A preliminary study on the growth of the Common hake (*Merluccius merluccius* L., 1758) in İzmir Bay, Aegean Sea

Dilek Uçkun, Melahat Toğulga and Ertan Taşkavak

Ege University, Faculty of Fisheries, 35100 Bornova-İzmir, Turkey

The present work is aimed at determining the growth parameters of the common hake, Merluccius merluccius, that is one of the most important commercial fish species in İzmir Bay (Aegean Sea). A total of 336 hake specimens were caught seasonally by various trawl surveys carried out between April 1994 and March 1995. Total length and total weight of the specimens ranged from 13.6 to 43.5 cm and from 16.0 to 662.0 g, respectively. Maximum age group determined was VII, and ratio between females and males was 1: 0.36. The most specimen took part in age group IV. The computed von BERTALANFFY's growth equations in length and weight were $L_t=81.70$ $[1-e^{-0.0845(t+1.155)}]$ and $Wt=5773.29$ $(1-e^{-0.0845(t+1.155)})^{3.194}$, respectively, for both sexes combined.

Key words: Growth, common hake, *Merluccius merluccius*, İzmir Bay, Aegean Sea, Turkey

INTRODUCTION

Merluccius merluccius (L. 1758), the common hake, is a demersal species, and has a wide geographical distribution throughout the Atlantic Ocean and the Mediterranean (from shallow waters to 700 m in depth). The common hake is commercially one of the most important fish species in the fishery of İzmir Bay, which is one of the most productive environments in the Aegean Region. Of the 453.123 t of marine fish production in Turkey in 1993, it contributed 9.734 t (ANONYMOUS, 1993). Considering the quantity of catch in the vicinity of Hekim Island, the common hake is the second species after the common bream, *Diplodus annularis*.

The biology and population dynamics of the common hake were investigated by numerous researchers in the Mediterranean Sea (BAGENAL, 1954; ŽUPANOVIĆ, 1968; FROGLIA, 1973; JARDAS, 1976; TSIMENIDIS *et al.*, 1978; BRUNO *et al.*, 1979; ALDEBERT, 1981; FLAMIGNI, 1982; ANDALORO *et al.*, 1983; PINEIRO and HUNT, 1989; PAPACONSTANTINOU *et al.*, 1985, 1986, 1991; PAPACONSTANTINOU and CARAGITSOU, 1987, 1992; JUKIĆ and ARNERI, 1992; HERNANDEZ and JUKIĆ, 1992; BIAGI *et al.*, 1995; BOZZANO *et al.*, 1997; DEMESTRE and SANCHEZ, 1998) in various countries. Studies of the biology of the Turkish common hake population are quite scarce (KARA and KINACIGİL, 1990; ÜNSAL, in press). Additional papers of relevance are the records of its presence in Turkish seas as given by DEVEJIAN (1926), ERAZİ (1942), AKŞIRAY (1954), KUTAYGİL (1965), GELDIAY (1969), MATER *et al.* (1988) and KAYA (1991).

Here, we report on preliminary information of growth of the common hake in İzmir Bay.

MATERIAL AND METHODS

A total of 336 *M. merluccius* specimens was caught seasonally over a year between April 1994 and March 1995. The trawl surveys were carried out in day time at the sandy and muddy bottoms, with a speed of 2-3 nm h^{-1} for 60 minutes at a depth of 40-45 m around Hekim and Uzun islands in İzmir Bay (Fig. 1).

Measurements of specimens caught, such as total length and total weight, were taken in the research vessel and the laboratory. Specimens were measured to the nearest 1 mm (total length, *TL*) and weighted to the nearest 0.01 g (total weight, *W*), and their otoliths were removed immediately and stored dry in properly labeled envelopes.

Because of the hake's morphologic characteristics (i.e. small-sized scales and nonexisting spine), otoliths were used for age determination. Thick otoliths were made thin with wetted sandpaper, while small ones immediately became transparent in 70 % alcohol. Otoliths prepared in this way and then mounted on a black background were examined by three readers under reflected light with a stereo microscope. In statistical analyses, we utilized the pooled data due to inadequate number of the male specimens. Distribution functions for female and male were also tested with KOLMOGOROW-SMIRNOV Two-Sample Test.

