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Some Biological Properties and Stock Estimates of *Zeus faber* L., 1758 (Pisces, Zeidae) in the Aegean Coasts of Turkey

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Özet: ***Ege Denizi Kıyılarında* Zeus faber *L., 1758 (Pisces, Zeidae)'in Bazı Biyolojik Özellikleri ve Stok Tahminleri.*** Bu çalışmada, *Zeus faber* L., 1758 bireyleri Batı Anadolu'nun kıyısal sularından (Ege Denizi) mevsimsel örneklemeyle Ekim 1993 – Ağustos 1995 arasında elde edilmiştir. Örneklenen populasyonda dişiler %57.2, erkekler %28.8 ve cinsiyeti belirsiz olanlar %14 olarak bulunmuştur. Bütün bireylerin total boy aralığı 6.5 – 50 cm arasındadır. Otolit okumalarından elde edilmiş yaşlara göre ortalama total boylar von Bertalanffy büyüme parametreleri tahmininde kullanılmıştır. Bu parametreler: $L\infty$=60.71 cm, K=0.298, t_0=0.326 dır. Populasyonda dominant yaş grubu I (%64.19) olarak bulunmuştur. Gonadosomatik indeks (GSI)'in mevsimsel karşılaştırması yumurtlamanın başlıca ilkbahar ve sonbaharda kısmi olarak vuku bulduğunu göstermektedir. *Z. faber,* başlıca balıklar (*Cepola rubescens, Mullus barbatus, Sardina pilchardus, Gobius spp., Argentina sphyraena* vs.), Crustacea'ler ve Mollusc'lar ile beslenmektedir. *Z. faber*'in ölüm oranları: doğal mortalite (M), 0.17 y^{-1}; balıkçılık mortalitesi (F), 0.75 y^{-1} ve toplam mortalite (Z), 0.92 y^{-1}şeklindedir. *Z. faber*'in maksimum ve minimum mevsimsel biyokütle değerleri sırasıyla sonbaharda 862.8 ton ve kışın 338.5 ton olarak bulunmuştur. Doğal olarak, birim çabaya düşen av da (CPUE, Kg $saat^{-1}$) aynı mevsimlerde artıp azalmıştır.

Anahtar Kelimeler: *Zeus faber*, yaş, büyüme, cinsiyet oranı, beslenme davranışları, biyokütle.

Abstract: *Zeus faber* L., 1758 specimens were collected from the coastal waters of the Western Anatolia (Aegean Sea), seasonal sampling from October 1993 to August 1995. In the population, females made up 57.2%, males 28.8% and unidentified 14% of the species. The total length of all specimens ranged from 6.5 to 50 cm. Mean total length at age data derived from otolith readings were used to estimate the growth parameters of von Bertalanffy equation. The estimated parameters were: $L\infty$=60.71 cm, K=0.298, t_0=0.326. The dominant age group was determined I (64.19%) in the population. The seasonal comparison of gonadosomatic index (GSI) indicated that the spawning occurred mainly in spring and autumn, partially. *Z. faber* fed mainly on fish (*Cepola rubescens, Mullus barbatus, Sardina pilchardus, Gobius spp., Argentina sphyraena* etc.) and Crustaceans and Molluscs. The mortality rates of *Z. faber* were found as follows: natural mortality (M), 0.17 y^{-1}; fishing mortality (F), 0.75 y^{-1} and total mortality (Z), 0.92 y^{-1}. The maximum and the minimum seasonal values for the biomass of *Z. faber* were found in autumn (862.8 tons) and winter (338.5 tons), respectively. Naturally, the Catch Per Unit of Effort (CPUE, Kg $hour^{-1}$) was also found to increase and decrease with the biomass in respective seasons.

Key Words: *Zeus faber*, age, growth, sex ratio, feeding habits, biomass.

