

## MESENTERIC FAT AND CONDITION OF CHUB MACKEREL, *Scomber colias* IN THE ADRIATIC SEA

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### Summary

The aim of the study was to investigate lipid storage (as mesenteric fat) and condition (as Fulton's, allometric and relative coefficient) of *Scomber colias* in the Adriatic Sea. A total of 4,189 chub mackerels were sampled between January 1998 and December 2007 with fork length and weight ranged from 10.1-39.1 cm (mean±SD: 23.8±4.68 cm) and 8.90-804.50 g (mean±SD: 164.49±102.70 g), respectively. Seasonality of the fat reserves as well as condition had been noticed in this investigation. Namely, during the warmer part of the year, the fishes were without fat reserves and condition coefficients (Fulton's, allometric and relative) were low. Females had shown lower values than males in all condition coefficients. After the spawning season, chub mackerel males accumulated fat much more quicker and faster than the females

**Key words:** *Scomber colias*, chub mackerel, Adriatic Sea, mesenteric fat, condition

### INTRODUCTION

The chub mackerel, *Scomber colias* Gmelin, 1789, is a pelagic, schooling fish species widely distributed in temperate and warm waters of the Atlantic, Pacific and Indian Ocean (Collete and Nauen, 1983), as well as in the Mediterranean and the Adriatic Sea (Whitehead et al., 1986). This migratory species usually dwells in the depths between 0 and 250 - 300 m. From April till September, it migrates towards the coastline and channel areas for spawning (Čikeš Keč and Zorica, 2012). After spawning, the adults and their offsprings migrate to the deeper and colder offshore areas (Nikolsky, 1954). Driven by feeding activities, chub mackerel is also well adapted to vertical daily migrations (Maugret and Ly, 1986).

Together with other small and mid-sized pelagic fish species, chub mackerel is an essential element of the marine ecosystems. Due to its biomass at intermediate levels of the

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food web, it plays a relevant role in associating the lower and upper trophic levels (Rice, 1995; Bakun, 1996; Cury et al., 2000). Besides its importance in the food web, chub mackerel is also commercially important fish that is traditionally exploited in the Adriatic by purse seiners (National fishery statistics).

The main goal of this investigation was to provide information on condition and lipid content of this species since it has not been yet investigated in the Adriatic Sea. The results will contribute to better understanding of this commercially important fish species' biology.

### *MATERIAL AND METHODS*

The studied specimens of chub mackerel were collected randomly from commercial landings. Samples were collected during the night, with artificial light, using a purse seine net with a stretched mesh size of 10 mm. The use of a purse seine with artificial light is preferred in the Adriatic Sea for capturing fish species which school or aggregate near to the surface, such as sardines, mackerels, anchovies, herring and some species of tuna.

A total of 4,189 chub mackerels were sampled between January 1998 and December 2007 from the eastern part of the Adriatic Sea (geographical range from N44°13.586'; E15°08.883' to N42°48.523'; E17°51.109'). Samples were taken once a month except when prevented with problems of logistics or bad weather. The number of specimens sampled per month ranged from 20 (May 2002) to 177 (September 2007) individuals. After landing, all the fish were immediately analysed in the laboratory. Fork length (*FL*) ( $\pm 0.1$  mm) and total body weight (*W*) ( $\pm 0.01$  g) were measured for each specimen ( $N=4,189$ ).

Sex was determined macroscopically by shape, appearance and gonad structure. 1,085 of the analysed specimens were male and 1,611 were female. The sex could not be determined for 1,493 specimens, because: (i) the specimens were immature; (ii) the specimens were in the resting phase of reproduction and macroscopic examination could not determine the sex; or (iii) the specimens were not well preserved because of the fishing activities.

Amount of mesenteric fat in the visceral cavity was determined according to the scale used by Sinovčić (1978): 0 - very thin fish, no traces of mesenteric fat; 1 - thin fish, traces of mesenteric fat around the digestion tract; 2 - fatter fish, mesenteric fat around the digestion tract; 3 - fat fish, significant amount of mesenteric fat; 4 - very fat fish, visceral cavity filled with mesenteric fat.

Condition of the chub mackerel during the 10-year period research was indicated with: (i) Fulton's coefficient:  $CF=100W/FL^3$  (Hille, 1936; Dulčić et al., 2000); (ii) Allometric coefficient:  $CA=100W/FL^b$  (Le Cren, 1951; Ricker, 1975); and (iii) Relative coefficient:  $CR=W/aFL^b$  (Le Cren, 1951; Ricker, 1975), where *a* and *b* were regression parameters originating from the length (*FL*) and weight (*W*) relationship obtained for each year (Sparre and Venema, 1992).

