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Preliminary Estimation of Growth, Mortality and the Exploitation rates of the Silverbelly (*Leiognathus klunzingeri* Steindachner, 1898) Population from the Yumurtalık Bight, Northeastern Mediterranean coast of Turkey

Meltem Özütok[1,*], Dursun Avşar[1]
[1] Faculty of Fisheries, Çukurova University, 01330 Balcalı, Adana, Turkey.

* Corresponding Author: Tel.: +90. 322 338 60 84; Fax: +90. 322 338 64 39;
E-mail: mozutok@cu.edu.tr

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Abstract

This study was carried out to determine the growth characteristics, mortality and the exploitation rates of the silverbelly (*Leiognathus klunzingeri*). The von Bertalanffy growth constants for this species were L_∞=10.28 cm, K=0.29 year^{-1}, t_0=-0.42 year, W_∞=11.75 g, and it was estimated that the greatest growth occurred between age groups I and II for length and between groups III and IV for weight. The total mortality rate was estimated to be Z=0.9609, its components being M=0.6460 and F=0.314. In addition to this, it was found that the exploitation rate on the silverbellies distributed along the Yumurtalık Bight (Northeastern Mediterranean coast of Turkey) was insufficient.

Key Words: Silverbelly *Leiognathus klunzingeri*, von Bertalanffy growth constants, mortality rates, exploitation rate.

Introduction

The largest area along the Northeastern Mediterranean coast where artisanal fishery is practiced is the large continental shelf between Iskenderun and Silifke in Turkey. In this region, the proportion of fishing made up by the long-established fishing of some species has been on a steady numerical decline in recent years (Gücü and Bingel, 1994); while that of other species has grown steadily over the same period of time. Indeed, the increase in the proportion of fishing of the species (lessepsian) migrating to the Mediterranean Sea from the Red Sea is particularly significant. Silverbelly (*Leiognathus klunzingeri*), which is one of the species showing such a trend, is found mainly in the demersal region of the North-eastern Mediterranean (Bingel, 1987). In addition to having a considerable fishing potential, this species, when assessed in the same way as other species that are not as economically viable in the same context, is also recognized as food source for other economical species (Ben-Tuvia, 1978; Bingel, 1987).

Extensive, significant research has not been done on either the biological features or the environmental situations of species that are found in large numbers in neritic regions of the Mediterranean, especially in the neritic areas of Levant Basin, although Steindachner (1898), Tortonese (1964; 1973), Roux (1986) Papaconstantinou (1990), and Golani (1993) have studied the geographical distribution of these species; Ben-Tuvia (1966; 1985), Ben Yami and Glaser (1974), the living areas in the eastern Mediterranean; Akşiray (1954; 1987), the areas for living, spawning and nourishment; Bingel (1981; 1987), the fishing rates in the same region; von Bertalanffy, growth coefficients; Avşar (1987), the stocks in Mersin Bay (Tuzla, Seyhan, Göksu and Tırtar); and Gücü *et al.* (1994), meristic and morphometric characteristics.

For the aforementioned reasons, this study aims to show how some of the characteristics of silverbelly caught in the Yumurtalık Bight are related to population parameters such as growth and mortality rates, as well as how they benefit from the stocks. Indeed, not only will the main characteristics of the species be determined, some fishery parameters such as growth in weight and length and the mortality rates will also be determined. In this way, the findings of the present study will contribute to the advancement scientific principles by generating the data needed to optimize the fishing of the related stock in studies to follow.

Materials and Methods

The material for this study were obtained from 6 stations located on the Yumurtalık Bight on the west coast of Iskenderun Bay {(36° 42' N), (35° E - 35° 49' E)} (Figure 1) between September 1997 and August 1998.

