LENGTH-WEIGHT RELATIONSHIPS OF FISHES IN SHALLOW WATERS OF ERDEK BAY (SEA OF MARMARA, TURKEY)

Çetin Keskin[1]*, Özcan Gaygusuz[2]

[1] *Istanbul University, Faculty of Fisheries, Department of Marine Biology, Ordu St. No:200, 34470 Laleli/Istanbul-Turkey.*

[2] *Istanbul University, Faculty of Fisheries, Department of Freshwater Biology, Ordu St. No:200, 34470 Laleli/Istanbul-Turkey.*

Abstract

The study was carried out monthly between April 2000 and December 2001 on the seagrass and/or sandy bottom in shallow waters of Erdek Bay (Sea of Marmara, Turkey). Samples were collected using 35 m long beach seine. Fish samples were identified, measured and weighed. The length-weight relationships of juvenile and adult specimens of 36 fish species were investigated. The parameters *a* and *b* were calculated by functional regression, as was the coefficient of determination (r^2). r^2 values were higher than 0.950 for 27 species in the list, while only one species was lower than 0.80. The exponent *b* ranged from 2.282 to 3.741.

Key words: Fish growth, allometry, shallow water, Sea of Marmara
*Corresponding author: Çetin Keskin (e-mail: seahorse@istanbul.edu.tr)
(Received: 21.01.2010 Accepted: 27.03.2010)

Erdek Körfezi (Marmara Denizi, Türkiye) sığ sularındaki balıkların boy-ağırlık ilişkileri

Özet

Bu çalışma Nisan 2000 ve Aralık 2001 tarihleri arasında aylık olarak Erdek Körfezi (Marmara Denizi, Türkiye)'nin deniz çayırları ve kumluk zeminlerinde gerçekleştirildi. Örnekler 35 m uzunluğunda kıyı ığrıbıyla toplandı. Balıkların tür teşhisleri, boy ve ağırlık ölçümleri yapıldı. 36 balık türüne ait jüvenil ve ergin bireylerin boy-ağırlık ilişkisi araştırıldı. *a* ve *b* değişkenleri r^2 regresyon katsayısının fonksiyonu olarak hesaplandı. 27 türde r^2 değeri 0.950'den yüksek iken sadece tek türde 0.80'den düşük değerde bulundu. *b* değeri 2.282 ile 3.741 arasında değişim gösterdi.

Anahtar Kelimeler: Balık büyümesi, allometri, sığ sular, Marmara Denizi

Introduction

The relation between length and weight of fishes can be used to estimate growth rates, to compare life histories of fish species between regions, to assess the condition of fish, to determine biomass from underwater length observation (visual census), and to assess possible differences between separate unit stocks of the same species (Petrakis and Stergiou, 1995; Binohlan and Pauly, 2000; King 2007).

The relationship between the length (*L*) and weight (*W*) of a fish is usually expressed by the equation $W = aL^b$. Values of the exponent *b* provide information on fish growth. When $b = 3$, increase in weight is isometric. When the value of *b* is other than 3, weight increase is

allometric (positive if $b > 3$, negative if $b < 3$) (Morey et al. 2003).

Although there are some studies on length-weight relationships in the Black Sea (Kalaycı et al., 2007), the Aegean Sea (Gurkan and Taşkavak, 2007; İşmen et al. 2007; Uçkun İlhan et al. 2008) and the eastern Mediterranean Sea (Çiçek et al. 2006) along the Turkish coast few studies on LWR of fish species in the Sea of Marmara (Tarkan et al. 2006; Ozen et al., 2009) have been conducted. Erdek Bay in the Sea of Marmara is an important area for fisheries, and used as reproduction or nursery area by commercial fish species (Arım 1957; Okuş et al. 1997; Keskin 2007). In this study, the length-weight relationships were determined for 36 fish species, caught from shallow waters of the Erdek Bay. Collected fish species in the study area includes common shallow water species and juveniles.

