RESEARCH ARTICLE **(Open Access)**

Length Frequencies Analysis and Aength-Aeight Aelationship of European Hake (*Merluccius merluccius*) and Red Mullet (*Mullus barbatus*) in the South - East Adriatic (Albanian Waters)

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Abstract

The European hake (*Merluccius merluccius*) and red mullet (*Mullus barbatus*), due to their abundance and high market value, represent important resources to the industrial fishery in the costal countries of the Adriatic Sea. Data on biology and population dynamic in the south-eastern part of the Adriatic are almost absent while in other parts of the Adriatic they are well studied. This study focuses on the length frequencies distribution according to the sample collected from industrial catches. The parameters *a* and *b* of the length-weight relationship are estimated by the logarithmic transformation of Le Cren equation $W = a \times L^b$. The samples were collected from July to September 2020, 70 – 90 samples for each species, were collected, each month, from the landings of the fishing vessels in the fishing port of Durres. The results show that 18.3 % of the samples are smaller than the minimum conservation size. They indicate that both species exhibited a negative allometric growth. Further studies should be implemented in the future in order to have a database for comprehensive studies and a detailed evaluation of the growth and status of both species.

Key words: Natural resources, Adriatic Sea, Growth, Exploitation

1. Introduction

European hake (*Merluccius merluccius*, Linnaeus, 1758) with 14.1% of the total catches and red mullet (*Mullus barbatus*, Linnaeus, 1758) with 5.6 % of the total catches are two of the most important resources exploited by the industrial fishery along the Albanian coast.

European hake is a demersal fish, generally found on muddy bottoms, which inhabits the north-east Atlantic from Norway to Mauritania, including the Mediterranean Sea (Froese & Pauly, 2014). European hake is a resource of major importance in the Mediterranean, due to its high market value (Pineiro & Saınza 2003). Hake is distributed throughout the Adriatic (Jukic & Arneri, 1984), its main nursery areas are the Pomo (Jabuka) pit in the central Adriatic (Zupanovic & Jardas, 1986), and in the southern part of the Albanian coast (Frattini and Paolini, 1995). Its depth distribution is up to 800 m in the South Adriatic Pit, unlike the northern and central part of the Adriatic Sea where adults are mainly caught at depths of 100 to 150 m in the southern Adriatic the largest individuals are caught in waters deeper than 200 m (Ungaro et al., 1993; Vrgoč et al., 2004).

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The observed maximum lengths of European hake in the Adriatic were 93.5 cm for females and 66.5 cm for males, both registered during MEDITS samplings; its usual length in trawl catches ranges from 10 to 60 cm (STECF 2019). Total landings of the European hake from the Albanian trawlers have been around 900 tonnes in the last 7 years, meanwhile the overall catches from the countries exploiting the same resources in the Adriatic have been around 6000 tonnes in the last five years.

Red mullet (*Mullus barbatus* L., 1758) is a benthic species that inhabits the sandy and muddy bottoms, it has a widespread geographical distribution all around the Mediterranean and Black Sea, in the eastern Atlantic from Scandinavia to Senegal (Fischer et al., 1987). The habitat ranges from the shallow littoral coasts down to 300 m although depths between 20 and 200 m are preferred (Tserpes et al., 2002). It prefers the shallower waters of the northern and central Adriatic, i.e. depths above 100 m, while the population abundance decreases with depth (Jukić and Piccinetti, 1981; Jukic & Arneri, 1984). Red mullet grows up to about 30 cm, its usual length in catches is 10 to 20 cm. On average, females have greater body length than males; they also grow faster, which can be already noticed in the first year of their life (Jardas, 1996; Haidar 1970). Almost all the bigger individuals are females (28 to 29 cm), meanwhile males do not grow more than about 20 cm (Relini *et al.*, 1999). Catches of red mullet in GSAs 17-18 show a constant pattern, with a slight increase from 2012 and a consistent increase in the last year (STECF, 2019).