Introduction

Zeus faber L., 1758 is a benthic species inhabiting depths ranging from 50 to 150 m. This species is widely distributed in the Mediterranean Sea (including the Black Sea), the western coastal waters of Europe, the English Channel, the North Sea, the coastal waters of South Africa, Australia, New Zealand, Japan and Korea (Janssen 1979; Heemstra 1980; Quero 1986). Total landings of *Z. faber* in the

Turkish Seas in 1996 as reported as 73 metric tons. Fifteen percent of this catch was obtained from the Aegean Sea (Anon. 1997). *Z. faber* is common in the trawl catch compositions of all around Turkish coasts, but usually in insignificant amounts. It would be unusual to see more than ten individuals of this species after a commercial trawling haul, which usually lasts between one to three hours. As they are usually not caught in sufficient amounts for sale in fish markets, *Z. faber* is, in general, consumed by fishermen themselves and some keen customers such as restaurant owners, and remains as unrecorded catch mainly for this reason. Therefore, the annual catch of this species may appear as insignificant in proportion to the total landings in trawl fisheries. There is lack of literature on *Z. faber*. Janssen (1979) studied its biology and population structure between 1960 and 1977 in the coastal waters of the Netherlands. Heemstra (1980) published descriptive information about Zeidae family of South Africa. Quero (1986) presented an identification key of *Z. faber.* Geldiay (1969) was the only researcher in Turkey published on *Z. faber.* This study, however, was focused only on the biology of the specimens collected from the Bay of Izmir.

The aim of this study is to assess the stock dimensions of *Z. faber* and the biological properties of this species in the coastal waters of the western Anatolia (Aegean Sea).

Materials and Methods

This study was carried out on board *R/V K. Piri Reis* during seasonal fishing cruises in October and November 1993; July, August and December 1994; and April, May and August 1995. Samples were collected from the coastal waters of the western Anatolia, the Aegean Sea, with a bottom trawl, which had a 40 mm mesh size at the cod-end. The Aegean Sea was divided into a total of 1064 squares, each of which was 9 square miles (Figure 1). Sampling squares for each season were chosen randomly. Speed and duration of trawl operations were kept constant at 2,5 knot and 30 minutes, respectively. The catch per unit of effort (CPUE) was calculated for 1 hour units. A total of 218 valid trawl hauls; 40 in autumn; 42 in winter; 48 in spring and 88 in summer, were conducted.

The fish samples were taken into the vessel's laboratory where their size (total length in mm) and weight (g) were measured and weighed to the nearest 1 mm and 1 g, respectively. Sex was determined by macroscopic observation of the gonads. The otoliths were used for age determination. The computer program Fisat (FAO-ICLARM Stock Assessment Tools) developed by Gayanilo *et al.* (1994) was used in the determination of Von Bertalanffy's growth parameters (L_∞, W_∞, K, t_0) (Bertalanffy, 1938). The values that were found have been put in the Von Bertalanffy growth formula as follows;

$$L_t=L_\infty\,[1-e^{-K(t-to)}] \text{ and } W_t= W_\infty\,[1-e^{-K(t-to)}]^3$$

where L_∞ and W_∞ are asymptotic sizes, and K is a constant which also called as Brody growth coefficient and t_0 is the theoretical age when fish would have been at zero total length.

The seasonal differences in the gonadosomatic index (GSI) was examined, formulated by Htun-Han (1978) as;

GSI=(the weight of gonad x 100 / whole body weight).

