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Length-Weight and Length-Length Relationships of The Bluefish *Pomatomus saltarix* (Linnaeus. 1766) Population in the South Marmara Sea of Turkey

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Abstract: A total of 1230 specimens of bluefish *Pomatomus saltatrix* (Linnaeus. 1766) were collected by purse seine fishing from January to December 2014 in South Marmara Sea of Turkey. Fish size in total length ranged from 12.3 cm (minimum) in January to 43.7 cm (maximum) in May. Mean of total length 20.57±0.17 cm and mean of weight 94.74±0.41 g was calculated as. The length-weight relationships were determined for males, females, unsexed and combined sexes as $W=0.102L^{2.9763}$, $W=0.0105L^{2.9638}$, $W=0.0152L^{2.8348}$, $W=0.0107L^{2.9574}$ respectively. All fishes have been found to be isometric (b=3) growth (t test. $p>0.05$). The results indicated further that the length-length relationships were highly correlated ($r^2>0.990$, $p<0.001$).

Keywords: Bluefish, Length-weight relationship, length-length relationship, South Marmara

Lüfer Balığı *Pomatomus saltatrix* (Linnaeus. 1766)'nın Güney Marmara Populasyonuna Ait Örneklerin Boy-Ağırlık ve Boy-Boy İlişkileri

Öz: Araştırma. 2014 yılında. Ocak-Aralık arasında yürütülmüş olup bu kapsamda toplam 1230 örnek incelenmiştir. Örnekleme gırgır balıkçılığından temin edilmiştir. İncelenen örneklerin ortalama 20.5±0.17 cm total boyunda. 94.6±0.41 g ağırlığında oldukları belirlenmiştir. Güney Marmara'da yürütülen çalışmada incelenen örneklerin izometrik (b=3) büyüme gösterdikleri tespit edilmiş olup (t testi; $p>0.05$), boy-ağırlık ilişkisi parametreleri dişiler için $W=0.0105L^{2.9638}$. erkekler için $W=0.102L^{2.9763}$. eşeyi belirlenememiş bireyler için $W=0.0105L^{2.9638}$ ve toplamda ise $W=0.0107L^{2.9574}$ olarak hesaplanmıştır. Ayrıca boy-boy ilişkisi değerlerinin birbirleriyle son derece ilişkili olduğu tespit edilmiştir ($r^2>0.990$, $p<0.001$)

Anahtar Kelimelerler: Lüfer Boy-Boy İlişkisi, Boy-Ağırlık İlişkisi, Güney Marmara Denizi

1. INTRODUCTION

The length-weight (LWR) and length-length (LLR) relationships have been applied for basic uses for assessment of fish stocks and populations (Ricker, 1968; Goncalves et al., 1996). The length-weight relationships also helps to figure out the condition reproduction history, life history and the general health of fishing species (Nikolsky, 1963; Wootton, 1992; Pauly. 1993; Erkoyuncu, 1995; Avşar, 1998) and is also useful in local and interregional morphological and life historical comparison in species and populations (Petrakis and Stergiou, 1995; Kara and Bayhan, 2008). Therefore, the length-length relations of species under various environmental conditions should be known. Although Sea of Marmara provides a significant proportion of the overall marine fish production in Turkey and is considered as one of the most important fishery grounds (Anonymous, 2009). There is little information on the continental ichthyofauna in the Sea of marina derivation (Keskin, 2007; Bilecenoğlu et al., 2000; Tuncer et al., 2008).

We describe the parameters of length–weight and length-length relationships of bluefish obtained from South Marmara Sea of Turkey. The results obtained from this study will be useful to fisheries biologist.

2. MATERIAL AND METHOD:

The samples were obtained monthly with purse seine fishing from January to December 2014 in South Marmara Sea of Turkey (Fig 1). Samples were brought with transport containers to the

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laboratory as soon as possible (within two hours). Fishes were measured for total length (TL), fork length (FL) and standard length (SL) to the nearest cm. Total weight (TW) was measured with a digital balance to an accuracy of 0.01 g. The estimation of the length-weight relationships (LWR) were calculated using the $W=a.L^b$ (Ricker, 1979). This can be expressed in linear form after logarithmic transformation by log W =log a +b log TL where "W" is total weight (g) and TL is total length (cm), "a" is intercept. and "b" is slope. The null hypotheses of isometric growth (H_0 b=3) were tested by the t-test (Sokal and Rholf. 1987). The degree of association between the variables was computed by the determination coefficient r^2.

