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OBSERVATIONS REGARDING THE BIOLOGY ASPECTS OF HORSE MACKEREL FROM ROMANIAN COAST BETWEEN 2018-2020

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Abstract

Due to the current situation when we observe numerous climate changes, manifested by rising air and seawater temperatures, there have been observed also, changes in recent years regarding the biology aspects of some fish species from the Romanian Black Sea coast. Trachurus mediterraneus (Steindachner, 1868) - horse mackerel, having economic importance it is necessary to observe its biology in order to develop an appropriate management required by the changes observed at the population level. This paper presents results on temporal variations of total length and weight, age composition, growth parameters and sex ratio of the Mediterranean horse mackerel from the Romanian Black Sea coast. Data were collected from commercial trap net catch and from pelagic trawl expeditions in the period 2018-2020. Significant differences were observed between the length distribution and the stations, with the specification that in 2020 individuals from classes of smaller lengths predominated compared to previous years.

Key words*: growth, morphometrics characteristics, sex ratio, temperature.*

INTRODUCTION

Horse mackerel (*Trachurus mediterraneus*) is one of the main species that have commercial importance and are caught in the Romanian waters. Horse mackerel fishing is conducted with different fishing gears including pelagic trawl, set nets and hand line.

There are a plenty of studies considering this species which is intensively caught in the Black Sea. It is necessary to constantly monitor reproduction, growth, migration, stock size, life span and death rates of horse mackerel population in the Black Sea ecosystem which are of importance for sustainable fisheries.

In this paper growth and other biological variable of the horse mackerel from the Romanian Black Sea coast were reported. The main goal of our study it was to observe the changes that may occur over time and space on different biological parameters.

The relationship between body length and weight are of great importance in fishery biology as they allow estimating fish growth parameters (Gulland, 1983).

Since the growth of teleosts is linked to the foraging behavior (Lloret et al., 2014) and the diet may change temporally, then growth may also vary temporally (Albo-Puigserver et al., 2017).

Growth and sex ratio are important parameters for fisheries management.

MATERIALS AND METHODS

For the purpose of this study, 817 individuals were collected from 15 stations with the trawl and traps net catches along the Black Sea area in the northern area (Navodari, Corbu, Vadu, Periboina, Perisor) and the southern area (Eforie Sud, Costinesti, Vama Veche) between May and November in 2018-2020 (Figure 1).

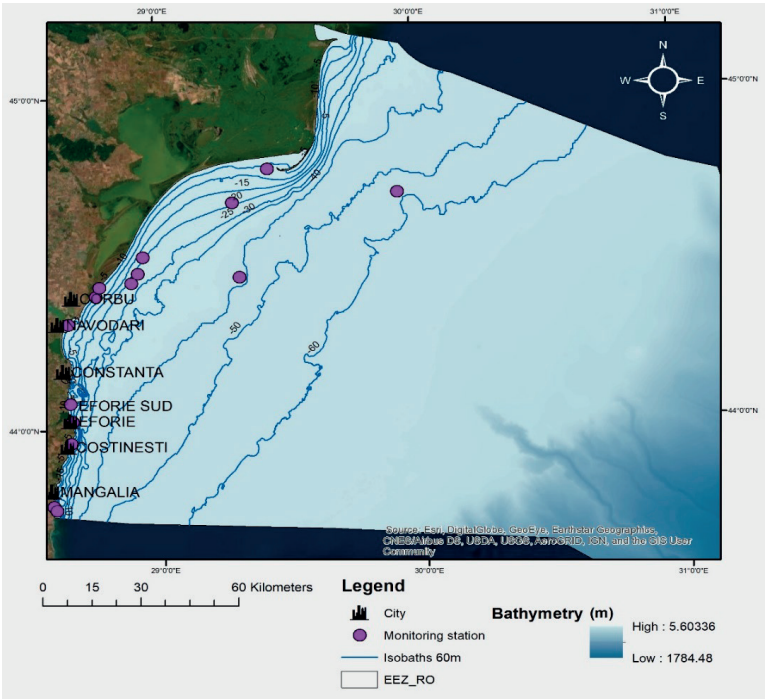

Figure 1. Sampling map

For each specimen, total length (Lt) was recorded (mm) and total weight (Wt) in grams (g). Sex was determined by macroscopic observation of the gonads to all individuals. Sexual maturity stages were assessed according to Nikolsky's scale (1963), and according Follesa, M. C., Carbonara, P., 2019; I: immature, II: resting, III: developing, IV: maturing, V: mature, VI: spent.