In this study, 440 silverbellies, comprising 230 females, 200 males, and 10 juveniles, were studied. The fish caught using a deep trawl net with a mesh size of 22 mm and catch removals of half an hour in duration were divided according to species after being cleaned of mud and organic and inorganic foreign matter. When the amount of sample was insufficient, whole samples were used; when the amount of sample was sufficient, some sub-samples were used in the analyses, as indicated by Holden and Raitt (1974). The samples were either kept in a 10% formaline

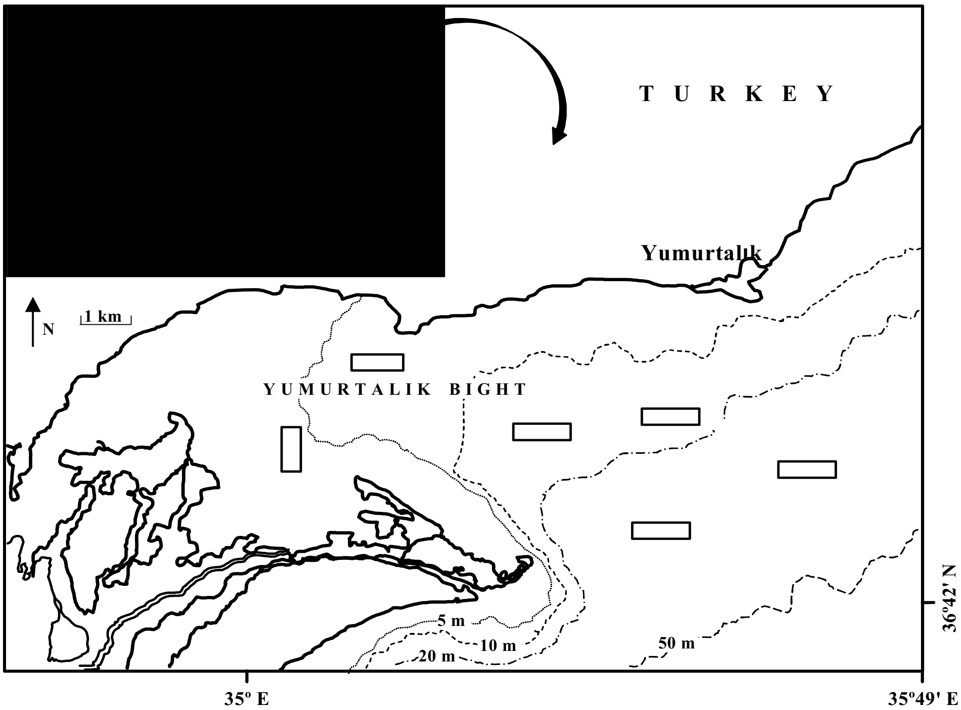

Figure 1. The deep trawl stations where the samples were held and the Yumurtalık Bight.

solution or protected in a deep freezer. Length measurements were made with 1.00 mm-class interval while body and gonad weight were weighed to 0.0001 sensitivity in the laboratory. The stage of maturity was established through examination of the gonads, while the age was determined through examination of the sagitta, stating in sacculus marsuplum in otoliths as suggested by Holden and Raitt (1974). Mean length and weight values were calculated separately for each age group. Growth in length and weight was analyzed separately for each sex and also by using von BERTALANFFY's (1938) growth equation $L_t = L\infty\left[1 - e^{-K(t-to)}\right]$ for both sexes, to estimate growth in length, and the relationship between length and weight was used to characterize weight gain. For this reason, corresponding numerical values were substituted for the variables in the equation $W_{(t)} = a*L_{(t)}^{b}$, namely, (t) in place of ($L_{(t)}$); the length-weight relationship constants in place of (a) and (b), to calculate the weight value ($W_{(t)}$) , at time t. ($W\infty$) was calculated using the same equation.

The Regression Method suggested by Bingel (1985) and Sparre and Venema (1992) was used to estimate the constants of growth in length. With regard to the statistics, the Chi-Square (χ^2) Test was used to determine whether or not there were any differences between the mean length and weight values that were found by measuring and calculating for each group.

The total mortality rate (Z) was divided into its components of fishing (F) and natural mortality rates (M), estimating (M) by using the mean weight method first used by Ursin (1967). The total mortality rate (Z) was determined by using Age Composition as suggested by Avşar (1998), and (F) was estimated from (Z) and (M). The level of exploitation from the stock was determined using the equation E = F/Z, given by Sparre and Venema (1992). Beverton and Holt's (1957) proposed Yield per Recruit Analysis method was used to create a plan of fishery so that it would be conducted with stock selected to produce the highest possible yield for this species continuously.