Allometric growth equation, $W = aL^b$ was used to examine length-weight relations. Growth in length was expressed in terms of the von BERTALANFFY equation (SPARRE *et al.*, 1989). All statistical analyses and graphics were prepared with the programs of Quattro Pro for Windows and Microsoft Excel.
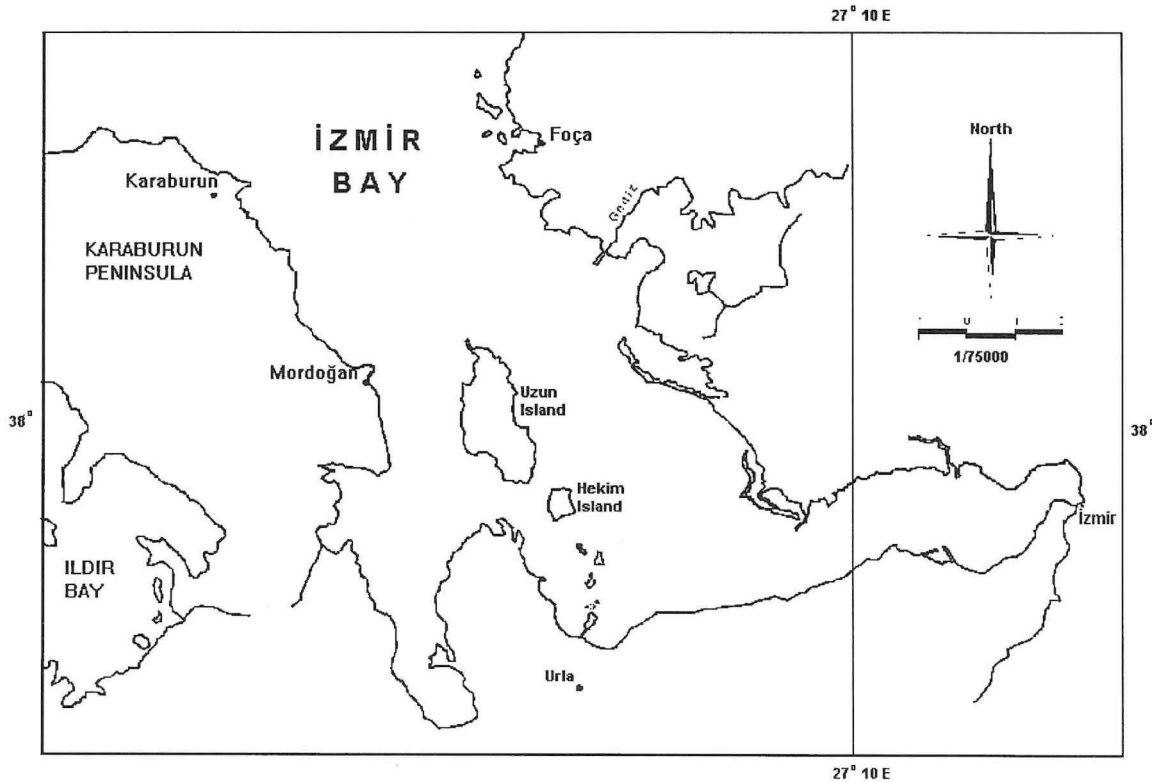

Fig. 1. Sampling areas

RESULTS

Length-Weight Frequency Distribution

Length and weight measurements of hakes include the distributions of total length and weight of all specimens caught. Total length of the hakes ranged from 13.6-43.5 cm (Fig. 2).

The most abundantly captured specimens for females and males ranged 26 to 32 cm (max-imum 26-27 cm) and 22 to 32 cm (maximum 28-29 cm) in length groups, respectively. The weight distribution of the specimens caught var-ied between 16 g and 662 g (Fig. 3) and the specimens of 220 g and 180 g were abundant for females and males, respectively.