To diminish the length influence on fish condition, only the specimens in length range between 20 and 30 cm were analyzed (3,250 overall, 998 males and 1,253 females) and presented as variations of condition during the time.

## RESULTS

### *Length and weight distribution*

The overall range in the analysed specimens ( $N=4,157$ ) fork length and weight was between 10.1-39.1 cm (mean  $\pm$  SD: 23.8 $\pm$ 4.68 cm) and between 8.90-804.50 g (mean  $\pm$  SD: 164.49 $\pm$ 102.70 g), respectively. The fork length of males ( $N=1,085$ ) varied from 17.9 to 38.8 cm (mean  $\pm$  SD: 26.0 $\pm$ 3.83 cm, modal at 25.5 cm) and of females ( $N=1,620$ ) from 14.9 to 39.0 cm (mean  $\pm$  SD: 25.3 $\pm$ 3.45 cm, modal at 23.5 cm). Total weight of males ranged from 22.95 to 710.60 g (mean  $\pm$  SD: 213.50 $\pm$ 114.69 g), whereas for females it varied from 16.51 and 701.66 g (mean $\pm$ SD: 186.16 $\pm$ 92.22 g). The fork lengths of males, females and overall were distributed according to the normal distribution (Kolmogorov-Smirnov test:  $d=0.0505$  males,  $d=0.0375$  females and  $d=0.0450$  total;  $P<0.05$ ). Length – frequency distribution and weight – frequency distribution are given as Figures 1 and 2.

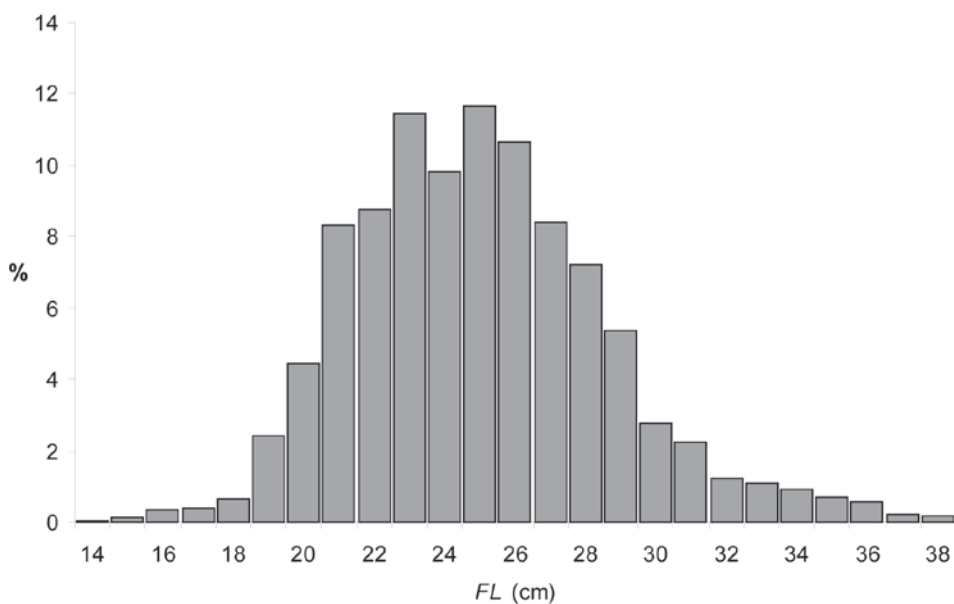
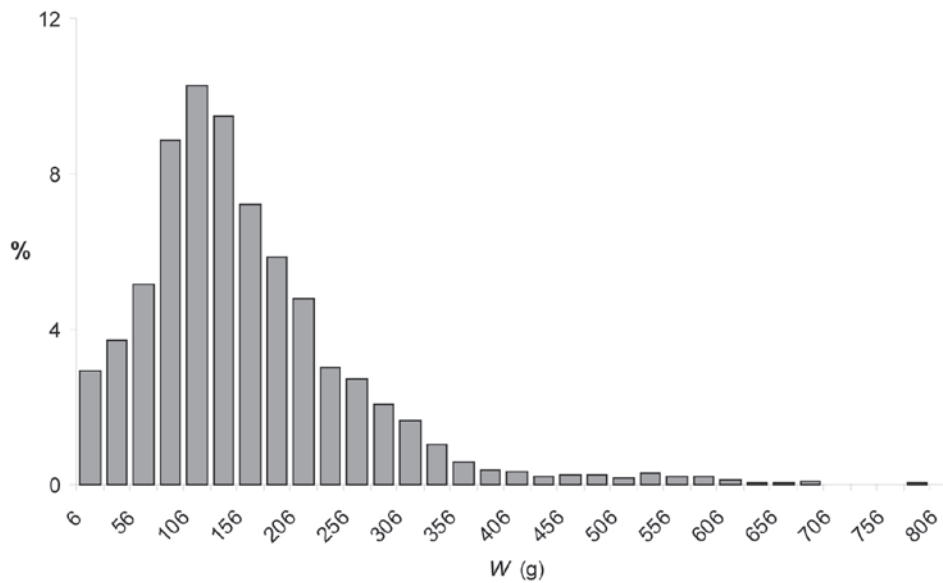