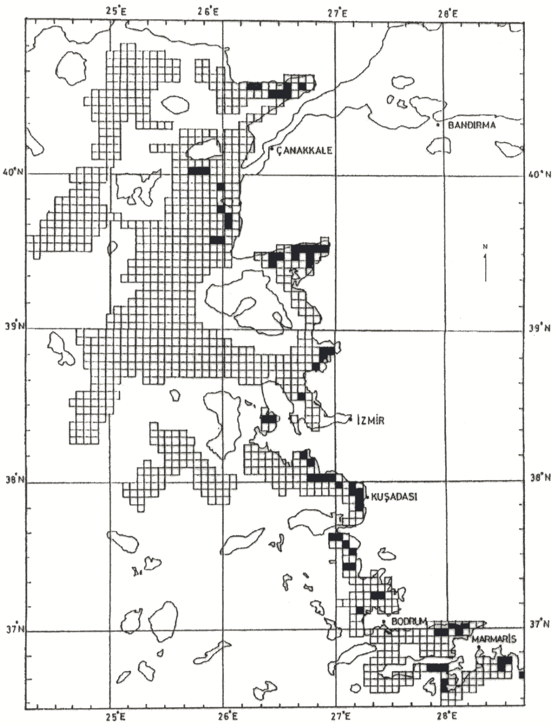

Figure 1. The sampling area

A binocular microscope was used for identification of small items during stomach content analysis. The results of this quantitative analysis were given according to gravimetric methods (Holden and Raitt 1974). This method is based on food weight. The contents of the dietary material were identified to the specific level where possible, but most items were identifiable only to the generic level. The contribution of different categories of prey to the diet of *Z. faber* was determined by 3 methods: (i) the percentage weight (Cw) of prey category to the number of the total stomach contents; (ii) the percentage abundance (Cn) of individuals of a prey category to the total number of prey individuals in the stomach; (iii) the percentage frequency of occurrence (f) of stomach in which a prey category occurred to the total number of stomach examined. The index of relative importance (IRI) combines the above 3 quantities into a single numerical index: IRI=(Cn+Cw)xf. The IRI index was used to assess the importance of various food items in the diet (Caragitsou and Papaconstantinou 1988). Survival rate (S) (Ricker 1975), total mortality (Z) (Beverton and Holt 1957) and natural mortality (M) (Ursin 1967) were calculated from the equations $S=e^{-Z}$, $Z=K(L_{\infty}-L_{mean})/(L_{mean}-l')$, where L_{∞} and K are the parameters of the Von Bertalanffy growth equation, L_{mean} is the mean length in the catch and l' is the smallest length of fish that are fully represented in catch and $M=W^{-1/3}$, where W is mean weight. Then from Z and M, fishing mortality (F) and exploitation rate (E) were obtained by using the equations F=Z-M and E=F/Z, respectively (Ricker 1975). The method of swept area was used in biomass estimation (Clarke 1981). Scanmar instruments were used to measure the winged spread of the sampling trawl for the calculation of swept area. This area was found 0.021 km^2 for one hour of towing duration, which corresponds to two hauls. Total biomass for each season was calculated according to Saville (1977), using the following equation; $B_i=A_iC_{mean}/a_iq_i$ where A_i is surface of sub-area, C_{mean} is mean catch, a_i is swept area of trawl and q_i is constant of catchability (assumed as 1). The CPUE was calculated according to Petrakis (1998) as Kg $hour^{-1}$ of fishing as follows: The total weight or weight of the species was standardised to one hour of towing: $W_i=w_i$ x 60/t where W_i is standardised weight, w_i is actual weight, t is duration of the tow. The CPUE was estimated as the mean of the standardised weight in the season. CPUE= $\Sigma W_i/N$ where N is number of hauls in the season.

Results

Studies have shown that the age composition of 215 fish samples caught in the Aegean Sea ranged from I to VI. The specimens of the population were 57.2% female, 28.8% male and 14% unidentified (Table 1). There were statistical differences between male and female numbers according to age groups ($\chi^2_{(5;0.05)}$ =11.07< $\chi^2_{(calc.)}$ =16.6). The mean value of total lengths and total weights of *Z. faber* for age groups of I-VI were found 11.89 cm - 30.13 g; 22.75 cm - 201.49 g; 33.97 cm - 547.16 g; 40.27 cm - 873.7 g; 46.14 cm - 1486.1 g and 50 cm – 1830 g, respectively (Table 2 and Table 3).

The first year class fish (64.19%) were the most abundant in the population (Table 4). Length frequency distribution of *Z. faber* is given in Figure 2. Majority of the specimens became dense in 7 – 16 cm total length range.

The von Bertalanffy growth formula which was estimated from mean total lengths and body weights at age data is as follows; $L_t=60.71[1-e^{-0.298(t-0.326)}]$ and $_t=2967.3[1-e^{-0.298(t-0.326)}]^3$.

The sex and level of maturity of sampled specimens were examined macroscopically. The seasonal GSI values are shown in Figure 3. Ripe gonads were observed more or less in all seasons, reaching to their peaks in Spring (1.59) and Autumn (1.15). Investigations of the stomach contents of 256 *Z. faber* specimens indicated that the most preferred preys were fish, such as *Cepola rubescens, Mullus barbatus, Sardina pilchardus, Gobius sp., Argentina sphyraena* etc. and then Crustaceans and the Molluscs (Table 5).

The mortality and the survival and exploitation rates of *Z. faber* were found as follows; natural mortality (M), $0.17y^{-1}$; fishing mortality (F), $0.75y^{-1}$; total mortality (Z), $0.92y^{-1}$; survival rate (S), $0.40y^{-1}$ and exploitation rate (E), $0.82y^{-1}$.

Table 1. Age-sex composition of *Z. faber*.

