

Observations on three condition indices of garfish *Belone belone* (L., 1761) from the Adriatic Sea

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ABSTRACT

*The objective of this study was to look at condition factors profiles of garfish *Belone belone* population inhabiting Adriatic Sea. All analysed specimens were caught with seine net in the Adriatic Sea (Croatian fishing ground) from January 2003 to December 2008. Trends of Fulton's, empirical and relative condition factors were analysed by sex, length and seasons. Due to analysis obtained, relative condition factor distinguishes itself as the most appropriate one for description of garfish well being.*

Keywords: Condition indices, *Belone belone*, Adriatic Sea

INTRODUCTION

Garfish, *Belone belone* (Linnaeus, 1761), is a pelagic, oceanodromous fish species largely spread in brackish and marine waters of the north-eastern Atlantic, Mediterranean and the Black Sea (Colette & Parin, 1986). As a pelagic fish species garfish has migratory pattern; they live mainly in offshore areas, except during the spawning period (January – May) when they migrate into coastal regions (Zorica *et al.*, 2010). Although it is widely distributed in the Adriatic Sea, garfish is considered as a minor commercially important fish species (National fishery statistics), and they are mainly caught with seine nets (stretched mesh size 10-30 mm) that are used only along the Middle Eastern Adriatic Sea (around the islands

Vis, Korčula, Iž and Susak). In recent years, biological knowledge of garfish population inhabiting Adriatic Sea is quite well documented (Zorica *et al.*, 2010; Zorica & Čikeš Keč, 2013), but the data concerning its condition are missing.

It is well known that condition factors are frequently used in standard fisheries ecology practice. Namely, numeric values of condition correspond to “well-being or the fitness” of fish populations (Booth & Keast 1986; Bolger & Connolly, 1989). Overview of the literature shows that it is obvious that scientist should be very careful in choosing the most suitable condition factor by taking into account and examining the properties of their data sets (Bolger & Connolly, 1989). Hence, the main aim of this study was to describe the trends of three condition indices and give an insight in garfish condition by describing their changes in females and males due to garfish length and seasons through study period, and in that way to detect the most suitable one for describing this fish species.

MATERIALS AND METHODS

Garfish specimens were collected monthly in the eastern part of the middle Adriatic Sea from January 2003 to December 2008 with the exception of a few months when, due either to logistical problems or weather conditions, sampling was not possible. Nevertheless, no samples were obtained in June throughout all investigation period, even though sampling and fishing effort did not cease.

Samples of garfish were collected at night using seine net with stretched mesh of size 10 mm (the main net) to 34 mm (the net cod end). A total of 3,393 individuals, 1,166 males and 1,195 females were analysed in the laboratory, immediately after landing. For each specimen, the total

length (TL) was measured to the nearest 0.1 cm, and body weight was measured on a digital balance with 0.1 g accuracy. Sex determination was done macroscopically.

Three condition factors were calculated separately for each sex and overall according to Le Cren equations (1951):

$$- \text{ Fulton's condition factor: } K = 100 \frac{W}{TL^3} \quad (1)$$

$$- \text{ Allometric condition factor: } K_a = 100 \frac{W}{TL^b} \quad (2)$$

$$- \text{ Relative condition factor: } K_n = 100 \frac{W}{aTL^b} \quad (3)$$

The parameters a and b were derivate from length-weight relationship (males: $a=0.0001$, $b=3.638$; females: $a=0.0002$, $b=3.4597$; total: $a=0.0002$, $b=3.4818$) which were previously published (Zorica & Čikeš Keč, 2013). All analysed condition indices for both sexes and overall were calculated as a function of total body length. Seasonal variations of mentioned parameters were also examined.

RESULTS

Total length of all collected garfish specimens ($N=3393$) ranged from 20.8 to 75.4 cm (mean \pm SD: 38.3 \pm 7.94 cm). Males and females garfish total length varied between 27.7 - 62.6 cm ($N=1166$; mean \pm SD: 37.4 \pm 5.37 cm) and 27.2 - 75.4 cm ($N=1195$; mean \pm SD: 43.6 \pm 9.12 cm), respectively (Figure 1). An overall sex ratio was 0.98, which insignificantly deviated from the hypothetical distribution of 1:1 ($\chi^2= 0.332$, d.f=1, $P<0.05$).