Materials and Methods

Erdek Bay is located in the south-western Sea of Marmara (27°20'- 27°52' E and 40°18'-40°28' N), the length of the coastline is 130 km, and maximum depth is 55 m. The Gönen Stream is the only freshwater inflow to the bay and, as in the Sea of Marmara, a two water layers system is present (Figure 1).

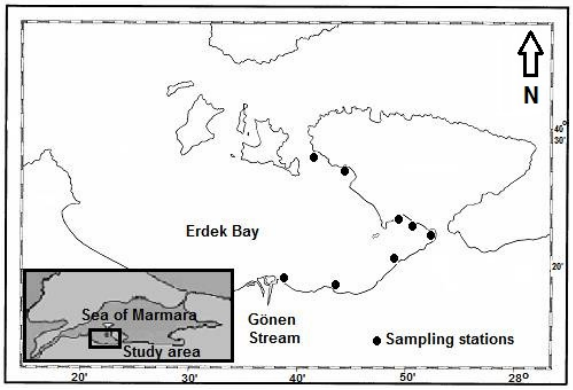

Figure 1: Map of sampling stations in Erdek Bay (Sea of Marmara, Turkey).

The study was carried out monthly between April 2000 and December 2001 in shallow waters of Erdek Bay. Samplings were made at 1 to 2 m depth; bottom type is characterized by seagrass (*Zostera marina* Linnaeus, 1758 and *Cymodocea nodosa* (Ucria) Ascherson, 1869) or sand. Samples were collected with a 35 m long beach seine. Net depth at the beginning of wings was 40 cm and 250 cm at the central part together with the sac. The mesh size was 6 mm at the outer wing and 4 mm at the central sac. Fish samples were preserved frozen after fishing operations. In the laboratory, all species were identified, measured (total length, *TL*) to the nearest 1 mm and weighed (total weight, *W*) to the nearest 0.01 g.

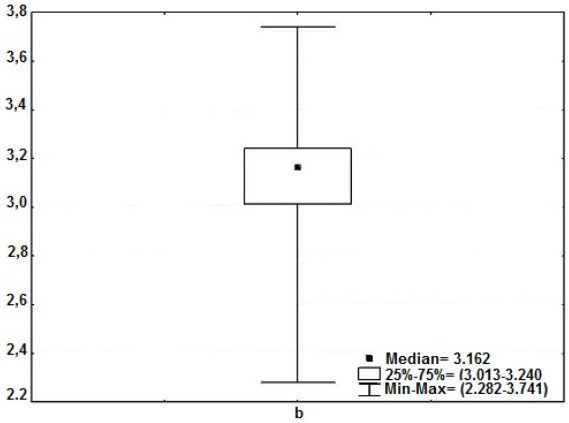

Figure 2: Box-Whisker plots of *b* of the length weight relationships for the 36 species of Erdek Bay (Sea of Marmara, Turkey).

The relationship between length and weight were calculated using the equation $W=aL^b$, in which *W* is total weight (g), *L* is TL (mm). The parameters *a* and *b* were calculated by functional regression, as was the coefficient of determination (r^2). The *b* value for each species was tested by *t*-test at the 0.05 significance level to verify that it was significantly different from the isometric growth ($b= 3$).

Results

A total of 3356 specimens belonging to 36 species (19 families) were analyzed during the study. Labridae, Atherinidae, and Mugilidae were the most abundant families. The sample size, the minimum and maximum length, the