In spite of inadequate number of the male specimens, KOLMOGOROW-SMIRNOV Two-Sample Test, which determines whether two samples come from the same distribution, also showed that there were no differences
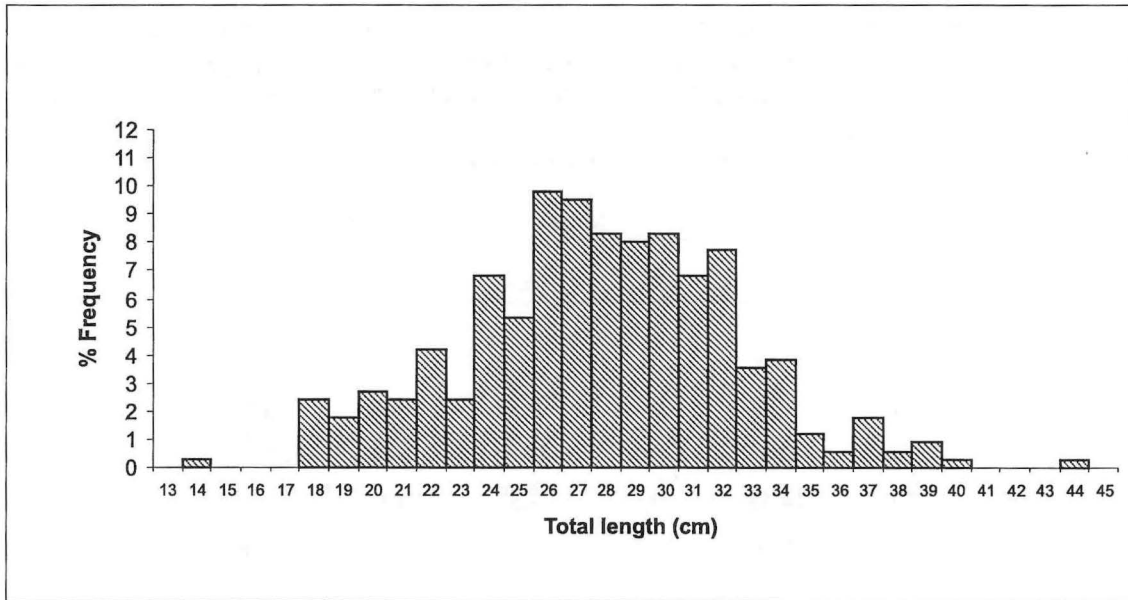

Fig. 2. Length distributions of sexes combined of common hakes caught in İzmir Bay
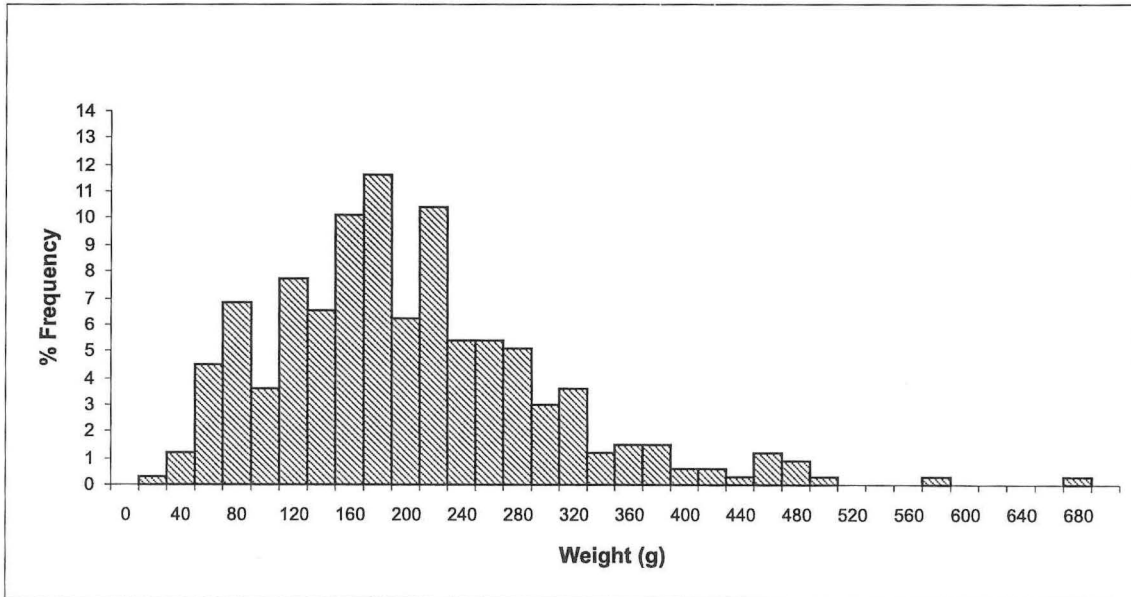

Fig. 3. Weight distributions of sexes combined of common hakes caught in İzmir Bay

between the distributions of length and weight values of female and male (for length; $DN = 0.214$, $K\text{-}S = 1.730$, $Sig.$ $Level = 0.005$; for weight; $DN = 0.240$, $K\text{-}S = 1.944$, $Sig.$ $Level = 0.001$).

