LENGTH – WEIGHT RELATIONSHIP, SEX RATIO AND LENGTH AT MATURATION OF *MERLUCCIUS MERLUCCIUS* (LINNAEUS 1758) FROM THE MONTENEGRIN SHELF

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RASPODELA DUŽINSKIH FREKVENCIJA, DUŽINSKO TEŽINSKI ODNOSI, ODNOS POLOVA I DUŽINA DOSTIZANJA POLNE ZRELOSTI OSLIĆA (*MERLUCCIUS MERLUCCIUS*, LINNAEUS 1758)

Abstrakt

U radu se iznose rezultati analize oslića (Merluccius merluccius, Linnaeus 1758). Analizirani su uzorci oslića iz ulova komercijalnih koćara. Uzorci su uzimani tokom dvanaest meseci, od 2007. do 2008. godine sa koćara iz tri najvažnije ribarske luke u Crnoj Gori (Bara, Budve i Herceg Novog). Analizirana je raspodela dužinskih frekvencija, izračunati su i dužinsko težinski odnosi, odnos polova i dužine dostizanja polne zrelosti.

Key words*: Merluccius merluccius, length-weight relationship, maturity, sex ratio, South Adriatic*

INTRODUCTION

This article is based on the research done within the frame of AdriaMed Trawl survey Project 2007/08. The Project encompassed monthly research of several target species in trawl fisheries of Montenegrin waters during one year.

European hake (*Merluccius merluccius*, Linnaeus, 1758) represents an important component of the demersal ecosystem and a resource of great economic value. It is widely distributed in all the Mediterranean, and it is one of the most heavily exploited

demersal species in European fisheries.

Earlier investigations of hake on Montenegrin shelf were related to the spatial distribution (M e r k e r *et al*., 1973; J u k i ć and A r n e r i, 1983), nutrition (R a d u j k o v i ć, 1980), and on length – weight relationship (R e g n e r and J o k s i m o v i ć, 2001).

MATERIALS AND METHODS

Investigated area included trawl fishery at open sea of Montenegrin territorial waters (Figure 1). Catch of commercial trawlers from three most important Montenegrin fish ports (Herceg Novi, Budva, Bar) were analyzed. Duration of hauls was 3 to 4 hours. Samples were collected and proccessed immediately after the fish landing. Total number of individuals was 450, and their weight was 34.89 kg.

Figure 1. Distribution of Montenegrin fishing effort in the Adriatic Sea (investigated area)

Hauls were performed at depths ranging from 80 to 200 m. Total length (TL) was measured to the nearest 1 mm, weight (W) was measured to the nearest 0.01 gram and maturity stages of the gonads were determined by a macroscopic observation of the gonads of 450 specimens. MEDITS protocol (http://www.ifremer.fr/Medits_indices/) was used for maturity determination.

The sex ratio, as a fraction of males over the total of males and females combined was computed for each survey.

Length-weight relationship was approximated with power function of the form:

$$W = aL^b \qquad (1),$$

where W is body weight (g), L is total length (cm), while *a* and *b* are constants.

The function (1) was linearized taking the logarithms W and L:

$$\log W = \log a + b * \log L \qquad (2).$$

Equation (2) was fitted to the data, and constants *a* and *b* were estimated with linear regression model (S o k a l & R o h l f 1981), where log L was independent and log W dependent variable.

Linear regression was estimated from logarithms of average values of 0.5 cm length class intervals.

RESULTS AND DISCUSSION

The following results for the length - weight relationship were obtained:

a = -2.318
b = 3.1095

Antilogarithm of the coefficient **a** is:

a = 0.0048

Standard error of the constant *b* was $S_b = 0.0325$, and the confidence limits for 95% probability levels were from -2.3776 to -2.2585, coefficients of determination and correlation were $r^2 = 0.997$ and $r = 0.999$.

So, the lenth-weight relationship of *Merluccius merluccius* in the open part of Montenegrin shelf is:

$$W = 0.0048\ L^{3.1095}$$

The length-weight relationship is shown in Figure 2.

The power coefficient of the LW relationship was ***b*** = 3.1165 in females, and ***b*** = 3.096 in males (Figure 2).