Results

Growth in Length and Weight

Sexes and monthly distributions obtained for the 440 silverbelly that were examined in this study are given in Table 1.

The growth constants, which were calculated after determining the ages of these fish, and which varied among fish belonging to age groups I–VI, are given in Table 2.

The mean length values, which were calculated by using the rates of the determined age groups and their mean length values, as well as their von Bertalanffy growth constants for length, are given in Table 3.

It was found that the of growth in length of silverbelly that occurred with advances in age, i.e., from group I–II, II–III, III–IV, IV–V and V–VI, were 1.83, 1.36, 0.97, 0.87, 0.5 cm for males on the one hand, and 1.64, 1.29, 1.02, 0.8, 0.63 cm for females on the other. For all individuals taken together, the

Table 1. For each sex and their sample size in monthly

Monthly	Sexes of Sample Size		
	Female	Male	Total
October 1997	18	26	44
December 1997	23	19	42
January 1998	26	7	33
February 1998	38	23	61
April 1998	39	39	78
May 1998	1	2	3
June 1998	6	13	19
July 1998	28	26	54
August 1998	20	20	40
September 1998	31	25	56

Table 2. von Bertalanffy growth constants in length and weight

Sexes	Growth Constants in Length and Weight			
	L_∞ (cm)	W_∞ (g)	K (yr^{-1})	t_o (yr)
Males	10.20	11.64	0.33	-0.30
Females	10.87	12.17	0.24	-0.44
Total	10.28	11.75	0.29	-0.42

Table 3. The mean total length values (cm) measured for each sex and their total in each age group and calculated by solving von Bertalanffy Equation (n: sample size)

Sexes	Age Groups					
	I	II	III	IV	V	VI
Males						
Measured	3.05	5.06	6.52	7.75	8.15	8.90
Calculated	3.57	5.40	6.76	7.73	8.40	8.90
n	4	62	82	32	13	7
Females						
Measured	3.80	5.09	6.58	7.58	8.16	9.14
Calculated	3.17	4.81	6.10	7.12	7.92	8.55
n	6	46	99	50	24	5
Total						
Measured	3.48	5.07	6.57	7.65	8.16	9.05
Calculated	3.14	5.10	6.41	7.42	8.14	8.68
n	19	109	181	82	32	12

corresponding figures came out to be 1.96, 1.31, 1.01, 0.72 and 0.54 cm. It was seen from these values that the age advance during which silverbelly showed the most growth in length was the one that occurred between groups I and II, in which their length increased by 1.96 cm.

Mean weight values, calculated using the evaluated weights of age groups and shown for the sexes taken separately as well as for all individuals, are given along with length-weight relationship constants in Table 4.

It can be seen in Table 4 that no statistical differences (χ^2; $p>0.05$) occurred between the values for mean weight calculated within each age group. This can be taken to imply that the von Bertalanffy Growth constants were calculated in to an acceptable degree of accuracy to characterize the growth of this species.

The growth in weight among the age groups was calculated as 1.28, 1.76, 2.33, 1.54, and 1.12 g for the males; 0.94, 2.03, 1.87, 1.45, and 2.00 g for the females; and 1.33, 1.93, 2.05, 1.7, and 1.32 g for their combined total. It can be understood from the results that the age groups between which males showed the most growth in weight, or an increase of 2.33 g, were groups III and IV; meanwhile, the females showed the most growth, or an increase of 2.03 g, between groups II and III; for the total, the most growth occurred in males between the age groups III and IV, with an increase of 2.05 g.