Age and Sex Compositions

According to the age determinations carried out on otoliths, the specimens were distributed among the age groups I to VII. Female : male ratio was 1:0.36. The age groups III, IV and V were the most abundant in the samples from the *M. merluccius* population studied (Table 1). All specimens examined in the age groups VI and

VII were females and the females predominated over males in the age groups II and V.

Age-Length Relationship

Average total length values per age group are given in Table 2. No specimen in age group 0 was caught. The smallest specimen caught (13.6 cm) was the only one in age group I.

Assuming that the length at age in the data represents annual growth, the length growth reaches its maximal value in the transition from age group III to IV. Utilizing the total length values of the specimens in all age groups, the von BERTALANFFY's growth equations were

Table 1. Age-Sex Composition

Age Group	Female		Male		Female +Male		
	N	%N	N	%N	N	%N	d:e
I	1	0.30	-	-	1	0.30	-
II	24	7.14	6	1.79	30	8.93	1:0.25
III	58	17.26	32	9.52	90	26.79	1:0.55
IV	104	30.95	39	11.61	143	42.56	1:0.38
V	49	14.58	12	3.57	61	18.15	1:0.24
VI	8	2.38	-	-	8	2.38	-
VII	3	0.89	-	-	3	0.89	-
Total	247	73.50	89	26.50	336	100	1:0.36

Table 2. A comparison of average length values of common hakes measured and computed

	Age	N	Measured L_1	SE	Computed L_2	$L_2 - L_1$	T Test TH	p=0.05
	I	1	13.60	-	13.60	0.00	-	-
	II	30	20.40	0.421	19.12	-1.28	3.040	p<0.05
Female + Male	III	90	23.91	0.132	24.19	+0.28	2.121	p<0.05
	IV	143	28.21	0.154	28.85	+0.64	4.156	p<0.05
	V	61	31.99	0.485	33.14	+1.15	2.371	p<0.05
	VI	8	36.83	1.086	37.07	+0.24	0.221	p>0.05
	VII	3	40.77	1.040	40.69	-0.08	0.077	p>0.05

computed as $Lt=81.70[1-e^{-0.0845(t+1.155)}]$ for both sexes combined. As indicated in Table 2, there are discernible differences between the measured and the computed average length values in the age groups II to V. No statistically significant difference was found in the age groups VI and VII.

The age-length relationship for all specimens was expressed as $Y=13.482\ L^{0.533}$ (Fig. 4). Average total length values of the specimens area increased regularly against the age groups. The specimens of age group IV were the most abundant (42.56 %) in the total sample.

Age-Weight Relationship

Average weight values for each age group are presented in Table 3. No significant difference was found between males and females. The computed von BERTALANFFY's growth equation in weight is $W_t=5773.29(1-e^{-0.0845(t+1.155)})^{3.194}$ for sexes combined.

Comparisons of the computed and the measured weight values for each age group show statistically significant differences in age groups of II and V (Table 3). The age-weight relationship equation was calculated as $Y=18.165x^{1.706}$ for sexes combined (Fig.5). The weight in the hake population studied increases regularly with age.
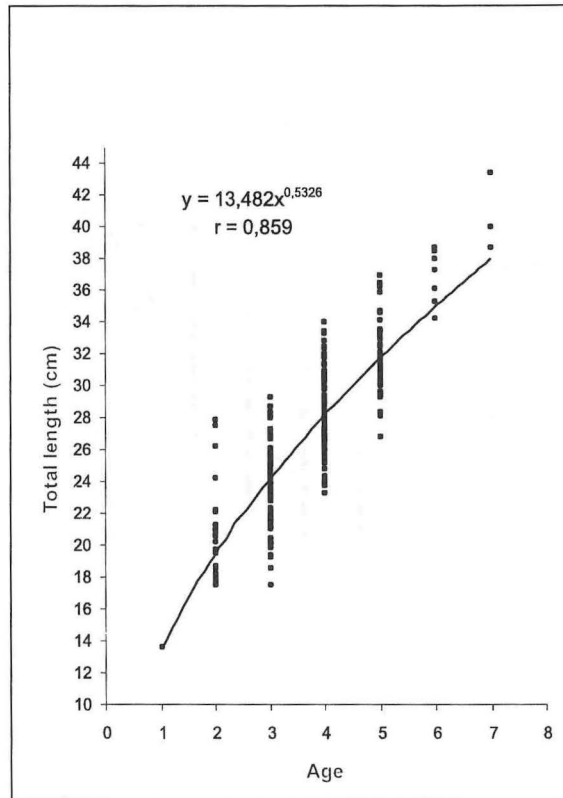

