

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

Aytaç ALTIN^{1*}, Hakan AYYILDIZ¹, Semih KALE², Cenk ALVER³

¹Department of Fisheries Technology, Gökçeada School of Applied Sciences, Çanakkale Onsekiz Mart University, Gökçeada, Çanakkale, Turkey

²Department of Fisheries Engineering, Faculty of Marine Science and Technology, Çanakkale Onsekiz Mart University, Terzioğlu Kampüsü, Çanakkale, Turkey

³Department of Fishing and Processing Technology, Institute of Natural Sciences, Çanakkale Onsekiz Mart University, Turkey

Received: 11.12.2014

Accepted/Published Online: 04.05.2015

Printed: 30.09.2015

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:

$\log(W) = \log(a) + b(\times) \log(L)$, 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,

* Correspondence: aytacaltin@gmail.com

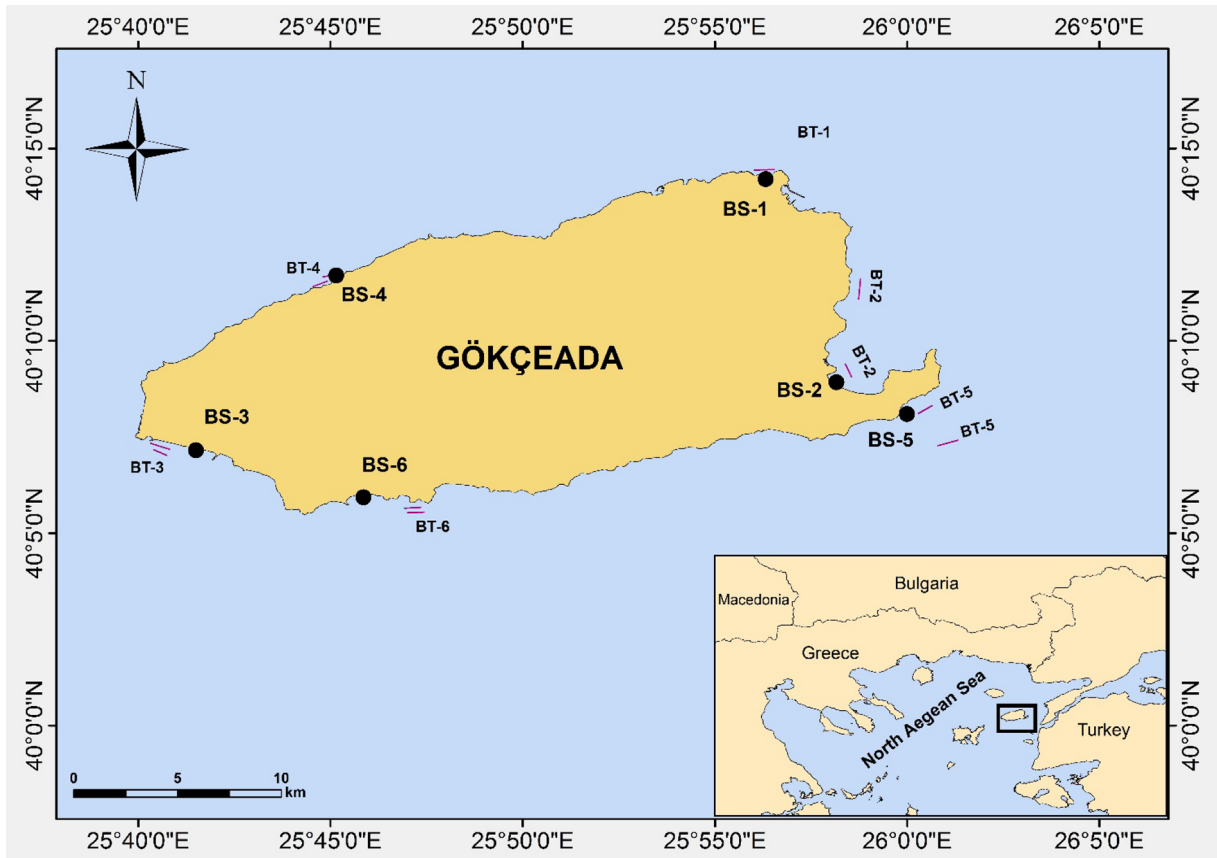


Figure. Sampling stations (BS: beach seine, BT: beam trawl).

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% CI of a	b	95% CI of b	r ²				
Atherinidae	<i>Atherina boyeri</i>	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	<i>Belone belone</i>	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	<i>Arnoglossus kessleri</i> *	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+
	<i>Arnoglossus laterna</i>	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
	<i>Arnoglossus thori</i>	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
	<i>Bothus podas</i>	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	<i>Trachinotus ovatus</i>	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	<i>Spicara maena</i>	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–
	<i>Spicara smaris</i>	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	<i>Sardina pilchardus</i>	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
	<i>Sprattus sprattus</i>	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	<i>Engraulis encrasicolus</i>	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	<i>Gobius geniporus</i> *	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+
	<i>Pomatoschistus marmoratus</i>	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	<i>Coris julis</i>	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+
	<i>Symphodus cinereus</i>	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+
	<i>Symphodus mediterraneus</i>	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).