Length-Weight Relationship

The length measurement values of the individuals used for determining the relation between length and weight change ranged from a minimum of 2.7 cm to a maximum of 9.5 cm for length, while weight change ranged from 0.1874 g to 10.3951 g. The equations of length-weight relationship for each sex separately and for the total were as follows:

Males : $W = 0.0106 * L^{3.0585}$ (n = 200, r = 0.955)
Females : $W = 0.0880 * L^{3.1693}$ (n = 230, r = 0.964)
Total : $W = 0.0100 * L^{3.0946}$ (n = 440, r = 0.961)

The value (b) of the regression coefficient in the length-weight relationship equation was calculated to be 3.0585 for the males, 3.1693 for females and 3.0946 for the total. Consequently, it can be seen that the females of this species were shorter and fatter than the males, while the males were more fusiform. It can also be said that the silverbelly showed positive allometry.

Mortality Rates and the Level of Exploitation from the Stock

The total mortality rates (Z), the natural mortality rates (M) and the fishing mortality rates (F) for each sex and their total are given in Table 5.

As seen in Table 5, it was found that the fishing mortality rate of the females was higher than that of the males, while the natural mortality rates for both sexes were more or less the same. The reason for this result may be related to the fact that the females had longer and fatter bodies and so they were caught more easily than the males.

The exploitation rate (E) was calculated for each sex and their total, and these values are also given in Table 4. Table 5 reveals that all exploitation rates were less than 0.5; consequently, the optimum value could not be attained in either of the sexes or in their total. The (E) value closest to optimum was found to be 0.44, in the females. As a result, it can be said that the aforementioned species would not adequately benefit from the Yumurtalık Bight stock.

Results of Yield per Recruit Analysis

The diagram obtained from the Yield per Recruit Analysis for silverbelly is given in Figure 2. It can be seen in Figure 2 that the intersection point (P) of the length at first capture (L_c = 5.9 cm) and the fishing mortality rate (F = 0.3149) exceed the optimum fishing state. This confirms that the method of fishery applied to silverbelly was not adequate. In other words, it can be stated that inadequate utilization occurred with this species (Figure 2).

Discussion

In this study, (b), which is one of the constants in the length-weight relationship formula, was calculated to be 3.1693 for females, 3.0585 for males, and 3.0946 for their total. Thus, it was found that the silverbelly females were smaller and fatter than the males, and the males have a more fusiform body than

Table 4. The mean weight values weighted for the sexes and their total in each age group and calculated by solving length-weight relationship (g) (n: sample size)

Sexes	Age Groups					
	I	II	III	IV	V	VI
Males						
Measured	0.32	1.60	3.36	5.69	6.81	8.35
Calculated	0.32	1.52	3.20	5.58	5.99	8.55
n	4	62	82	32	13	7
Females						
Measured	0.65	1.59	3.62	5.49	6.94	8.94
Calculated	0.68	1.54	3.46	5.46	6.83	9.79
n	6	46	99	50	24	5
Total						
Measured	0.57	1.59	3.52	5.57	6.89	8.59
Calculated	0.57	1.78	3.40	5.48	6.46	9.03
n	19	109	181	82	32	12

Table 5. The total (Z), Natural (M), the fishing mortality rates (F), the exploitation rates (E) for each sex and their total

Sexes	Z	M	F	E
Males	0.7599	0.6620	0.0979	0.13
Females	1.0984	0.6453	0.4431	0.44
Total	0.9609	0.6460	0.3149	0.33

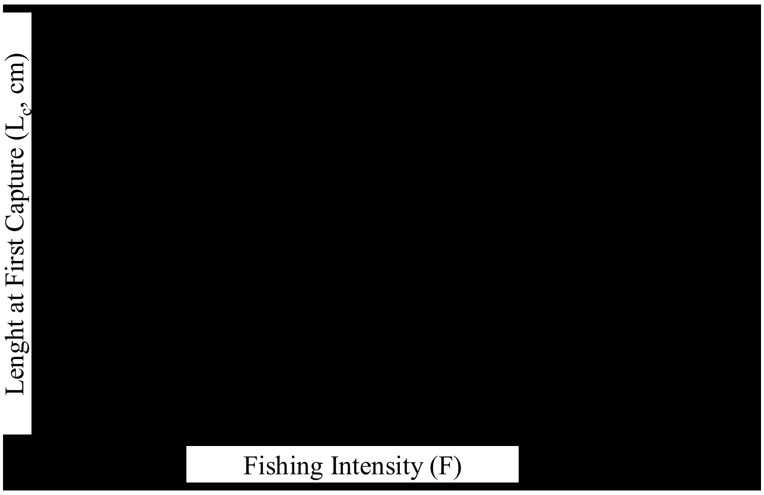

Figure 2. Yield isopleths diagram obtained for silverbelly in Yumurtalik Bight.