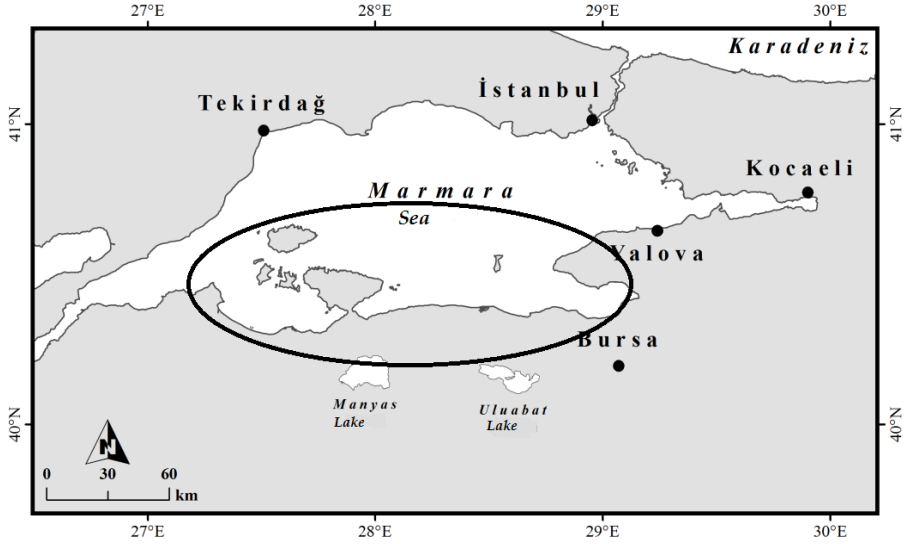

Figure 1. The Sea of Marmara and study area (South Marmara Sea).

3. RESULTS AND DISCUSSION:

In this study 1230 bluefish (*P. saltatrix*) examined. It was determined that 41% of the samples were females (n=503), 36% males (n=447), 23% unsexed (n=280). The shortest individual, 12.3 cm (TL) was obtained in January and the longest 47.3 cm (TL) in May.

Length-weight relationships for males, females, unsexed and the total sample populations were determined as $W=0.0102L^{2.9763}$, $W=0.0105L^{2.9638}$, $W=0.0152L^{2.8348}$, $W=0.0107L^{2.9574}$ respectively (Table 1). Monthly LWR of bluefish presented in Table 1 show that the calculated growth coefficients vary between 2.1619 (June) and 3.0513 (August) in males, between 2.1547 (February) and 3.1046 (October) in females, and between 2.239 (March) and 3.4637 (September) in unsexed. The parameters of the fish length-weight relationships are affected by a habitat, stomach fullness, gonad maturity, diet, sex (Tesch, 1971; Bagenal and Tesch, 1978; Hossain et al., 2006). The length-weight relationships parameter b typically varies between 2.0 and 3.5 (Froese and Pauly, 2010). In the present study, all growth coefficients (b) estimated were within the expected range 2.1-3.4 (Table 1). Blue fishes have been found to be isometric (b=3) growth (t test. $p>0.05$).

Overall length-length relationship were highly significant ($p<0.01$) and presented Table 2. Previous studies providing length-weight (LWR) and length-length (LLR) relationships for bluefish (*P. saltarix*) Turkish Seas and other localities are shown Table 3 for comparative purpose.

The value of b found in studies conducted on *P. saltatrix* in South Marmara Sea of Turkey indicated isometric of growth. However, in other parts of the Turkey and World Sea this species exhibit allometric growth values as well as those positively approaching isometry (Table 3). The researchers believe that the results obtained from this study will be useful to fisheries biologist.

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Table 1. Monthly descriptive statistics and estimated parameters of length-weight relationships for all sexes of *P. saltatrix* in Turkey Seas from January to December 2014 (M: male, F: female, H: hermaphrodite, A: all sexes, n: number of individuals, a: intercept, b: slope, r^2: coefficient of determination).