	<i>Symphodus melanocercus</i>	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+
	<i>Symphodus ocellatus*</i>	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+
	<i>Symphodus rostratus*</i>	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+
	<i>Symphodus tinca</i>	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	<i>Chelon labrosus</i>	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-
	<i>Liza aurata</i>	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	<i>Mullus barbatus barbatus</i>	61	4.7	24	0.34	100	0.004	0.002	0.005	3.436	3.215	3.657	0.943	0.000	A+
	<i>Mullus surmuletus</i>	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	<i>Chromis chromis</i>	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	<i>Scorpaena maderensis*</i>	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
	<i>Scorpaena notata</i>	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
	<i>Scorpaena porcus</i>	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
	<i>Scorpaena scrofa</i>	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	<i>Serranus cabrilla</i>	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-
	<i>Serranus hepatus</i>	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-
	<i>Serranus scriba</i>	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	<i>Diplodus annularis</i>	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+
	<i>Diplodus puntazzo</i>	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+
	<i>Diplodus sargus sargus</i>	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+
	<i>Diplodus vulgaris</i>	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+
	<i>Lithognathus mormyrus</i>	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-
	<i>Pagellus acarne</i>	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+
	<i>Pagellus bogaraveo</i>	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
	<i>Pagellus erythrinus</i>	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+
	<i>Sarpa salpa</i>	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
	<i>Spondyliosoma cantharus</i>	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	<i>Nerophis ophidion</i>	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
	<i>Syngnathus abaster</i>	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
	<i>Syngnathus acus</i>	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+
	<i>Syngnathus typhle</i>	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	<i>Trachinus draco</i>	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	<i>Uranoscopus scaber</i>	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							Present study	
		Koutrakis 2003	Karakulak, 2006	İsmen, 2007	Karachle, 2008	Ozen, 2008	Çakır, 2008	Özekinci, 2009		Cengiz, 2013
Atherinidae	<i>Atherina boyeri</i>	3.023								3.398
Belonidae	<i>Belone belone</i>	3.04			2.972				3.19	3.280
Bothidae	<i>Arnoglossus kessleri</i>					3.15	3.124			3.292
	<i>Arnoglossus laterna</i>		2.747	3.006			3.242	3.183		3.238
	<i>Arnoglossus thori</i>		3.123				2.945	3.564		3.149
	<i>Bothus podas</i>				3.034					3.367
Carangidae	<i>Trachinotus ovatus*</i>									2.660
Centracanthidae	<i>Spicara maena</i>		3.505	3.01	3.18					2.817
	<i>Spicara smaris</i>		2.877	2.917	2.991		2.855		3.01	3.142
Clupeidae	<i>Sardina pilchardus</i>	3.46			3.144		2.76		3.12	2.949
	<i>Sprattus sprattus*</i>									3.351
Engraulidae	<i>Engraulis encrasicolus</i>	2.728		2.972	3.822		2.77			3.229
Gobiidae	<i>Gobius geniporus</i>					3.21				3.255
	<i>Pomatoschistus marmoratus</i>	3.308								3.168
Labridae	<i>Coris julis</i>		3.054	3.157	3.036				3.18	3.215
	<i>Symphodus cinereus*</i>									3.180
	<i>Symphodus mediterraneus</i>		2.902		2.14					3.157
	<i>Symphodus melanocercus*</i>									3.181
	<i>Symphodus ocellatus*</i>									3.229
	<i>Symphodus rostratus</i>		2.836							3.193
Mugilidae	<i>Symphodus tinca</i>		3.046		2.799					3.269
	<i>Chelon labrosus</i>	2.948								2.862
	<i>Liza aurata</i>	2.993								2.770
Mullidae	<i>Mullus barbatus barbatus</i>		3.273	3.094			3.348		3.22	3.436
	<i>Mullus surmuletus</i>	3.51	3.192		3.492					3.342
Pomacentridae	<i>Chromis chromis</i>		2.703		2.895					3.058
Scorpaenidae	<i>Scorpaena maderensis*</i>									2.980
	<i>Scorpaena notata</i>		3.023	2.748	3.25					2.876
	<i>Scorpaena porcus</i>		2.915	2.877	3.182					3.080
	<i>Scorpaena scrofa</i>		3.005					2.96		3.135
Serranidae	<i>Serranus cabrilla</i>		2.997	3.061	2.935		2.626		3.03	2.908
	<i>Serranus hepatus</i>				3.258		2.801			2.903
	<i>Serranus scriba</i>		3.244		3.09				3.16	3.066
Sparidae	<i>Diplodus annularis</i>	3.142	3.315	3.019	3.192		2.82		3.05	3.103
	<i>Diplodus puntazzo</i>		2.662							3.564
	<i>Diplodus sargus sargus*</i>									3.121
	<i>Diplodus vulgaris</i>		2.431	3.137	3.125				2.92	3.134
	<i>Lithognathus mormyrus</i>	3.196							2.86	2.907
	<i>Pagellus acarne</i>				3.051				3.03	3.594
	<i>Pagellus bogaraveo</i>			3.198	3.167				2.78	3.034
	<i>Pagellus erythrinus</i>		3.012	3.058	2.966		2.659		2.84	3.218
<i>Sarpa salpa</i>	3.195	3.134		2.74				3.02	3.074	
<i>Spondyliosoma cantharus</i>		2.87	3.175	2.86				3.26	3.176	
Syngnathidae	<i>Nerophis ophidion*</i>									3.124
	<i>Syngnathus abaster</i>	3.156								3.359
	<i>Syngnathus acus</i>	3.729								3.592
	<i>Syngnathus typhle*</i>									2.985
Trachinidae	<i>Trachinus draco</i>		2.578		3.062					2.847
Uranoscopidae	<i>Uranoscopus scaber</i>		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.