Fig 1. Length frequency distribution of chub mackerel in the Adriatic Sea sampled from January 1998 to December 2007

Slika 1. Dužinska raspodjela lokarde u Jadranskom moru od siječnja 1998. do prosinca 2007. god.



*Fig. 2. Weight frequency distribution of chub mackerel in the Adriatic Sea sampled from January 1998 to December 2007*

*Slika 2. Masena raspodjela lokarde u Jadranskom moru od siječnja 1998. do prosinca 2007. god.*

### *Mesenteric fat*

Mesenteric fat was determined in all analysed specimens of chub mackerel during the ten-year period (January 1998 to December 2007).

The presence of mesenteric fat in the visceral cavity of this species was noticed throughout almost a whole year (Fig.3).

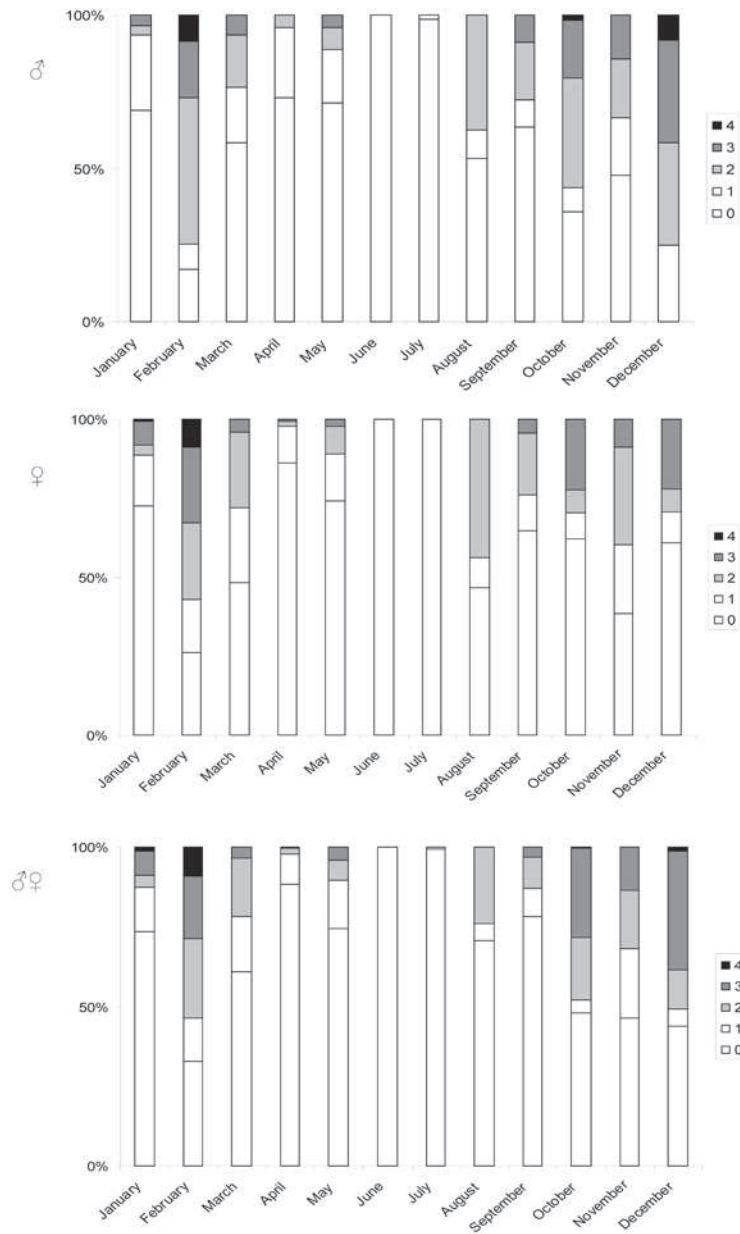


Fig.3. Monthly portion of mesenteric fat in the chub mackerel cavity for males (♂), females (♀) and overall specimens (♂♀) which were sampled from January 1998 to December 2007 in Adriatic Sea