Months	Sex	N	Lmin-Lmax	L.Mean±SD	Wmin-Wmax	W.Mean±SD	a	b	r^2
January	M	14	12.3-19.5	17.42±3.23	21.4-69.3	49.46±18.50	0.0209	2.7079	0.9187
	F	15	16.2-31.0	20.70±1.5	36.29-266.26	84.18±55.9	0.014	2.8421	0.9583
	U	2	17.2-19.0	18.17±3.10	48.82-65.07	54.44±14.10			
	C	31	12.3-31.0	19.10±3.22	36.29-266.26	61.58±43.34	0.0168	2.7822	0.958
February	M	17	20.0-32.0	23.30±3.22	62.3-219.06	110.13±42.34	0.0272	2.6282	0.963
	F	8	20.0-37.0	24.90±3.57	73.36-243.84	130.8±51.96	0.12	2.1547	0.9348
	U	14	17.8-25.0	21.10±3.61	51.0-97.8	75.24±49.2	0.0124	2.8799	0.8097
	C	39	17.8-37.0	19.10±3.22	51.0-243.84	106.87±52.0	0.0116	2.4868	0.927
March	M	12	15.8-19.0	17.10±0.88	35.3-57.14	45.20±6.66	0.025	2.6377	0.9034
	F	10	15.4-19.4	17.32±4.05	33.07-63.18	43.34±7.90	0.0335	2.5309	0.9734
	U	19	15.5-23.0	18.13±4.12	31.95-73.54	50.34±10.53	0.0595	2.329	0.857
	C	41	15.4-23.0	17.63±1.48	31.95-73.54	48.10±10.24	0.0628	2.4571	0.772
April	M	13	32.0-28.0	24.13±2.46	98.76-187.04	126.55±34.33	0.0086	3.0084	0.9614
	F	12	22.0-33.0	24.54±2.36	99.08-230.48	132.77±32.46	0.1022	2.2325	0.9544
	U	7	21.0-25.4	23.12±1.15	83.9-140.54	111.16±15.40	0.0285	2.6298	0.9877
	C	32	21.0-33.0	24.10±2.43	83.9-230.48	125.51±33.85	0.0497	2.4571	0.9459
May	M	42	15.0-47.3	21.76±7.63	24.59-794.1	120.64±127.40	0.01	2.9429	0.9888
	F	39	15.0-36.7	25.20±4.63	26.75-495.96	164.98±108.57	0.0105	2.9257	0.9848
	U	15	15.2-31.6	22.50±6.92	24.45-277.96	119.08±91.29	0.0128	2.8542	0.9852
	C	96	15.0-47.3	23.28±7.63	24.59-794.1	138.41±127.40	0.0106	2.9214	0.987
June	M	15	21.1-29.0	24.10±2.54	102.86-216.13	140.18±43.90	0.1445	2.1619	0.9337
	F	23	21.6-29.9	25.01±2.43	106.64-263.5	163.23±41.8	0.0337	2.6282	0.964
	C	38	21.1-29.9	24.60±2.43	102.86-263.5	154.13±41.8	0.0471	2.5204	0.9498
	C	44	19.9-23.9	22.34±0.76	89.45-134.31	108.34±9.76	0.114	2.2158	0.7136

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August	M	19	22.3-32.3	26.10±2.90	109.27-339.19	186.86±66.14	0.0084	3.0513	0.9899
	F	20	24.3-32.0	26.86±2.82	140.6-322.66	200.22±64.85	0.0087	3.0423	0.9768
	C	39	22.3-32.3	26.60±2.87	109.27-339.19	194.75±65.52	0.0091	3.0277	0.9835
September	M	45	14.9-33.1	21.50±5.76	32.28-373.11	122.70±103.53	0.0104	2.9992	0.9902
	F	52	14.6-37.0	23.35±5.72	30.11-478.21	154.69±102.69	0.011	2.961	0.996
	U	11	13.0-19.7	17.41±5.74	18.99-79.83	57.69±106.48	0.0028	3.4637	0.9809
	C	108	13.0-37.0	21.98±5.71	18.99-471.21	131.48±102.44	0.011	2.976	0.9931
October	M	49	12.7-31.7	16.55±2.96	22.56-301.64	52.44±39.71	0.0108	2.9644	0.9866
	F	54	13.1-28.7	16.35±2.32	20.87-273.35	47.47±33.02	0.0074	3.1046	0.9755
	U	37	13.0-19.6	15.52±1.53	21.44-78.04	39.27±12.80	0.0098	3.0105	0.9476
	C	140	12.7-31.7	16.20±2.96	20.87-301.64	47.05±39.71	0.0098	3.0039	0.9768
November	M	15	14.0-20.0	17.25±2.25	27.25-80.58	53.91±18.52	0.0161	2.8344	0.9812
	F	11	14.0-22.0	17.80±2.70	28.7-107.91	61.23±24.63	0.0195	2.7702	0.964
	C	26	14.0-22.0	17.48±2.70	27.25-107-91	57.01±24.63	0.0176	2.8034	0.9721
December	M	41	17.9-22.3	19.73±1.46	56.06-105.94	75.27±17.03	0.0152	2.8494	0.9065
	F	77	17.4-23.6	20.07±1.46	53.33-127.28	79.31±16.97	0.014	2.8761	0.9416
	U	63	17.3-20.1	19.36±1.40	48.45-114.51	71.49±16.10	0.019	2.7729	0.9298
	C	181	17.3-23.6	19.74±1.46	48.45-127.28	75.67±17.0	0.0159	2.8343	0.934
Overall	M	447	12.3-47.3	20.60±4.75	20.19-794.1	99.30±3.91	0.0102	2.9763	0.9779
	F	503	13.1-37.0	21.10±4.51	20.87-652.17	103.12±3.74	0.0105	2.9638	0.9778
	U	280	13.0-31.6	18.70±2.97	18.99-277.96	66.31±4.38	0.0152	2.8348	0.9532
	C	1230	12.3-47.3	20.34±4.45	18.99-794.1	93.60±2.42	0.0107	2.9574	0.976