parameters *a* and *b* of length weight relationship, the standard error (±SE) of *b* and coefficient of determination r^2 are given in Table 1 for each species. The sample size ranged from 5 specimens for *Serranus hepatus* and *Solea nasuta* to 606 for *Atherina boyeri*. The length (*TL*) ranged from 18 mm for *Symphodus ocellatus* to 378 mm for *Syngnathus acus*. r^2 values ranged from 0.795 for *Sprattus sprattus* to 0.999 for *S. hepatus*. Twenty-seven of the 36 species showed r^2 values greater than 0.950 while only one of them presented r^2<0.80 (*S. sprattus*). The exponent *b* ranged from 2.282 for *Belone belone* to 3.741 for *Sardina pilchardus*. *b* values were lower than 2.5 for one species (*B. belone*), while higher than 3.5 for two species (*S. pilchardus* and *S. sprattus*). The median value of *b* was 3.162; 50% of the *b* values ranged between 3.013 and 3.240 (Figure 1). The mean value of *b* was 3.126 (± 0.044). The type of growth was determined by the *t-test*: *B. belone, Callionymus risso* and *Nerophis ophidion* showed negative allometric growth (b<3; *t-test*, p<0.05). *A. boyeri, A. hepsetus, Arnoglossus kessleri, Gymnammodytes cicerellus, Pomatoschistus bathi, S. pilchardus, Sardinella aurita, S. sprattus, Syngnathus abaster* and *Syngnathus thyple* showed positive allometric growth (b>3; *t-test*, p<0.05). All remaining species showed isometric growth (b~3; *t-test*, p>0.05) (Table 1).

Table 1: Length-weight relationships for 36 fish species caught in Erdek Bay (Sea of Marmara, Turkey). n: number of specimens; min and max, minimal and maximal total length (mm); *a* and *b*, relationship parameters; SE(*b*): standard error of *b*; r^2: coefficient of determination; P: P-value for *t-test* comparing differences for isometric growth (*b*=3); G: growth type (I: Isometric, A+: Positive allometric, A-: Negative allometric).

Family	Species	n	Min	Max	*a*	*b*	SE(*b*)	r^2	P	G
Ammodytidae	***Gymnammodytes cicerellus (Rafinesque, 1810)***	13	66	97	0.0012	3.307	0.327	0.848	<0.05	A+
Atherinidae	*Atherina boyeri* Risso, 1810	606	25	112	0.0045	3.215	0.042	0.974	<0.05	A+
	Atherina hepsetus Linnaeus, 1758	65	27	148	0.0037	3.236	0.119	0.979	<0.05	A+
Belonidae	*Belone belone* (Linnaeus, 1761)	10	34	120	0.0034	2.282	0.416	0.949	<0.05	A-
Blennidae	*Parablennius sanguinolentus* (Pallas, 1814)	10	31	147	0,0082	3,165	0,228	0,992	>0.05	I
	Parablennius tentacularis (Brünnich, 1768)	64	35	100	0.0072	3.125	0.143	0.973	>0.05	I
Bothidae	*Arnoglossus kessleri* Schmidt, 1915	24	42	87	0.0041	3.474	0.283	0.968	<0.05	A+
	Arnoglossus laterna Walbaum, 1792	7	52	123	0.0207	2.670	0.448	0.976	>0.05	I
Callionymidae	*Callionymus risso* Lesueur, 1814	13	32	70	0.0137	2.705	0.460	0.938	<0.05	A-
Clupeidae	*Sardina pilchardus* Walbaum, 1792	38	47	67	0.0015	3.741	0.523	0.855	<0.05	A+
	Sardinella aurita Valenciennes, 1847	24	46	68	0.0031	3.439	0.754	0.805	<0.05	A+
	Sprattus sprattus (Linnaeus, 1758)	52	38	55	0.0023	3.528	0.510	0.795	<0.05	A+
Gadidae	*Gaidropsarus mediterraneus* (Linnaeus, 1758)	8	42	207	0,0068	3,010	0,292	0,997	>0.05	I
Gobiidae	***Pomatoschistus bathi* Miller, 1982**	19	28	63	0.0052	3.245	0.103	0.980	<0.05	A+
Labridae	*Symphodus cinereus* (Bonnaterre, 1788)	173	23	113	0.0093	3.179	0.048	0.990	>0.05	I
	Symphodus ocellatus (Forsskål 1775)	575	18	107	0.0102	3.080	0.039	0.977	>0.05	I
	Symphodus roissali (Risso, 1810)	22	24	141	0.0069	3.386	0.179	0.987	>0.05	I
	Symphodus tinca (Linnaeus, 1758)	41	21	155	0.0111	3.098	0.093	0.992	>0.05	I
Mugilidae	*Chelon labrosus* (Risso, 1827)	6	36	153	0.0071	3.183	0.254	0.997	>0.05	I
	Liza aurata (Risso, 1810)	446	23	174	0.0088	3.017	0.055	0.964	>0.05	I
	Liza saliens (Risso, 1810)	57	23	186	0.0092	3.008	0.093	0.987	>0.05	I
	Oedalechilus labeo (Cuvier, 1829)	41	25	132	0.0115	2.833	0.151	0.974	>0.05	I