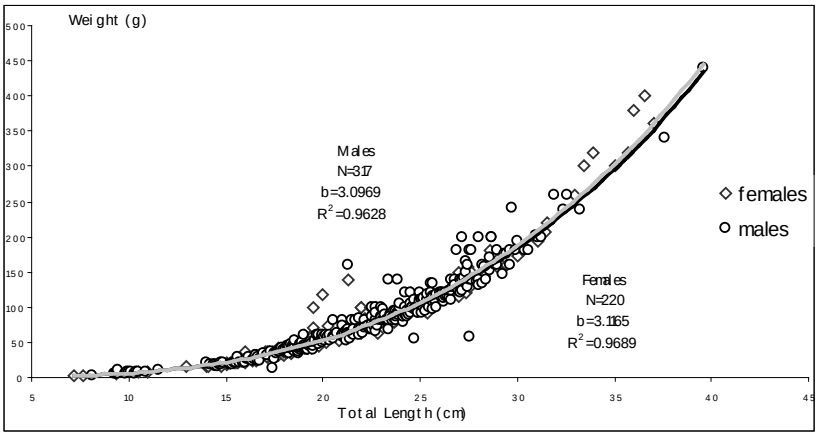

Figure 2. Length-weight relationship curves for males and females *Merluccius merluccius* in territorial waters of Montenegro.

R e g n e r and J o k s i m o v i ć (2001) found that length – weight relationship parameters for unsexed hake, collected from the same area during the period from 1997 to 2000 was ***a*** = 0.0035, and **b** = 3.1548. These vales of ***a*** and ***b*** are in good accordance with our data. Values of ***a*** and ***b*** obtained from these two surveys show that length – weight relationship of hake did not vary significantly over long period of time.

The catches of *M. Merluccius* were characterised by a very broad size range, from 7.2 to 39.6 cm, but quite rearly, TL exceeded 31 cm. The males mean size (21.71 cm) was greater than females (20.76 cm).

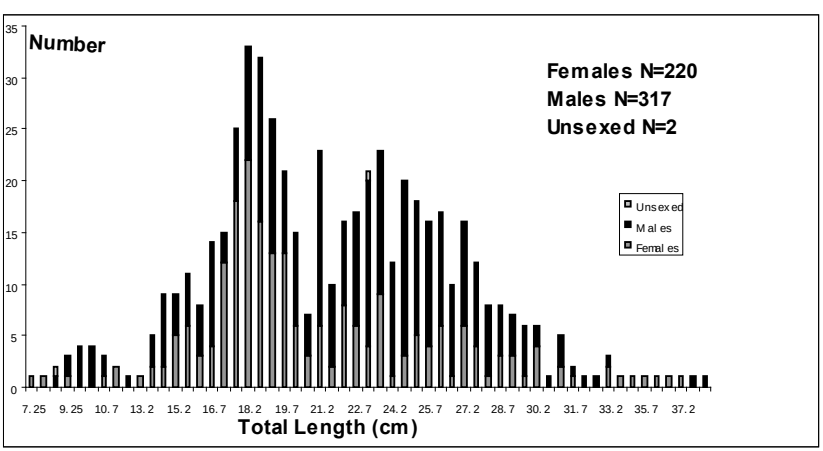

Figure 3. Length frequency distribution by sex of *Merluccius merluccius*. N = number of specimens

Percentages of males and females, computed from the total sample of 450 individuals showed that males took the largest fraction (Fig. 4).

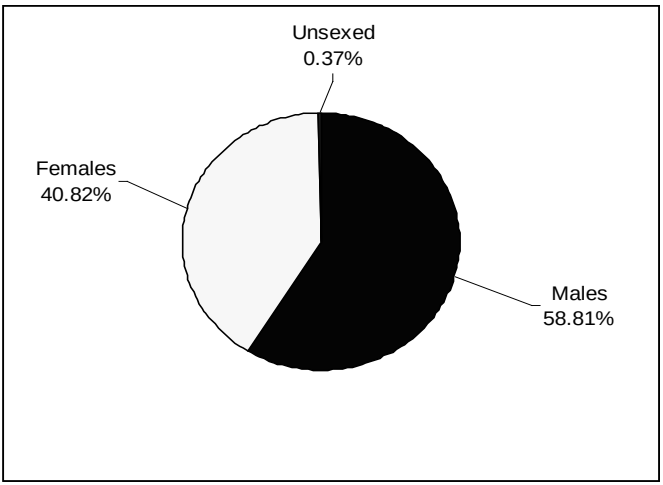

Figure 4. Sex ratio computed from the total sample of catch of *Merluccius merluccius*.