	Female		Male		Unidentified		Total	
Age Groups	N	%	N	%	N	%	N	%
I	77	62.6	31	50.0	30	100	138	64.2
II	19	15.4	23	37.1			42	19.5
III	7	5.7	5	8.1			12	5.6
IV	7	5.7	3	4.8			10	4.6
V	12	9.8					12	5.6
VI	1	0.8					1	0.5
Total	123	57.2	62	28.8	30	14.0	215	100

Table 2. The mean lengths of age groups of *Z. faber* and their 95% confidence intervals (St.Dev. = Standart deviation, N = Number of fish, C.I. = Confidence interval).

		Total Length (cm)			
Age Groups	N	Min.	Max.	St.Dev.	95% C.I.
I	138	6.5	22.8	3.03	11.89±0.51
II	42	15.2	34.5	5.82	22.75±1.79
III	12	27	40.5	4.25	33.97±2.68
IV	10	37	47.1	3.32	40.27±2.37
V	12	42.7	49.8	2.28	46.14±1.54
VI	1	50			50

Table 3. The mean weights of age groups of *Z. faber* and their 95% confidence intervals (St.Dev. = Standart deviation, N = Number of fish, C.I. = Confidence interval).

		Total Weight (g)			
Age Groups	N	Min.	Max.	St.Dev.	95% C.I.
I	138	4	138	24.01	30.13±4.04
II	42	46	630	164.8	201.45±51.3
III	12	280	988	218.1	547.16±138.7
IV	10	635	1314	221.2	873.7±158.3
V	12	1100	2078	272.9	1486±173.6
VI	1	1830			1830

Table 4. Age-length key of *Z. faber*.

	Age Groups							
TL (cm)	I	II	III	IV	V	VI	N	Cumulative
6	26						26	26
9	39						39	65
12	50						50	115
15	17	3					20	135
18	5	7					12	147
21	1	7					8	155
24		11					11	166
27		6	2				8	174
30		1	3				4	178
33		2	4				6	184
36		5	1				6	190
39			2	5			7	197
42				4	4		8	205
45				1	5		6	211
48					3	1	4	215
N	138	42	12	10	12	1	215	

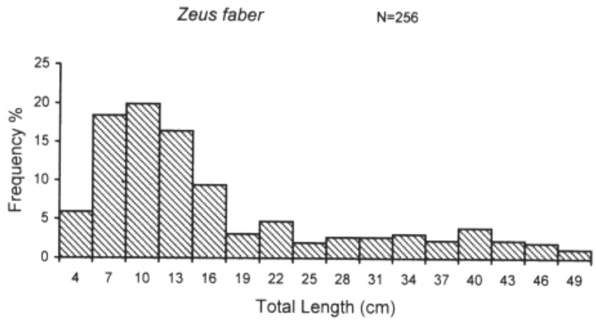

Figure 2. Length frequency distribution of *Z. faber*.

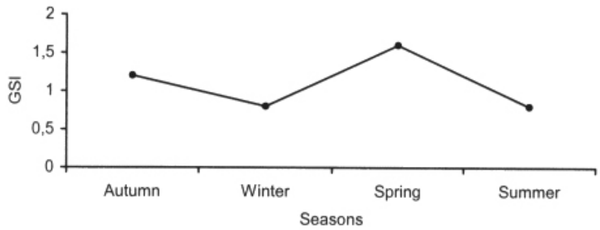

Figure 3. Seasonal comparison of GSI values of *Z. faber* in the Aegean Sea.

Table 5. Food preference of *Z. faber* (f = frequency occurrence, Cn = percent abundance composition, Cw = percent gravimetric composition, IRI = index of relative importance)