Slika 3. Mjesečni udio mezenterične masnoće u trbušnoj šupljini mužjaka (♂), ženki (♀) i ukupnog uzorka (♂♀) lokarde iz Jadranskog mora od siječnja 1998. do prosinca 2007. god.

The only exception was in the month of June when there was no trace of mesenteric fat in any of the specimens analysed. During July the fish started to accumulate mesenteric fat, which reached its in December. Thin fish were found during the whole year but were predominant in the warmer part of the year (from March to September).

The differences between the sexes regarding amount of mesenteric fat of chub mackerel were noticed in the fattest fishes. Thus, the fattest males predominated in October, December and February (1.6%; 8.4% and 8.4% respectively) and the fattest females in January and February (0.7% and 9.0%). Small differences were also found within thin fishes as some males had mesenteric fat in the traces surrounding the intestinal tract (1.3%) but all the females were fat free, during July.

### Condition

Fulton's allometric and relative condition coefficients are presented in the Table 1 where it is obvious that Fulton's coefficient (*CF*) showed an increase with increase in length except for the smallest specimens. Males had also shown higher values of this coefficient than females in almost all length classes (except in 26.0 cm and 39.0 cm). Allometric condition coefficient (*CA*) as well as relative condition coefficient (*CR*), showed very little variability in length except for the smallest specimens. The females had lower values of condition coefficients than the males.

Table 1. Variations in Fulton's (*CF*), allometric (*CA*) and relative (*CR*) condition coefficients as regard to the fork length (*FL*) of *Scomber colias* males (♂), females (♀) and overall analyzed materials (*tot*), from January 1998 to December 2007 in the Adriatic Sea

Tablica 1. Kolebanje Fultonovog (*CF*), alometrijskog (*CA*) i relativnog (*CR*) koeficijenta kondicije mužjaka (♂), ženki (♀) i ukupnog uzorka (*tot*) u odnosu na viličnu dužinu tijela (*FL*) lokarde iz Jadranskog mora od siječnja 1998. do prosinca 2007. god.

FL(cm)	CF			CA			CR		
	♂	♀	tot	♂	♀	tot	♂	♀	tot
10.0-10.9			0.98			0.58			1.11
11.0-11.9			0.90			0.53			1.02
12.0-12.9			0.87			0.52			1.00
13.0-13.9			0.87			0.50			0.96
14.0-14.9			0.97			0.54			1.04
15.0-15.9		0.93	0.99		0.59	0.53		1.03	1.02
16.0-16.9		0.90	1.00		0.58	0.52		1.03	1.00
17.0-17.9		0.88	0.98		0.56	0.51		0.98	0.99
18.0-18.9	1.22	0.99	1.00	0.64	0.56	0.51	1.05	0.97	0.99