the females did. In agreement with this, Bingel (1987) found that the (b) value of silverbelly was 2.9286 for the Mersin and Iskenderun bays in the Northeastern Mediterranean. We can therefore state that silverbelly in the Yumurtalık Bight had a smaller and fatter bodies and showed more positive allometry in their growth than silverbelly in the Northeastern Mediterranean. The common length for silverbelly in Yumurtalık Bight was found to be between 5 and 7 cm. Bingel (1987) determined the common length for silverbelly in the Mersin and Iskenderun bays to be 5–7 cm, and Ben-Tuvia (1966) also arrived at the same value for silverbelly in the Mediterranean Sea. Hence, it can be claimed that the common-length groups in the studies mentioned above in this study show suitability.

It is reported that the maximum length of this species, or in other words its asymptotic length (L_∞), is 11 cm in the Mediterranean Sea and in the Suez Canal (Tortonese, 1975), 18 cm on the coasts of Turkey (Akşiray, 1987), and 11 cm once again in the Northeastern Mediterranean. In this study, the maximum length obtained was 10.20 cm for the males, 10.87 cm for the females, and 10.28 cm for their total. It can be seen that these values obtained for the Yumurtalık Bight were comparable to those reported by Bingel (1987) for the Northeastern Mediterranean.

Bingel (1987) found the fishing mortality rates (F) to be 1.280 and 1.130; the natural mortality rates, 1.728 and 1.071; and the total mortality rates, 1.405 and 2.050 for silverbellies in the Mersin and Iskenderun bays, and reported that the total mortality rates of this species in both bays were very high. In this study, however, the corresponding values were calculated to be (M) = 0.646; (F) = 0.315; and (Z) = 0.961 were calculated (Table 5). Clearly, the mortality rates calculated in the present study were much lower than the those reported by Bingel (1987). Due to this, it can be claimed that less fishing pressure was applied to silverbelly in the Yumurtalık Bight than in the other states of the region. The fact that artisanal fishery in Yumurtalık Bight was continuously forbidden further supports this hypothesis.

The total, natural, and fishing mortality rates, which were calculated to be 0.9609, 0.6460 and 0.3149, respectively, showed that natural mortality rates were higher than fishing mortality rates and as a result, the benefit seen in the related stock was inadequate. In a situation using the mortality parameters, it the exploitation rate of silverbelly in Yumurtalık Bight came out to be 0.33 (Table 5). Considering that the maximum level of production was obtained when the exploitation or the utilization rate was $E \cong 0.5$ or in other words, when $F \cong M$, which indicates either inadequate use or overuse of the stocks, it is suggested that the existing exploitation rate be increased by 37% in order to maximize benefit from the stock. Moreover, it is clear that this species was experiencing inadequate fishing pressure (Figure 2). There was no match between the length at first capture of the fish and fishing power; in other words, the benefit from the species fell short of optimal. Bingel (1987) found in his study that the exploitation rates of the population of silverbelly in the Mersin and Iskenderun bays were 0.84 and 0.74, respectively, so these stocks were being exploited at an extremely high rate, and there was no match between fishing power and fish body length at first capture. In the same study, he shows in a yield isopleth diagram that the same amount of yield can be obtained even when the mesh size was increased and intensity of fishing was decreased by 50% following the period of first capture. In other words, there was a contradiction between our results and Bingel's (1987), in which he found approximately the same level of exploitation of silverbelly 15 years ago as in the present study. It may even be the case that the fishing power applied to this species decreased over the past 15 years. If so, it can be reasonably inferred that the level of exploitation was found to be inadequate in this study.

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