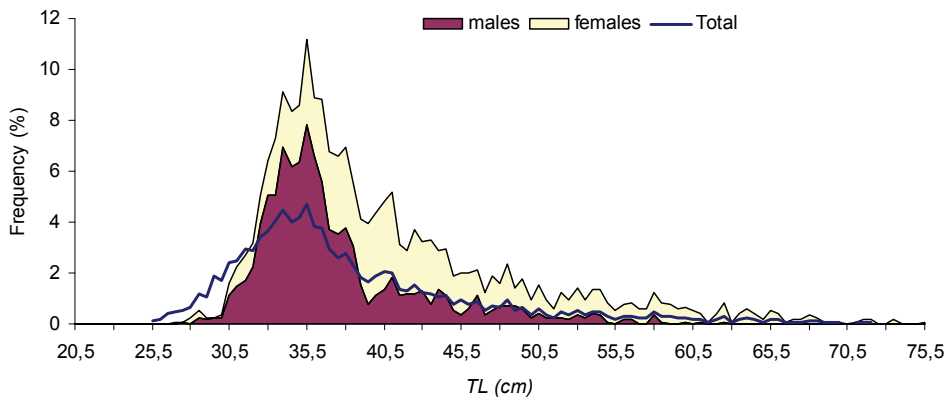


Figure 1. Length frequency distribution of male, female and overall garfish specimens, Middle Eastern Adriatic Sea, 2003 – 2008.

All three condition indices analysed as the function of the total length for both sexes and overall are shown in Figure 2.

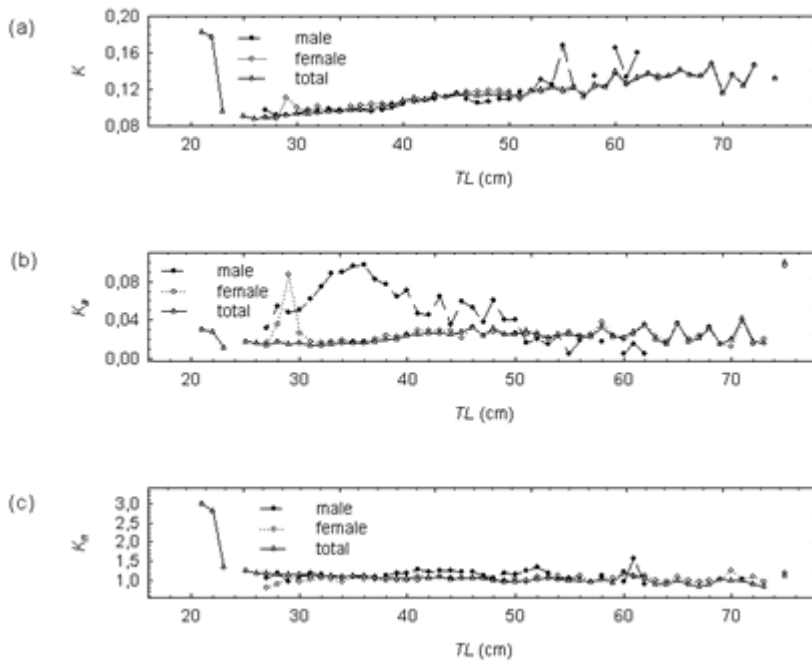


Figure 2. Oscillations of Fulton's (a), allometric (b) and relative (c) condition factors with garfish size (TL , cm) obtained separately for each sex and overall, middle Eastern Adriatic Sea, 2003 – 2008

For garfish male specimens Fulton's condition factor (K) values fluctuated from 0.092 to 0.169 (mean $K=0.113 \pm 0.020$), while for females this value was within the limits of 0.088 to 0.149 (mean $K=0.117 \pm 0.015$). Mean value of Fulton's condition factor for the whole analysed material, which included also the specimens which sex was not possible to determine ($N = 1032$), was 0.117 ± 0.020 , with a minimum and maximum value of 0.088 and 0.182, respectively. According to obtained values of Fulton's condition factor (Figure 2a) it seems that values of mentioned factor increased with an increase in total body length. Significant "leaps" of this condition factor have been observed for garfish specimens from the 21.0 cm to 22.0 cm length classes, and for males in length classes between 55.0 cm to 62.0 cm.

The mean value of the allometric condition factor (K_a) in relation to the length of males ranged within the limits of 0.004 to 0.097, females 0.013 to 0.096, while the mean values for males and females were 0.047 ± 0.276 and 0.027 ± 0.015 , respectively. Overall values of mentioned factor varied from 0.011 to 0.099, with the mean value of 0.024 ± 0.013 . For males values of the allometric condition factor increased with an increase in total body length till total length of 36.0 cm was reached ($K_a = 0.10$), while onwards slight decreases with increasing total length (LT) was observed (Figure 2b). Although the values of the allometric condition factor of male's decreases after length class of 36.0 cm, it was evident that males were still in better shape than females till total length values reached 50.0 cm. Afterwards, females had slightly greater allometric condition factor values than males. Allometric condition factor values obtained for a whole sample reveal its slightly increasing trend with an increase in total

garfish body length, with pronounced fluctuations in larger specimens ($TL > 45.0$ cm) (Figure 2b).