The scientific surveys carried out in the Adriatic have revealed an increase in the density and in the biomass indices, but still the fishing mortality (F) is very high and the catches of the European hake, which are dominated by juveniles, should be reduced by at least 58%, meanwhile the catches of red mullet should be reduced by at least 22% to reach $F_{MSY.}$ Since both species have a great commercial value, they are a main target species of coastal fisheries in the Mediterranean. Accordingly, they are subject to regular stock assessment, which has provided evidence of their status in most geographical Mediterranean sub-areas (STECF, 2019).

Length–weight relationships for fish were originally used to provide information on the condition of fish to determine whether somatic growth was isometric or allometric (Le Cren, 1951; Ricker, 1975). They are very useful for fisheries research because they: allow conversion of growth-in-length equations to growth-in-weight for use in stock assessment models, allow the estimation of biomass from length observations, allow an estimate of the condition of the fish, and are useful for between-region comparisons of life histories of certain species (Froese and Pauly, 1998; Moutopoulos and Stergiou, 2002). Fish can attain either isometric growth, negative allometric growth or positive allometric growth. When there is no change of body shape as an organism grows the growth can be considered as isometric. When fish become more elongated as it increases in weight it is considered as a negative allometric growth while positive allometric growth implies the fish becoming relatively stouter or deeperbodied as it increases in length (Riedel et al., 2007).

There are not many studies on the length–weight relationship (LWR) of fish along the coasts of Albania, future studies concerning the LWRs of the fish species may be important to estimate the growth rate and to assess the condition and other components of fish population dynamics.

2. Material and Methods

2.1 Sampling Area

Samples for both species, European hake and red mullet, were collected randomly from the landings of the fishing vessels in the fishing port of Durres (Figure 1). 6 samplings were done from July to September 2020, distributed respectively: one sampling in June and July and two samplings in August and September. The sample size was 70-90 individuals for each species and it was done following the DCRF recommendations. Species were measured to the nearest 0.5 - cm total length (TL) and weighted to the nearest 0.01 g (total weight, TW).

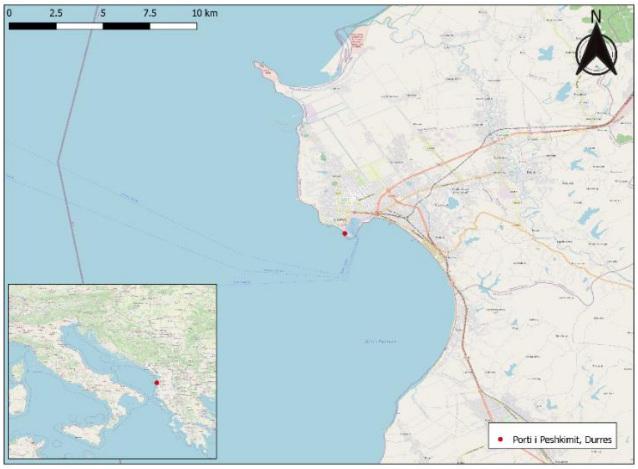

Figure 1. Geographic demonstration of the sampling area, the red dot indicating the fishing port of Durres

2.2 Length – weight relationship

Length-to-weight relationship for total body weight was calculated using the equation $W = a*L^b$, where W is the total weight (expressed in grams), L is the total length (expressed in centimetres), a is a coefficient related to body form and b is an exponent indicating isometric growth when equal to 3 (Ricker and Carter, 1958). In practice, fish that have thin elongated bodies will tend to have values of ***b*** that are less than 3 while fish that have thicker bodies will tend to have values of ***b*** that are greater than 3. Values of *b* smaller, equal and larger than 3 indicate isometry, negative allometry and positive allometry respectively.

When $b>3$, large specimens increase in height or width faster than in length. Conversely, when $b<3$, the large specimens have changed body shape, they become more elongated (Kuriakose, 2017). The parameters a and b were estimated by linear regression on the transformed equation: $\log(W) = \log(a) + b \log(L)$.

Table 1. Minimum, maximum and mean length and weight, the length-weight relationship parameters for European hake and red mullet.