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19.0-19.9	1.14	1.07	1.03	0.61	0.59	0.52	0.99	1.03	1.00
20.0-20.9	1.10	1.03	1.03	0.61	0.57	0.52	1.00	1.00	1.00
21.0-21.9	1.10	1.05	1.05	0.61	0.57	0.52	1.00	1.01	1.00
22.0-22.9	1.08	1.04	1.04	0.61	0.57	0.52	1.00	0.99	0.99
23.0-23.9	1.09	1.06	1.07	0.61	0.57	0.52	1.00	1.00	1.00
24.0-24.9	1.09	1.07	1.07	0.61	0.56	0.51	0.99	0.99	0.99
25.0-25.9	1.08	1.07	1.08	0.61	0.57	0.52	1.00	1.01	1.00
26.0-26.9	1.10	1.09	1.09	0.61	0.57	0.52	1.00	1.00	1.00
27.0-27.9	1.09	1.08	1.08	0.62	0.57	0.52	1.02	1.00	1.00
28.0-28.9	1.14	1.06	1.09	0.61	0.57	0.52	1.01	1.01	1.01
29.0-29.9	1.13	1.09	1.11	0.61	0.57	0.52	1.00	1.00	1.00
30.0-30.9	1.11	1.10	1.10	0.61	0.57	0.52	1.00	0.99	0.99
31.0-31.9	1.15	1.11	1.12	0.61	0.57	0.52	1.01	1.01	1.01
32.0-32.9	1.19	1.14	1.13	0.61	0.57	0.53	1.00	1.00	1.01
33.0-33.9	1.23	1.13	1.17	0.61	0.61	0.53	1.01	1.07	1.02
34.0-34.9	1.28	1.13	1.23	0.61	0.57	0.52	1.00	1.01	1.00
35.0-35.9	1.27	1.26	1.25	0.60	0.57	0.52	0.99	1.00	1.00
36.0-36.9	1.23	1.25	1.24	0.61	0.56	0.52	0.99	0.99	0.99
37.0-37.9	1.39	1.22	1.27	0.60	0.56	0.51	0.99	0.99	0.99
38.0-38.9	1.21	1.20	1.21	0.62	0.56	0.52	1.01	0.98	1.00
39.0-39.9	1.33	1.36	1.20	0.60	0.57	0.52	0.98	1.00	1.01
Total	1.17	1.09	1.07	0.61	0.57	0.52	1.00	1.00	1.00
SD	0.09	0.11	0.11	0.01	0.01	0.01	0.01	0.02	0.02

Monthly variations of condition coefficients were studied as well. Monthly fluctuations were noticed only in the allometric coefficient (Fig. 4). Namely, this condition coefficient showed the lowest values during the warmer part of the year (from April to September). The other two condition coefficients have not showed seasonal variations.

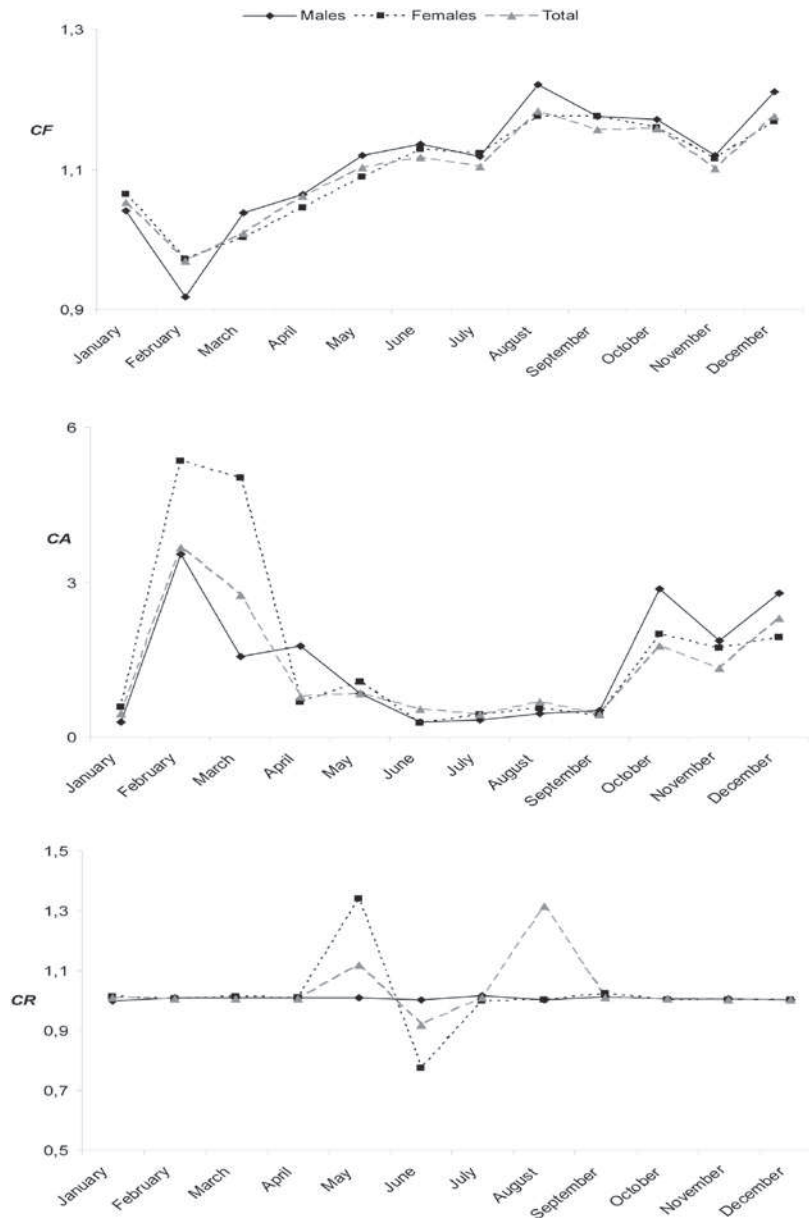


Fig.4. Monthly variations in the Fulton's (CF), allometric (CA) and relative (CR) condition coefficient of chub mackerels (lengths from 20.0 cm to 30.0 cm), which were sampled from January 1998 to December 2007 in the Adriatic Sea