The range of the relative condition index (K_n) values for males, seen in the function of the total length was between 0.897 to 1.560 (mean $K_n = 1.148 \pm 0.120$), while for females fluctuated from 0.793 to 1.258 (mean $K_n = 1.042 \pm 0.076$). In the whole analysed sample the relative condition factor ranged from 0.832 to 2.989, with the mean value of 1.119 ± 0.369 . The values of relative condition factor for males and females, and the overall shown almost the same trend – K_n slightly decreased with the increase in total body length (Figure 2c). Also, smaller garfish individuals had a better condition than individuals from higher length classes.

Fluctuations of these three factors were also observed during the seasons (Figure 3) separately for each sex and overall. In this case, the analysis was done only on individuals whose total body length ranged from 30.0 cm to 50.0 cm in order to minimize the impact of the length.

Seasonal fluctuations of the mean Fulton's condition coefficient were very poorly expressed in both sexes and no regularity was observed (Figure 3). The highest mean value of this coefficient for males was recorded during the autumn ($\bar{K} = 0.115 \pm 0.014$), and lowest during the spring ($\bar{K} = 0.099 \pm 0.010$). In females, the mean value of the same coefficient was the highest in spring ($\bar{K} = 0.118 \pm 0.016$), and lowest in winter ($\bar{K} = 0.102 \pm 0.012$).

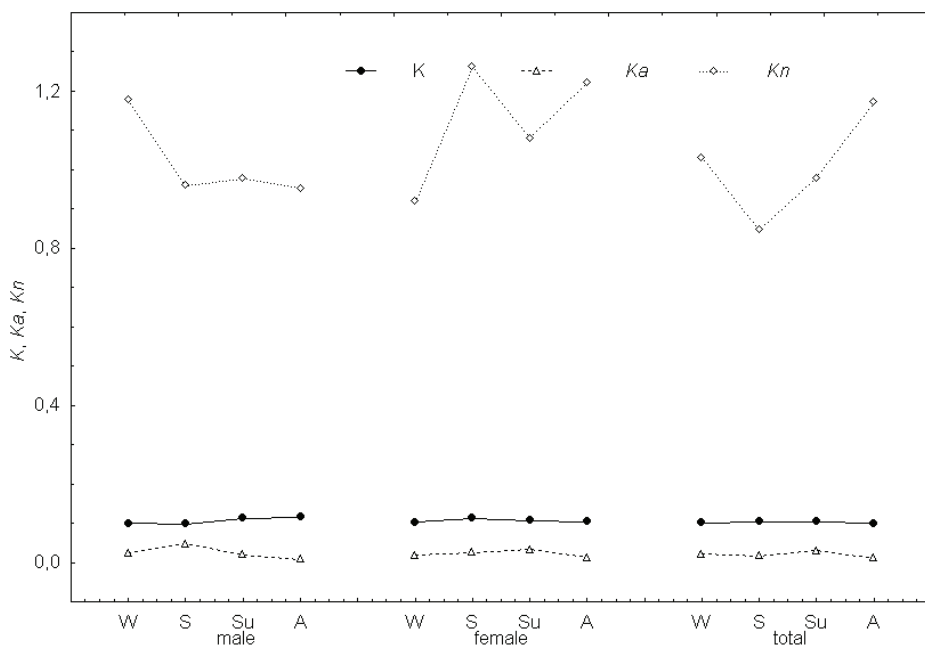


Figure 3. Seasonal fluctuations of three condition factors (K , K_a , K_{rel}) by sex and for whole garfish sample collected along Middle Eastern Adriatic Sea from 2003 to 2008.

Males monthly mean values of the allometric condition index oscillated during the year and in terms of seasons, allometric condition factor reached its maximum value during the middle of winter ($\bar{K}_a = 0.077 \pm 0.005$). After that, the value of the condition factor gradually decreased to the minimum average value ($\bar{K}_a = 0.016 \pm 0.002$) recorded in the autumn. In females, the mean values of this condition index reached their peak during the summer ($\bar{K}_a = 0.050 \pm 0.005$), while the minimum average value of the observed condition factor was noted in the autumn ($\bar{K}_a = 0.012 \pm 0.002$), as well as it was in males (Figure 3).