Fig. 4. *Relation between age and total length of common hakes for sexes combined*

Table 3. *Average weight values of common hakes, measured and computed*

	AGE	N	Measured W_1	SE	Computed W_2	W_2-W_1	T Test TH	p=0.05
	I	1	16.00	-	18.71	+2.71	-	-
Female + Male	II	30	71.03	7.199	55.61	-15.42	-2.142	p<0.05
	III	90	120.56	4.186	117.98	-2.58	-0.616	p>0.05
	IV	143	199.00	4.267	207.20	+8.2	+1.922	p>0.05
	V	61	285.87	7.859	322.49	+36.62	+4.660	p<0.05
	VI	8	443.00	16.870	461.64	+18.64	+1.105	p>0.05
	VII	3	566.00	54.580	621.60	+55.60	+1.019	p>0.05

$$y = 18{,}165x^{1{,}7056}$$
$$r = 0{,}850$$
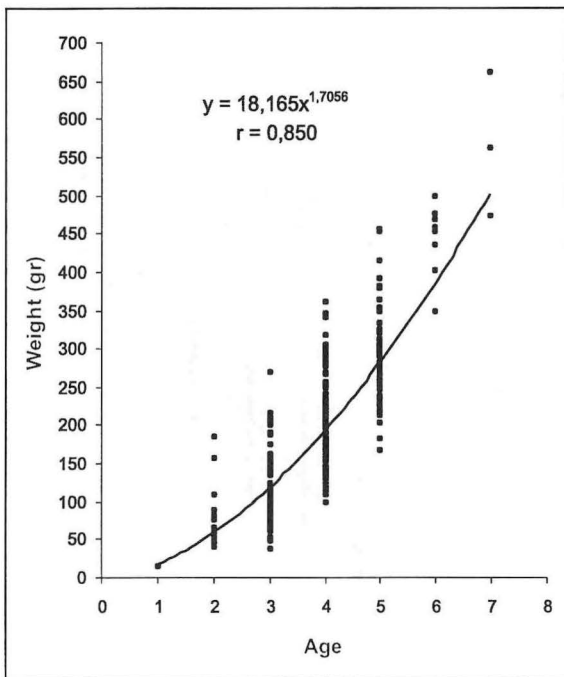
Fig. 5. Relation between age and total weight of common hakes for sexes combined

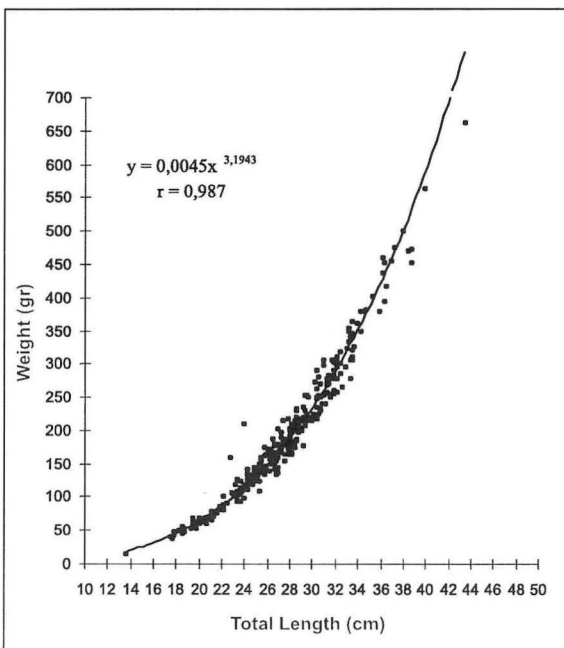$$y = 0{,}0045x^{3{,}1943}$$
$$r = 0{,}987$$

Fig. 6. Relation between total length and total weight of common hakes for sexes combined

Length-Weight Relationship

The equation of length-weight relationship for the combined sexes is $W= 0.0045L^{3.1943}$ $(r=0.987)$. The correlation coefficients computed for the length-weight relationship suggested that the growth in the population was harmonious and balanced. The "n" values in these formulas indicate that habitat in the study area is well suited for hake population (Fig.6).