Slika 4. Mjesečno kolebanje Fultonovog (CF), alometrijskog (CA) i relativnog (CR) koeficijenta kondicije lokarde (dužina od 20,0 do 30,0 cm) u Jadranskom moru od siječnja 1998. do prosinca 2007. god.



## DISCUSSION

Energy stored in fishes is often used to fuel metabolic activities during unfavourable conditions, migrations and/or gonadal development (Reznick and Braun, 1987; Schultz and Conover, 1997; Schultz, 1999). Temporary energy storage in fishes is achieved by production and deposition of lipids as triacylglycerols (Hadley, 1985). In some species lipid storage primarily occurs in the liver, while in others it occurs inbetween the muscles, in the mesentery, along the lateral line or on the bases of fins (Hadley, 1985). Previous research (Saldaña and Venables, 1983; Junk, 1985; Gomes and Agostinho, 1997) documented seasonal deposition of fat in migratory fishes during periods of high resource availability (food), and subsequent consumption of these fat storages during periods of either decreased resource availability or increased energetic demands (migration, reproduction).

Condition indices have been used by fishery scientists as indicators of general well being of fish or fitness of population under consideration. Condition is actually a state of fish which can be influenced by fattening, gonad development, stomach fullness and so on (Le Cren, 1951).

This investigation revealed seasonality of fat reserves and condition. Namely, during the warmer part of the year the fishes were without fat reserves and condition coefficients were low. This time of the year (April – September) is spawning time for the chub mackerel in the Adriatic Sea (Čikeš Keč and Zorica, 2012) so the above mentioned is possibly due to fish usage of all available energy for maturing and releasing of its sexual products. Also, females had shown lower values in all condition coefficients, which suggest greater exhaustion of females during their life cycles while after spawning period males had higher values, suggesting the more rapid increase in condition for males, but also gradual recovery of energy in the resting phase of sexual cycle for both sexes. Besides, it seems that chub mackerel males after spawning accumulate fat more efficiently and faster than the females. On the other hand, the fattest fishes were scarcely found during the entire year although large quantities of chub mackerels were noticeable during the colder months of the year. This may be explained by the swimming speed (Nauen and Lauder, 2002; He and Wardle, 1986.) consuming the fat reserves or by conditions of poor nutrition (Vučetić, 1963) during the winter when chub mackerel should be summing up the reserves.

These results concerning the mesenteric fat and condition of the *S. colias* population inhabiting the Adriatic Sea contribute to a better understanding of the basic biology of this commercially important species, although further research remains to be done.

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**Sažetak**

**MEZENTERIČNA MASNOĆA I KONDICIJA LOKARDE *Scomber colias* U JADRANSKOM MORU**

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U ovom radu je istraživano skladištenje lipida (u obliku mezenterične masnoće) i kondicija (preko Fultonovog, alometrijskog i relativnog koeficijenta kondicije) vrste *Scomber colias* u Jadranskom moru. U tu svrhu su prikupljene 4189 lokarde u razdoblju od siječnja 1998. do prosinca 2007. godine, dužinskog raspona od 10,1 cm do 39,1 cm (srednja vrijednost  $\pm SD$ :  $23,8 \pm 4,68$  cm) i masenog raspona od 8,90 g do 804,50 g (srednja vrijednost  $\pm SD$ :  $164,49 \pm 102,70$  g). Uočene su sezonske razlike između rezervi masnoće kao i kondicije kod ove vrste. Naime, tijekom toplijih mjeseci ribe su bile bez masnih rezervi a koeficijenti kondicije su bili niski. Ženke su imale niže vrijednosti svih koeficijenata kondicije (Fultonov, relativni i alometrijski) od mužjaka. Nakon razdoblja mriješćenja mužjaci su brže i više nakupili masnoću od ženki u istom periodu.

**Ključne riječi:** *Scomber colias*, lokarda, Jadransko more, mezenterična masnoća, kondicija

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