The relative condition index and its mean values showed a different seasonal oscillation trends between the sexes (Figure 3). In males the

lowest mean value of the relative condition factor was observed during the spring ($\bar{K}_n=0.972\pm0.889$). After that, its value with mild oscillations grew slowly and reached maximum during the winter ($\bar{K}_n=1.220\pm0.127$). Mean values of relative condition index for females oscillated and the highest value was recorded during the summer ($\bar{K}_n=1.136\pm0.152$), followed by decrease through autumn and winter when the minimum value was reached ($\bar{K}_n=0.964\pm0.101$).

DISCUSSION

Analysis of garfish length frequencies were earlier published and discussed for the same population by Zorica *et al.* (2010) and Zorica & Čikeš Keč (2013), in papers dealing with its reproduction and growth pattern. Namely, observed garfish length range was the widest reported in comparison to length range of the same species obtained for Mediterranean and Black Sea probably due to used fishing gear and its vulnerability and selectivity.

Condition of garfish was described by three aforementioned coefficients (K, K_a, K_n). The values of the Fulton's coefficient were almost equal for males and females, although larger males ($TL>55.0$ cm) were in somewhat better condition than females of the same length. Nevertheless, Fulton's condition factor observed in function of length, in general, show increasing trend – as garfish grow its condition is getting better and better. The available literature data on condition or fitness of garfish individuals were described solely by Fulton's condition factor. Monthly mean values of Fulton's condition factor obtained for garfish population inhabiting Mediterranean Sea were slightly lower than those observed in this study -

from 0.08 to 0.14 (Bedoui et al., 2002). For the garfish specimens originating from the Black Sea aforementioned condition factor was reported by Uçkun *et al.* (2004) in greater range ($0.02 < K < 0.24$) than the one obtained in this study. Dorman (1989) recorded that values of the Fulton's coefficient ranged 0.104 - 0.134, but author analysed only garfish individuals caught during the peak of the spawning period along the south coast of Ireland. Garfish specimens caught along the coastal waters of Sweden had Fulton's condition factor between 0.129 and 0.143 (Dorman, 1991). The observed discrepancies in Fulton's condition factor values were most likely related to the fact that the total length of garfish specimens analyzed during this study was in much wider range - from 20.3 cm to 75.4 cm, whereas the mentioned authors examined garfish specimens whose total length varied from 24.0 to 57.0 cm. Seasonal oscillations of Fulton's condition factor showed an opposite trend to gonosomatic index (Dorman 1989, 1991; Bedoui *et al.*, 2002; Uckun *et al.*, 2004; Zorica *et al.*, 2010) pointing out that garfish were in worst condition during the peak of spawning period.

The values of the allometric condition factor (K_a) significantly varied in relation to the total garfish body length, especially in males (Figure 2). Generally, their oscillation was much more pronounced than the ones obtained for other two condition factors, which makes this parameter most unreliable.

Values of relative condition factor for males and females as well as for the overall sample were slightly decreasing with the increase in total body length but actually no significant fluctuations were observed. According to obtained values of the relative condition factor it was established that smallest garfish individuals ($21.0 < TL < 23.0$ cm) were in

best condition. In a way this was expected as those garfish specimens still did not reach length at first maturity, which was reported by Zorica *et al.* (2010) at 28.5 cm in the Adriatic Sea.

Taking into account all three indices, the relative condition index (K_n) seems to be the most appropriate condition factor to be used for monitoring seasonal fluctuations (Figure 2c) due to its stability obtained in function of total garfish body length. Observed seasonal variations of relative condition factor were correlated with spawning cycle of the same garfish specimens that were previously published by Zorica *et al.* (2010). Namely, spawning season of garfish in Adriatic begins in January peaking during March to May, but males begin to spawn one month earlier (April) than females (May). In males the lowest mean value of the relative condition factor was observed during the spring in the most intense period of spawning, hence can be concluded that male garfish individuals most probably spent almost all of their energy on releasing of spawning products. Female garfish had the highest mean value of the relative condition index during the summer when the spawning was completed. So, it appears that female garfish consume significantly more available energy for ovary recovery and development (autumn and winter).

It is known that each of the condition factors used to describe fish condition or fitness had its limitations which were well documented in some previous studies (Bolger & Connolly, 1989; Godinho, 1997). Hence, in this study all available garfish biological information was taken into account in order to analysis three condition indices. The results obtained gave preference to relative condition factor as the most suitable one for description of Adriatic garfish population well being.

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