DISCUSSION

The total length of the specimens covered by this study ranged from 13.6 cm to 43.5 cm. This range was compared with the results given by ANDALORO et al. (1983), PAPACONSTANTINOU et al. (1985), PAPACONSTANTINOU et al. (1991), HERNANDEZ and JUKIĆ (1992) and DEMESTRE and SANCHEZ (1998) for the hake populations of the Sicilian (45-740 mm) and the Greek Sea (4-52 cm), the Aegean Sea (55-800 mm), the Adriatic Sea (6.7-87.0 cm) and Catalan coast of NW Mediterranean (2-73 cm), respectively. The range values in our sample somewhat differ from those given above probably due to their widely ranging sampling depths (25-550 m; 48-300 m) and the larger number of their specimens. In addition, selectivity effect of the bottom trawl net used during survey may cause the scarce number of small sized specimens. Regarding Turkish seas, ÜNSAL's (in press) values for the Marmara population (9.5-44 cm) and the values of KARA and KINACIGİL (1990) for Bay of İzmir (12.5-40 cm) are quite similar to those calculated by us.

We have determined that a fraction of the population examined by us consisted of specimens referable to age groups I-VII. While ŽUPANOVIĆ (1968) reported the age groups between I and IX for the Adriatic, and ANDALORO et al. (1983) stated that females maximally reach age group VII, and males age group XI in the Sicilian common hake population. This broader range in ages resulted from the differences in sample size and sampling

Table 4. Average length values versus age groups of the hake population in various seas (*indicates the values taken from ÜNSAL, in press)

Localities	References / Age Groups	0	1	2	3	4	5	6	7	8	9
Atlantic	HICKLING (1929)	-	-	20.0	25.0	34.0	42.1	50.0	-	-	-
	ŽUPANOVIĆ (1968)*										
	GHIRARDELLI (1959)*	-	18.80	23.04	28.80	38.0	-	-	-	-	-
	BRUNO et al. (1979)*	7.97	13.59	19.10	24.29	28.74	33.81	39.40	-	-	-
Mediterranean	ALDEBERT (1981)* f	-	11.60	19.40	26.50	32.60	37.80	41.40	45.40	49.0	
	m	-	11.20	18.50	24.50	29.40	33.50	36.40	39.20	-	-
	ALDEBERT-OLIVER (1983)*	-	12.0	19.80	26.30	31.80	36.50	-	-	-	-
	WURTZ-MATRICARDI (1986)*	-	12.70	19.30	25.72	29.0	33.34	-	-	-	-
	OLIVER et al. (1990)*	11.20	16.30	21.90	28.40	34.70	38.20	40.90	43.50	45.80	48.70
	KUTAYGIL (1965)* f	-	15.50	20.20	24.80	27.70	31.50	33.80	40.0	47.0	49.5
Marmara	m	-	15.20	18.80	21.70	24.20	24.70	26.80	30.40	35.80	44.0
	ÜNSAL (in press)* f	-	13.92	20.12	25.66	29.61	33.87	38.37	42.89	-	-
	m	-	13.57	19.79	24.12	27.46	30.14	33.85	38.13	-	-
Adriatic	FLAMIGNI (1982)* May	-	14.3±0.3	21.3±0.6	29.0±1	35±3	-	-	-	-	-
	November	11.0±0.4	19.0±0.3	26.2±0.4	33.3±0.7	39.0±5	-	-	-	-	-
	PAPACONSTANTINOU (1988)	10.0-14.5	14.5-15.5	21.5-27.5	28.5-30.5	30.5	-	-	-	-	-
Aegean	VIVA (1988)	10.0-15.5	10.5-26.2	25.5-29.5	30.5-33.5	-	-	-	-	-	-
	LIVADAS (1988)	10.0-14.5	12.5-15.5	13.5-26.2	21.9-30.5	-	-	-	-	-	-
	In this survey	-	13.6	17.5-27.29	17.6-29.3	23.3-37.0	28.2-38.0	34.3-40.0	38.8-43.5	-	-

depth. Our results are similar to PETRAKIS *et al.* (1991), who reported the presence of age groups of 0-VIII from the Aegean Sea.