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Table 2. Length-length relationships between total length (TL), fork length (FL) and standard length (SL) of *P. saltatrix* in Marmara Sea from January to December 2014 (n: number of individuals, a: intercept, b: slope, r^2: coefficient of determination).

Sex	n	Equation	a	b	r^2
Male	447	TL=a+bFL	-0.406	1.13	0.986
		FL=a+bSL	1.250	1.03	0.973
		SL=a+bTL	-0.206	0.82	0.972
Female	503	TL=a+bFL	-0.299	1.12	0.990
		FL=a+bSL	1.610	1.01	0.961
		SL=a+bTL	-0.630	0.84	0.973
Unsexed	280	TL=a+bFL	-0.175	1.12	0.960
		FL=a+bSL	1.860	0.99	0.920
		SL=a+bTL	-0.218	0.82	0.940
Overall	1230	TL=a+bFL	-0.342	1.13	0.983
		FL=a+bSL	1.500	1.02	0.964
		SL=a+bTL	-0.438	0.83	0.970

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Table 3. Length-weight relationships of *P. saltatrix* from different localities.

Author (s)	Area	N	Sex	Length range (cm)	Length type	a	b	Growth type
Barger, 1990	South. Atlantic	-	Overall	-	TL	0.010	2.77	A^-
Erkoyuncu et al., 1994	Middle Black Sea	-	Overall	-	TL	0.038	2.56	A^-
Bernards and Rossi, 2000	South Coast of Brazil	92	Overall	24.0-48.0	TL	6.0E-06	3.05	I
Haimovici and Velesco, 2000	South Coast of Brazil	275	Overall	8.6-25.0	TL	6.79E-06	3.05	I
Morato et al., 2001	Atlantic	-	Overall	8.6-91.0	TL	0.091	3.01	I
Frota et al., 2004	Middle Coast of Brazil	67	Overall	48.0-75.5	-	0.059	2.50	A^-
Ceyhan, 2005	Aegean & Marmara Sea	2817	Overall	8.4-45.3	FL	0.006	3.22	-
Kalaycı et al., 2007	Middle Black Sea	76	Females	14.3-21.7	TL	0.011	2.92	I
		67	Males	13.2-21.7	TL	0.015	2.79	A^-
		143	Overall	13.2-21.7	TL	0.013	2.86	A^-
Özdemir et al., 2009	Middle Black Sea	820	Overall	9.2-23.4	TL	0.003	3.32	-
Ak et al., 2009	Eastern Black Sea	14	Overall	11.6-22.2	TL	0.003	3.33	A^+
Bok et al., 2011	North Marmara Sea	290	Overall	10.6-24.0	TL	0.032	2.52	A^-
Kasapoğlu and Düzgüneş, 2013	Black Sea	25	Overall	12.5-20.2	TL	0.009	3.00	-
This study	South Marmara	503	Females	13.1-37.0	TL	0.010	2.96	I
		447	Males	12.3-47.3	TL	0.010	2.97	I
		280	Unsexed	13.0-31.6	TL	0.015	2.83	I
		1230	Overall	12.3-47.3	TL	0.010	2.95	I

N: Sample size, a and b Parameters of length-weight relationships, I: Isometric, A^+ Positive allometric and A^- : Negative allometric

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