	Autumn				Winter				Spring				Summer			
Taxa	f	Cn	Cw	IRI	f	Cn	Cw	IRI	f	Cn	Cw	IRI	f	Cn	Cw	IRI
Cepola rubescens	14,3	10,7	27,3	543					20	12,7	25,6	766	13,1	12,4	31,9	580
Mullus barbatus	7,1	5,4	32,9	272									3,6	3,8	18,4	80
Sardina pilchardus	7,1	3,6	7,2	77												
Lesueurigobius friesii					10	10	3,3	133					19,5	21	7,3	552
Argentina sphyraena													3,6	3,8	5,5	33
Gobius sp.									4	3,2	2,9	24	1,2	0,1	0,6	2
Callionymus lyra									16	6,4	1,8	131				
Scorpaena sp.													1,2	0,1	0,3	1
Serranus hepatus													1,2	0,1	2	3
Parapanaeus longirostris									4	15,9	21,9	151				
Loligo sp.													1,2	0,1	0,44	2
Mycidacea	7,1	35,7	0,8	259									2,4	1,9	0,1	5
Decapoda	3,6	1,8	0,08	7					4	34,9	0,15	140	1,2	0,1	0,2	1
Polychaeta	3,6	1,8	0,4	8												
Amphipoda													1,2	0,1	0,1	1
Euphausiacea									8	7,9	0,15	64				
Isopoda													5,9	5,7	1,1	40
Nematoda													1,2	3,8	0,03	5
Fish larvae	7,1	3,6	0,4	28					8	3,2	1,5	38	2,4	2,9	0,7	9
Digested fish	50	37,5	30,8	3415	90	90	96,7	16830	36	15,9	46	2228	41,7	39,1	31,2	2931
No of stomach	50				23				39				144			
No of empty stomach	22				12				16				60			
% of empty stomach	44				52,2				41				41,7			

The maximum and the minimum seasonal values for the biomass of *Z. faber* were found in Autumn (862.8 tons) and Winter (338.5 tons), respectively. Naturally the CPUE was also found to increase and decrease with the biomass in respective seasons (Table 6).

Table 6. The seasonal estimates of biomass of *Z. faber* and the CPUE values

Seasons	Total Catch (kg/h)	CPUE (kg/h)	Biomass (tons)
Autumn	23.04	0.576	862.8
Winter	9.48	0.226	338.5
Spring	17.18	0.357	536.2
Summer	45.54	0.517	775.9

Discussion

The ages of *Z. faber* caught from the Aegean Sea ranged from I-VI and the first year class (64.19%) was the dominant group in the population. Length range of this species obtained from 30 to 280 m depth of the Aegean Sea was found as 6.5 to 50 cm. Janssen (1979) reported the mean total length of the fish at the age groups of I to IV as 15 cm, 27 cm, 37 cm and 42 cm, respectively. This researcher also reported that he had not found any individual smaller than 11 cm in the coastal waters of the Netherlands. Janssen (1979) and Quero (1986) reported that the spawning period of *Z. faber* is July and August in the English Channel, the Gulf of Biscay and the Irish Sea. Their results indicate that *Z. faber* prefer warm waters for spawning. However, in this study, the consistent observations of ripe gonads in all seasons are strong evidence that the partial spawning of *Z. faber* continuing throughout the year, with prominent increases in Spring (GSI=1.59) and Autumn (GSI=1.15).

The stomach content examinations of *Z. faber* indicated that it is a carnivorous species. The results of the stomach content analysis of this study revealed that the initial food preference of *Z. faber* is fish (Table 5). Small specimens were found to prefer fish larvae and Crustaceans such as Mysidacea and Decapoda. Janssen (1979) reported that *Z. faber* fed on gobies (*Pomatoschistus sp.*), herring (*Clupea harengus*), sand eel (Ammodytidae), scad (*Trachurus trachurus*), sardine (*Sardina pilchardus*), squid (*Alloteuthis subulata*) and Crustaceans. Quero (1986) also reported that this species preferred particularly demersal fish, Alpheid, Pandalid and Palaemonid Crustaceans. Stergiou and Fourtouni (1991) mentioned that *Z. faber* is a stenophagus species, which begins life feeding almost exclusively on zooplankton until it is about 80 mm long, then shifts to feeding exclusively on demersal fish. These authors found that Mysids were the most important food for small sized fish (<141mm), whereas fish sizes bigger than 141 mm preferred *Cepola macropthalma* and to a lesser extent other species *Callionymus maculatus, Gaidropsaurus sp.* and *Trigla lyra*. All of these results indicate a great similarity. The mortality and exploitation rates indicate that there is a fishing pressure on *Z. faber* stock of the coastal waters of western Anatolia. High ratio of small fish in the catch, especially first year class which contributed to the 64.2% of the catch, supports this point of view.

Although *Z. faber* is not one of the target species in Turkish territorial waters, it has a considerable size of stock and an important market value. However, this species is very often found in trawl catch compositions, but usual in small quantities. To secure the existence of *Z. faber* in the longterm, a careful approach to its exploitation practice, and particularly detailed research on the biology of the species are essential.

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