Species	Nr.	Total length (cm)			Total weight (g)			LW Relationship		
		Min.	Max.	Mean ± SD	Min.	Max.	Mean ± SD	a	b	R^2
Merluccius merluccius	360	15	51	26.9 ±7.8	30	930	169.4	0.012105	2.81513	0.964
Mullus barbatus	320	13	28	18.3±3	25	175	75	0.03456	2.62402	0.936

3. Results and Discussion

During this study, a total of 680 specimens were collected from whom 360 specimens of European hake and 320 specimens of red mullet. The length range, weight range and LW relationship parameters (a, b and R^2) were estimated for both species (Table 1). As it is very clear from the results the European hake specimens are larger compared to red mullet whose total length is less than 30 cm. The total length range was 15-51cm (Mean = 26.9 ± 7.8 cm) for *Merluccius merluccius* and 13-28 cm (Mean = 18.3 ± 3 cm) for *Mullus barbatus.*

Around 18 % of the hake individuals sampled were found out to be less than the minimum conservation size of 20 cm, while this issue was not observed in the case of red mullet where all the sampled individuals were within the conservation size of 11 cm (Figure 2). Similar concerns about European hake are observed also in other parts of the Adriatic Sea, highlighted also from the EWG working in the stock assessment of demersal fish in GSA 17 and GSA 18, implying exploitation is far from MSY (STECF 2019).

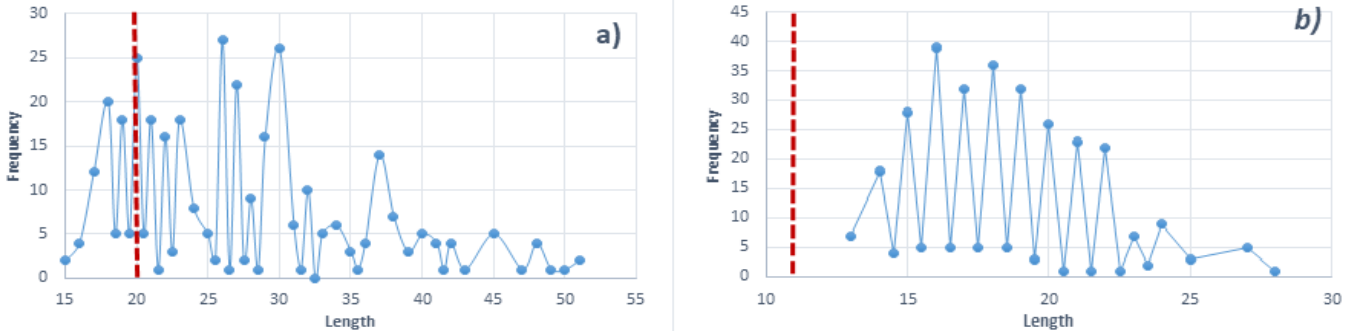

Figure 2. Catch at length frequency for both species, a) Merluccius merluccius, b) Mullus barbatus

European hake length classes mostly observed during our study were 20-24.5 and 25-29.5 cm, indicating that the majority of species are caught immediately after their recruitment in the population. High presence of young individuals and the low presence of larger length classes in the sample may be an indicator of high exploitation of this species. (Figure 3) (Martínez-Baños et al. 2018). The maximum length observed was 51 cm (930 g), which is compatible with the usual length in the trawl catches but far from the maximum grow length of 130 cm (STECF 2019, Jardas, 1996).

The mean and maximum value of the total lengths of the individuals obtained during July is slightly greater compared with the samples collected overall the study period (Figure 4).

