3.137	3.125				2.92	3.134
	Lithognathus mormyrus	3.196							2.86	2.907
	Pagellus acarne				3.051				3.03	3.594
	Pagellus bogaraveo			3.198	3.167				2.78	3.034
	Pagellus erythrinus		3.012	3.058	2.966		2.659		2.84	3.218
	Sarpa salpa	3.195	3.134		2.74				3.02	3.074
	Spondyliosoma cantharus		2.87	3.175	2.86				3.26	3.176
Syngnathidae	*Nerophis ophidion**									3.124
	Syngnathus abaster	3.156								3.359
	Syngnathus acus	3.729								3.592
	*Syngnathus typhle**									2.985
Trachinidae	*Trachinus draco*		2.578		3.062					2.847
Uranoscopidae	*Uranoscopus scaber*		2.998	3.248	3.091					3.084

*First time reported in the northern Aegean Sea.

communication with the shallow waters (Olson et al., 2007). In this regard, the biological characteristics of the species in the northern Aegean Sea should be identified and monitored.

In conclusion, the results of the present study contribute useful information for coastal zone management.

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