References

- Çakır DT, Koç HT, Başusta A, Başusta N (2008). Length–weight relationships of 24 fish species from Edremit Bay, Aegean Sea. *e-Journal of New World Sciences Academy* 3: 47–51.
- Cengiz O (2013). Length–weight relationships of 22 fish species from the Gallipoli Peninsula and Dardanelles (northeastern Mediterranean, Turkey). *Turk J Zool* 37: 419–422.
- Froese R (2006). Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. *J Appl Ichthyol* 22: 241–253.
- Froese R, Pauly D (2014) FishBase. World Wide Web electronic publication. Available at: <http://www.fishbase.org> (accessed on 11 December 2014).
- Ismen A, Ozen O, Altinagac U, Ozekinci U, Ayaz A (2007). Weight–length relationships of 63 fish species in Saros Bay, Turkey. *J Appl Ichthyol* 23: 707–708.
- Ismen A, Yigin CC, Altinagac U, Ayaz A (2009). Length–weight relationships for ten shark species from Saros Bay (North Aegean Sea). *J Appl Ichthyol* 25: 109–112.
- Karachle PK, Stergiou KI (2008). Length–length and length–weight relationships of several fish species from the North Aegean Sea (Greece). *J Biol Res-Thessalon* 10: 149–157.
- Karakulak FS, Erk H, Bilgin B (2006). Length–weight relationships for 47 coastal fish species from the northern Aegean Sea, Turkey. *J Appl Ichthyol* 22: 274–278.
- Koutrakis ET, Tsikliras AC (2003). Length–weight relationships of fishes from three northern Aegean estuarine systems (Greece). *J Appl Ichthyol* 19: 258–260.
- Metaxas DA (1973). Air–sea interaction in the Greek seas and resultant Etesian characteristics. Tech Rep 5, University of Ioannina, pp. 1–32.
- Acknowledgments**
This study was funded by the Scientific and Technological Research Council of Turkey (TÜBİTAK, project number: 112Y062). We are especially indebted to İ. Burak Daban, Fatih Eker, and Ata Aksu for their help in the laboratory.
- Olson DB, Kourafalou VH, Johns WE, Samuels G, Veneziani M (2007). Aegean surface circulation from a satellite-tracked drifter array. *J Phys Oceanogr* 37: 1898–1917.
- Ozekinci U, Cengiz O, Ismen A, Altinagac U, Ayaz A (2009). Length–weight relationships of thirteen flatfishes (Pisces: Pleuronectiformes) from Saroz Bay (North Aegean Sea, Turkey). *J Anim Vet Adv* 8: 1800–1801.
- Ozen O, Ayyildiz H, Oztekin A, Altin A (2009). Length–weight relationships of 17 less-studied fish species from Canakkale, Marmara region of Turkey. *J Appl Ichthyol* 25: 238–239.
- Petrakis G, Stergiou KI (1995). Weight–length relationships for 33 fish species in Greek waters. *Fish Res* 21: 465–469.
- Tesch FW (1968). Age and growth. In: Ricker, WE, editor. *Methods for Assessment of Fish Production in Fresh Waters*. Oxford, UK: Blackwell Scientific Publications, pp. 93–123.
- Whitehead P, Bauchot M, Hureau J, Nielsen J, Tortonese E (1986). *Fishes of the North-eastern Atlantic and the Mediterranean*. Volumes I, II, and III. Paris, France: UNESCO.
- Yigin CC, Ismen A (2009). Length–weight relationships for seven rays from Saros Bay (North Aegean Sea). *J Appl Ichthyol* 25: 106–108.
- Zar JH (1999). *Biostatistical Analysis*. 4th ed. Upper Saddle River, NJ, USA: Prentice Hall.
- Zodiatis G, Balopoulos E (1993). Structure and characteristics of fronts in the North Aegean Sea. *Boll Oceanol Teor Applic* 11: 113–124.