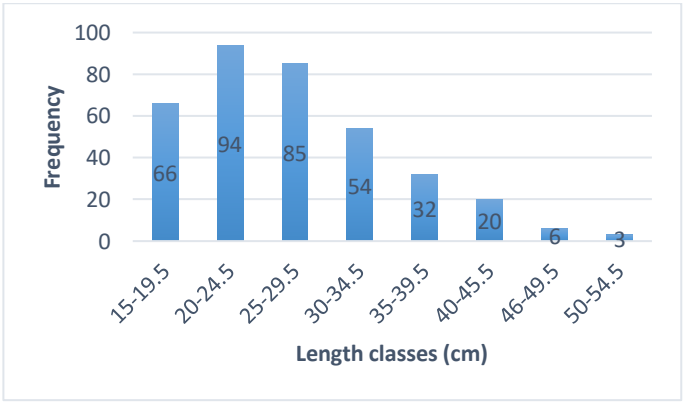

Figure 3. Length frequency distribution for European hake

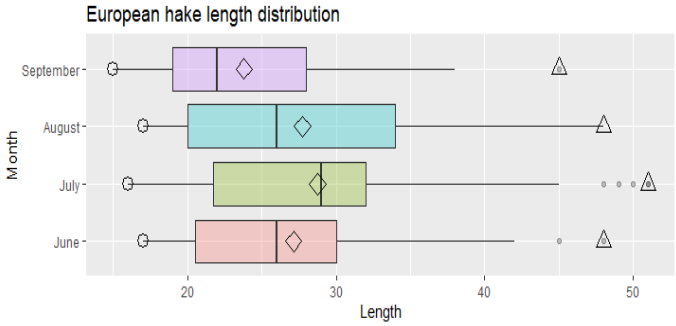

Figure 4. Boxplot of length distribution of European hake across the study period. (○ – indicates the minimum length, ◊ - indicates the mean length, Δ – indicates the maximum length)

Individuals of M. barbatus measuring less than the minimum conservation size of 11 cm TL, were not recorded. The maximum length obtained was 28 cm (170 g), which is compatible with previous records and the maximum grow length of 30 cm (Jardas, 1996). The most frequent length classes were 15-20 cm (Figure 5). The presence of length classes larger than 25 cm is very low. The minimum, maximum and mean lengths of the samples collected were similar for every month during the study period (Figure 6).

The length weight relationship for hake is expressed by the equation: $W= 0.01295 * L^{2.81513}$. The R^2 value ($R^2 = 0.964$) indicates that there is a good relationship between length and weight data. The "b" coefficient equal to 2.81513, indicates negative allometry, hake species have changed their body shape, they become more elongated (Figure 7). The length weight relationship for red mullet is expressed by the equation: $W = 0.0345 * L^{2.62}$. The R^2 value ($R^2 = 0.9368$) indicates that there is a good relationship between length and weight data.

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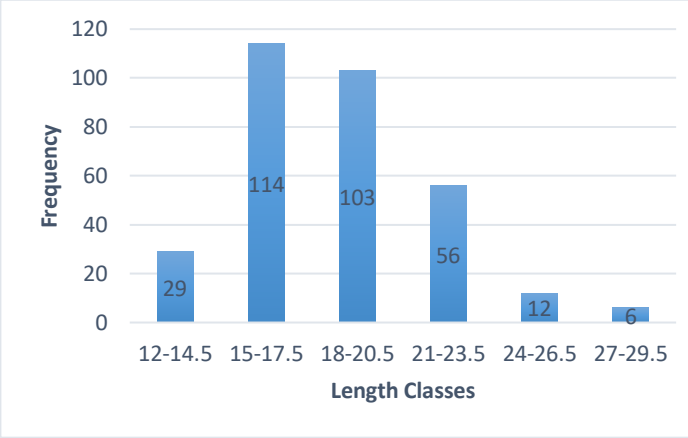

Figure 5. Overall length frequency distribution for red mullet

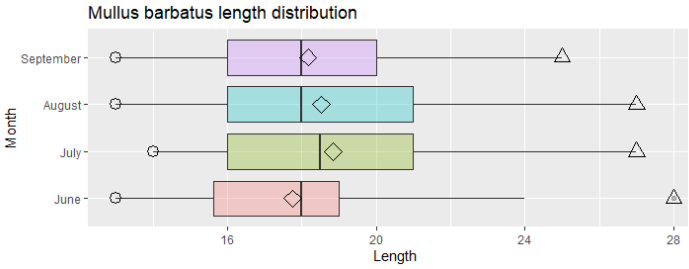

Figure 6. Boxplot of length distribution of Mullus barbatus across the study period. (○ – indicates the minimum length, ◊ - indicates the mean length, Δ – indicates the maximum length)