Mullidae	*Mullus surmuletus* Linnaeus, 1758	17	47	94	0.0045	3.385	0.153	0.993	>0.05	I
Sciaenidae	*Sciaena umbra* Linnaeus, 1758	12	29	120	0.0069	3.159	0.338	0.977	>0.05	I
Scorpaenidae	*Scorpaena porcus* Linnaeus, 1758	45	49	190	0.0158	3.088	0.289	0.983	>0.05	I
Serranidae	*Serranus hepatus* (Linnaeus, 1758)	5	20	68	0.0153	2.998	0.209	0.999	>0.05	I
Soleidae	*Solea nasuta* (Pallas, 1814)	5	57	176	0,0050	3,225	0,357	0,996	>0.05	I
Sparidae	*Diplodus annularis* (Linnaeus, 1758)	7	36	169	0.0134	3.1104	0.238	0.996	>0.05	I
	Diplodus puntazzo (Cetti, 1777)	18	26	76	0.0114	3.165	0.126	0.994	>0.05	I
	Diplodus sargus (Linnaeus, 1758)	10	26	85	0.0084	3.314	0.665	0.943	>0.05	I
	Lithognathus mormyrus (Linnaeus, 1758)	41	21	126	0.0097	3.095	0.098	0.991	>0.05	I
Syngnathidae	*Syngnathus abaster* Risso, 1827	298	45	151	0.0002	3.181	0.120	0.901	<0.05	A+
	Syngnathus acus Linnaeus, 1758	15	103	378	0.0004	3.069	0.358	0.964	>0.05	I
	Syngnathus typhle Linnaeus, 1758	375	62	316	0.0002	3.196	0.062	0.965	<0.05	A+
	Nerophis ophidion (Linnaeus, 1758)	177	97	212	0.0002	2.749	0.190	0.821	<0.05	A-
Triglidae	*Chelidonichthys lucernus* (Linnaeus, 1758)	17	63	151	0.0113	2.898	0.237	0.978	>0.05	I

Table 2 : Number of specimens (n), total length range (TL range) and b values for those species between this study and the other studies from the Sea of Marmara, the Black Sea and the Aegean Sea. List of species was given by alphabetic order.