European hake spawns all around the year, but most intensive spawning is in the winter and spring in 100-300 m of depth. Females reach maturity between 23-33 cm (mostly 29-32) and males between 20-28 cm (23-25).

Females attain larger size than males, who grow more slowly after maturation at the age of three or four years. Consequently, the proportion of males in the population is higher in lower length classes and proportion of females is higher at greater lengths. In the central and northern Adriatic, females already start dominating the population at lengths of about 30 to 33 cm. (V r g o č, 1995).

Mature specimens of *M. Merluccius* were found at wide size range, TL varying between 13 and 37 cm in females and 14 and 39.6 cm in males. Only one post-spawning female and one post-spawning male were caught during the whole sampling activity. Percentages of immature (stage 1), maturing (stage 2), mature (stage 3) and post-spawning (stage 4) specimens are shown in table 1.

Table 1. Percentage of immature(stage 1), maturing (stage 2), mature (stage 3) and resting (4) *M. Merluccius* specimens per sex.

Maturity stage				
	1 (%)	**2 (%)**	**3 (%)**	**4 (%)**
Females	29.66	67.04	2.75	0.55
Males	32.55	59.22	7.84	0.39

The length frequencies of females and males (Fig. 3), show that 67.3% of individuals caught were below 23 cm lenght. Such a disproportional cathch of immature individuals may cause serious problems for the recruitment of the hake. This implies that some measures have to be undertaken to avoid overfishing of recruits. Possible measures are either decreasing of fishing effort or increasing the mesh size of the trawls codends. The latter seems to be more realistic, since there is no general overfishing of demersal species in Montenegrin territorial waters. Namely, after the data FAOAdriaMed (2004),

Montenegrin fleet of trawlers is one order of magnitude smaller than the fleets of the other Adriatic countries, particularly if the numbers of trawlers per surface unit of fishing areas are compared. Consequently, owing to low fishing capacity, it cannot cause overfishing of demersal species.

The logistic model fitted to proportion of mature specimens as a function of length (TL) provided an estimate of $L_{50\%}$ of 16.9 cm TL for both sexes combined. (Figure 5)

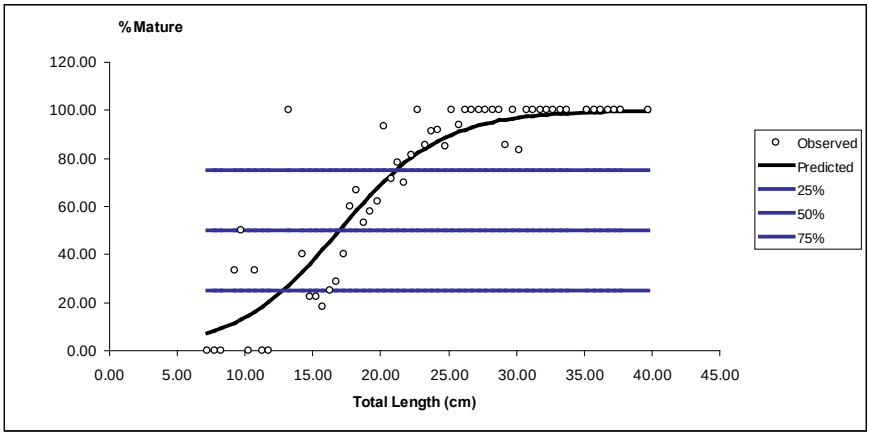

Figure 5. The results of logistic curve fitted to the proportion of mature *Merluccius merluccius* specimens by length groups.

R e g n e r and J o k s i m o v i ć (2001), using the method of polynomial decomposition of length – weight data developed by R e g n e r and D u l č i ć (1994), found two inflection points in L – W data series of the hake on Montenegrin shelf. The first one was at the length of 14.32 cm, and the second at 28.21 cm. They concluded that the first point shows transition from juvenile to adolescent phase, while the second points out the length of full maturation. This length coincides well with our estimate of the length of 100% maturation (Fig. 5).

CONCLUSIONS

Researches showed that the parameters of length – weight relationship of the hake do not vary significantly over long period. They also show that the catches consisted of disproportional high number of immature fish. Some measures, such as increasing the mesh size of codends, have to be undertaken to avoid observed overfishing of recruits.

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