The "b" coefficient is significantly different from 3 and it shows a negative allometric growth, the fish becomes thinner with increase in length (Figure 8). The parameter b may vary seasonally and it is affected by a number of factors including gonad maturity, sex, diet, stomach fullness, health, and preservation techniques as well as season and habitat (Türker and Bal, 2018). Further studies distributed through all the year and with a bigger sample size may give more accurate results.

4. Conclusions

Even though hake and red mullet are two of the most important species for trawl fishery in the Albanian coast, the biology and population dynamics of this species in this part of the Adriatic Sea are less studied, while it is well studied in other parts of the Adriatic. The minimum and maximum lengths observed for European hake were 15 cm (30 g) and 51 cm (930 g), while for red mullet 13 cm (25 g) and 25 cm (170 g), the observed lengths are compatible with the usual length in the trawl catches reported in the Adriatic.

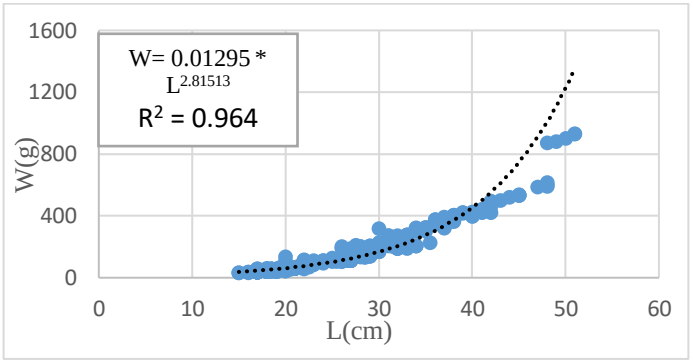

Figure 7. Length weight relationship of European hake (n = 360 individuals)

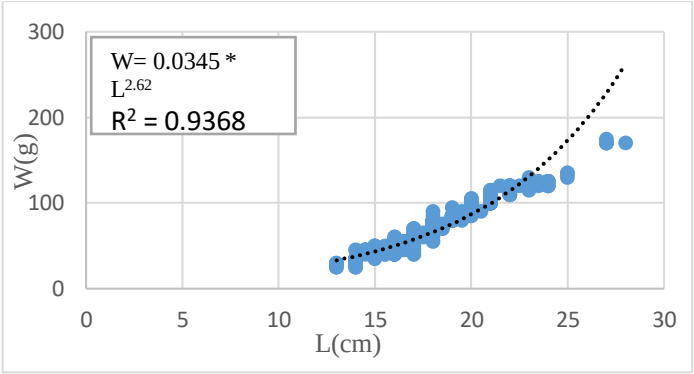

Figure 8. Length weight relationship of red mullet (n = 320 individuals)

High presence of young individuals in the catches for European hake is an indicator that this species has suffered overexploitation in the past. This data, supported even by the recommendations of EWG, working in the stock assessment of demersal species in the Adriatic, suggest a reduction of fishing mortality in order to reach the MSY. The presence of large individuals in the sample is very low for both species.

The estimation of growth parameters, "b" coefficient is significantly different than 3, showing a negative allometric growth for both species. According to LWR the fish becomes thinner with an increase in length. As this is a benthos species, the composition of sea bottom has a significant impact as well as the organic productivity of the area and intensity of fishing. All these factors have complex interactions and therefore influence the population dynamics of

these species. (Joksimović et al., 2008). A continuous monitoring of the fish populations is important in order to evaluate the basic parameters of fish biology in an up-to-date manner. The growth parameters, together with other population dynamics data are very important in the formulation of fisheries policies for the efficient use of the fishery resources.

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