	In this study			Sea of Marmara			Black Sea			Aegean Sea		
Species	n	TL range	*b*	n	TL range	*b*	n	TL range	*b*	n	TL range	*b*
A. boyeri	606	25-112	3.215	15	39-111	3.31 [(2)]						
A. kessleri	24	42-87	3.474	44	29-98	3.15 [(7)]						
A. laterna	7	52-123	2.670							1805	55-242	3.0062 [(5)]
C. risso	13	32-70	2.705	42	24-64	2.71 [(7)]						
C. lucernus	17	63-151	2.898	224	123-415	3.019 [(1)]				829	125-760	2.9287 [(5)]
D. annularis	7	36-169	3.1104							108	88-156	3.0192 [(5)]
N. ophidion	177	97-212	2.749							86	78-214	2.42 [(4)]
S. pilchardus	38	47-67	3.741	11	90-153	3.54 [(2)]						
S. porcus	45	49-190	3.088				136	85-292	3.0337 [(3)]	10	100-220	2.8776 [(5)]
S. sprattus	52	35-55	3.528				5087	56-126	2,8676 [(3)]			
S. cinereus	173	23-113	3.179							92	45-101	3.031 [(6)]
S. ocellatus	575	18-107	3.080							328	47-92	3.187 [(6)]
S. tinca	41	21-155	3.098							277	67-243	2.907 [(6)]
S. acus	15	103-378	3.069							570	33-256	3.54 [(4)]
S. typhle	375	62-316	3.196							125	40-258	3.00 [(4)]

[(1)]Eryılmaz and Meriç, 2005 ; [(2)]Tarkan et al., 2006 ; [(3)]Kalaycı et al., 2007 ; [(4)]Gurkan and Taşkavak, 2007 ; [(5)]Ismen et al., 2007 ; [(6)](Uçkun) İlhan et al., 2008 ; [(7)]Ozen et al., 2009.

Discussion

According to Tesch (1971), the values *b* varies between 2 to 4, and mostly remained within the expected range of 2.5-3.5. The extreme values of *b* (i.e. *S. pilchardus*) in this study are possibly caused by the narrow sample size or length range. Parameters of length weight relationships are affected by several factors such as season, habitat, gonad maturity, sex, diet and stomach fullness, health and preservation techniques (Bagenal and Tesch 1978). All of these effects were not considered in the present study. Our results can be considered as mean annual values for the species since the fish samples were collected during different seasons throughout the sampling period, and the data do not represent a particular season or time of the year.

The comparison of *b* values obtained by the Sea of Marmara, the Black Sea and the North Aegean Sea were shown in Table 2. The regional differences of obtained *b* values may present spatial variations resulting from the influence of water quality or food availability on fish growth (Sparre et al., 1989; Mommsen, 1998). Observed differences in our comparisons can be due to the different sampling method, since the number of specimens and length ranges of the species came from distinct regions.

Our results show that nineteen of the 36 species have commercial importance. The rests of them are major contributors to the fish community in the study area, and may play a significant role in trophodynamic processes. In the present study; Length weight relationships were available for both commercial and noncommercial species in particular those living on seagrass or sand habitats in shallow waters of Erdek Bay. Reported parameters of length - weight relationships in the present study should be used taking into consideration that most of the specimens were juvenile. For this reason, the use of the relationships should be limited to the size range used to estimate the parameters (Bagenal and Tesch 1978; Petrakis and Stergiou 1995). Length - weight relationship information of *G. cicerellus* and *P. bathi* in the listed species in the Table 1 were not available in FishBase (Froese and Pauly, 2009).

References

Arım, N. (1957) Marmara ve Karadeniz'de bazı kemikli balıkların (Teleost'ların) Yumurta ve Larvalarının Morfolojileri ve ekolojileri. *Hidrobiyoloji Mec.,* (A) 4(1-2): 7-56. (in Turkish)

Bagenal, T.B. and Tesch, F.W. (1978) *Age and growth. In Methods for assessment of fish production in fresh water.* IBP handbook 3. T. Bagenal (Ed.) Blackwell Scientific Publications. Oxford. UK. pp. 101-136.

Binohlan, C. and Pauly, D. (2000) *The length-weight table. In Fishbase 2000: Concepts, design and data sources.* R. Froese and D. Pauly (Eds). ICLARM, Manila, Philippines, pp. 131–134.

Çiçek, E., Avşar, D., Yeldan, H., Özütok, M. (2006) Length–weight relationships for 31 teleost fishes caught by bottom trawl net in the Babadillimani Bight (northeastern Mediterranean). *J. Appl. Ichthyol.* 22: 290–292.