KUTAYGIL (1965) and ÜNSAL (in press) determined the age groups I-X and I-VII for the Sea of Marmara, respectively. Sex ratios in this study (73.5% for females and 26.5% for males) differ from those computed by ÜNSAL, (*op.cit.*) for the Marmara population (55.5% for females and 44.3% for males). A comparison of mean length values per age groups is given in Table 4.

The Atlantic common hake has a relatively fast growth rate, while the others (BRUNO *et al.*, 1979; ALDEBERT, 1981; FLAMIGNI, 1982; ÜNSAL, in press) are closer in growth rate to the specimens we examined.

The $L\infty$ and $W\infty$ values calculated for sexes combined are 81.70 cm and 5773.29 g, respectively. PAPACONSTANTINOU *et al.* (1985) calculated the $L\infty$ values as 63.8 cm and 65.9 cm for the Patraikos and Korinthiakos Bays, respectively, and 71.7 cm for the Ionian Sea. Similarly, the value given by FLAMIGNI (1982) for the Adriatic was 85.0 cm. The $L\infty$ values given by ÜNSAL (in press) for the Sea of Marmara are 91.541, 94.320 and 63.248 cm for sexes combined, females and males, respectively. Our values computed in this study are contradict with those given by ÜNSAL (in press) for males of the Marmara Sea because the number of male specimens, especially the males in age group II, is scarce.

Thus, transition from age II to III does not reflect the growth of males in our study.

The $W\infty$ value calculated in this study could not be compared with those given above due to the absence of relevant data. However, regarding the measure of the rate at which length approaches $L\infty$, growth of common hake is somewhat more rapid in İzmir Bay ($K=0.0846$) than in the gulfs of Patraikos ($K=0.0751$) and Korinthiakos ($K=0.0681$), and the Ionian Sea ($K=0.0809$) (PAPACONSTANTINOU *et al.*, 1985). Furthermore, the growth rate in the İzmir specimens is slower than that in the Adriatic Sea ($K=0.12$; FLAMIGNI, 1982), whereas it is largely similar to that calculated by OLIVER *et al.* (1992) for the population of the Balearic Islands ($K=0.086$).

On the other hand, except for the weak relationship given by ÜNSAL (in press) for the Sea of Marmara, length-weight relationship of the hake established here for İzmir Bay is in close agreement with those obtained by TSIMENIDIS *et al.* (1978) for the Saronikos Bay, and by PAPACONSTANTINOU *et al.* (1985) for the Patraikos and Korinthiakos Bays, and the Ionian Sea.

ACKNOWLEDGEMENTS

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Preliminarna studija o rastu oslića (*Merluccius merluccius* L., 1758) u Izmirskom zaljevu, Egejsko more

Dilek UÇKUN, Melahat TOĞULGA i Ertan TAŞKAVAK

Egejsko Sveučilište, Ribarstveni fakultet, 35100 Bornova-Izmir, Turska

SAŽETAK

U radu se pokušalo odrediti parametre rasta oslića, *Merluccius merluccius* L. koji je jedna od najvažnijih komercijalnih vrsta riba u Izmirskom zaljevu (Egejsko more). Ukupno je ulovljeno 336 primjeraka oslića između travnja 1994 i ožujka 1995. Ukupna dužina i težina primjeraka kretale su se od 13.6 do 43.5 cm odnosno 16.0 do 662.0 g. Najviša određena starosna grupa bila je VII, a odnos između mužjaka i ženki iznosio je 1:0.36. Većina primjeraka pripadalo je starosnoj grupi IV. Von BERTALANFFY-jeve jednadžbe dužinskog i težinskog rasta bile su $L_t=81.70 \ [1-e^{-0.0845(t+1.155)}]$ i $W_t=5773.29 \ (1-e^{-0.0845(t+1.155)})^{3.194}$, zajedno za oba spola.