Eryılmaz, L., Meriç, N. (2005) Some Biological Characteristics of the Tub Gurnard, *Chelidonichthys lucernus* (Linnaeus, 1758) in the Sea of Marmara. *Turk. J. Vet. Anim. Sci.* 29:367-374.

Froese, R. and D., Pauly. (Eds). (2009) FishBase.World Wide Web electronic publication. www.fishbase.org, version (10/2009).

Gurkan, Ş., Taşkavak, E. (2007) Length-Weight Relationsips for Syngnathid Fishes of the Aegean Sea, Turkey. *Belg. J. Zool*. 137 (2):219-222.

İşmen, A., Özen, Ö., Altınağaç, U., Özekinci, U., Ayaz, A. (2007) Weight–length relationships of 63 fish species in Saros Bay, Turkey. *J. Appl. Ichthyol.,* 23: 707-708.

Kalaycı, F., Samsun, N., Bilgin, S., Samsun, O. (2007) Length-Weight Relationship of 10 fish Species Caught by Bottom Trawl and Midwater Trawl from the Middle Black Sea,

Turkey. *Turkish Journal of Fisheries and Aquatic Sciences.* 7:33-36.

Keskin, C., (2007) Temporal variation of fish assemblages in different shallow-water habitats in Erdek Bay, Marmara Sea, Turkey. *J. Black Sea/Mediterr. Environ.* 13, 215-234.

King, M.G., (2007) *Fisheries biology, assessment, and management.* Second edition published by Blackwell Publishing Ltd., ISBN. 978-1-4051-5831-2, pp. 189–194.

Mommsen, T.P. (1998) Growth and Metabolism. In: Eans, D.H. (Ed.), The Physiology of Fishes. CRC Press, New York, pp. 65-97.

Morey, G., Moranta, J., Massutì, E., Grau, A., Linde, M., Riera, F., Morales-Nin, B. (2003) Weight–length relationships of littoral to lower slope fishes from the western Mediterranean. *Fish. Res.* 62: 89–96.

Okuş, E., Yüksek, A., Uysal, A., Orhon, V. (1997) *Marmara Denizi'nde bazı demersal balıkların stok tayini projesi.* 1992-1995 Kesin Sonuç Raporu, TÜBİTAK-DEBAG-116/G. İ.Ü. Deniz Bilimleri İşletmeciliği Enstitüsü ve Tarım ve Köy İşleri Bakanlığı, pp. 327. (in Turkish)

Ozen, O., Ayyildiz, H., Oztekin, A., Altin, A. (2009) Length-Weight Relationships of 17 Less-Studied Fish Species from Çanakkale, Marmara Region of Turkey. *J. Appl. Ichthyol.* 25:238-239.

Petrakis, G., Stergiou, K.I. (1995) Weight–length relationships for 33 fish species in Greek waters. *Fish. Res.* 21, 465–469.

Sparre, P., Ursin, E., Venema, S.C. (1989) Introduction to tropicalfish stock assessment. Part 1. Manual. FAO Fisheries Technical Paper No:306.

Tarkan, A.S., Gaygusuz, Ö., Acıpınar, H., Gürsoy, Ç., Özuluğ, M. (2006) Length-weight relationship of fishes from the Marmara Region (NW-Turkey). *J. Appl. Ichthyol.* 22: 271-273.

Tesch, F.W. (1971) *Age and growth. In: Methods for assessment of fish production in fresh water.* W.E. Ricker (Ed.) Blackwell Scientific Publications. Oxford. UK. pp. 98-103.

Uçkun İlhan, D., Akalın, S., Tosunoğlu, Z., Özaydın, O. (2008) Length-Weight Relationships of Five *Symphodus* Species (Pisces:Perciformes) from İzmir Bay, Aegean Sea. *E.U. Journal of Fisheries & Aquatic Sciences*. 25 (3): 245-246.