The length of a fish is proportional with weight, being strongly connected to development stages (juvenile and adults, and adults different reproduction related stage; size at first maturity, gonad development and spawning) (Serajuddin et al., 2013). Studying the length-weight relationship allows comparing population spatially and temporally (Pandev et al., 1974). Related to biomass data, this relationship may also allow establishing the recruitment yield (Richter, 1958; Beverton et al., 1957) and estimating the biomass of potential exploitable fishes. Length and weight parameters are used in calculating fishing gear selectivity and mainly in sizing the mesh, aiming at improving the catch per unit effort. For age determination, all the 817 individuals were selected from each 1 cm size interval to represent all length groups. The sagittal otolith pairs were removed and cleaned, and stored in dry conditions inside the microplate. Age determination was performed using a stereoscopic zoom microscope under reflected light against a black underground. Opaque and transparent rings were counted: 1 opaque zone, together with 1 transparent zone, was considered the annual macrostructure (Aydin & Karadurmus, 2012). Age estimations were made by 2 independent readers.

The sexual maturity in fish has a great practical importance in the analysis of many population parameters. In general, fish are considered to be mature when they reach the middle of their maximum size (Holden & Raitt, 1974). So, the sex, sex-ratio and reproduction stages were estimated for all the individuals. Identification of sex and sexual maturity stages find their primary application in providing basic knowledge of the reproductive biology of the stock.

Fulton's relative body condition factor (Ricker, 1975) was calculated for 563 individuals using the following formula: $K = (TW \times 100)/TL^3$, with TW = total mass (in grams) and TL = total length (in centimetres).

The non-parametric analyses of variance (Kruskal-Wallis) were performed using the STATISTICA 13.1 in order to analyse differences between years, months, areas and sex.

RESULTS AND DISCUSSIONS

Total length

The mean length of the analyzed individuals was 11.5 ± 2.1 cm. High significant differences were shown between years, followed by differences between months and the lowest ones between sexes (see H tests values in Tables 1 to 3).

The highest mean of length was registered in 2018 (12.3 ± 1.3 cm), and the lowest one in 2020 (10.9 ± 1.2 cm) (Table 1).

The highest values were recorded in May, July and October and the lowest ones in August, September and November (Table 2).

Significant different values were found only between females and juveniles (Table 3).

Table 1. Mean values and standard error of the total length (TL), total weight (TW) and Fulton index (K) by year

Year		TL (cm)		TW (g)		K	
	N	Mean	SE	Mean	SE	Mean	SE
2018	180	12.3	1.3 ^{a}	18.3	6.1	0.9	0.1 ^{a}
2019	322	11.9	1.7 ^{b}	16.2	6.7 ^{b}	0.9	0.1 ^{a}
2020	315	10.9	1.2 ^{c}	11.9	4.2 ^{c}	0.8	0.1 ^{a}
		H = 34.19		H = 58.90		H = 159.65	
		p < 0.001		p < 0.001		p < 0.0001	

N.B. H represents the test statistics of Kruskal-Wallis testing the significance of the differences between years. P = associated p-value. Superscript letters represent post-hoc groups. For each variable values with similar post-hoc letters are not significantly different (P > 0.05). N= number of analysed individuals. SE = standard error.

Table 2. Mean values and standard error of the total length (TL), total weight (TW), Fulton index (K), age (A) and degree of maturity (DM) by month

		TL (cm)		TW (g)		K			Age (y)			DM	
Month	N	Mean	SE	Mean	SE	Mean	SE	N	Mean	SE	N	Mean	SE
May	10	12.97	1.0	20.95	5.78	0.94	0.08	10	1.8	0.8	10	2.9	0.6
June	52	11.8	2.1 ^{bc}	13.5	6.9 ^{bc}	0.80	0.45 ^{a}	52	1.5	1.2 ^{c}	52	2.6	1.1 ^{b}
July	233	12.2	1.7 ^{c}	17.3	8.0 ^{c}	0.91	0.09 ^{c}	233	1.5	1.2 ^{b}	233	2.9	0.9 ^{c}
August	196	10.7	2.0 ^{b}	10.8	6.6 ^{b}	0.78	0.11 ^{c}	196	0.9	1.0 ^{b}	196	2.2	1.0 ^{a}
September	84	10.6	1.5 ^{bc}	11.1	6.1 ^{bc}	0.87	0.06 ^{ab}	84	0.6	0.9 ^{b}	84	2.2	0.8 ^{bc}
October	145	12.3	2.9 ^{a}	18.0	11.1 ^{a}	0.83	0.12 ^{b}	145	1.7	1.4 ^{a}	145	2.9	1.5 ^{a}
November	97	10.8	1.1 ^{a}	10.0	3.1	0.82	0.07 ^{b}	97	0.7	0.8 ^{a}	97	2.2	0.5 ^{a}
		H = 125.23		H = 150.2		H = 265.78			H = 100.82			H = 114.73	
		p < 0.001		p < 0.001		p < 0.0001			p < 0.001			p < 0.0001	

N.B. H represents the test statistics of Kruskal-Wallis testing the significance of the differences between months. P = associated p-value. Superscript letters represent post-hoc groups. For each variable values with similar post-hoc letters are not significantly different (P > 0.05). N= number of analysed individuals. SE = standard error.

Table 3. Mean values and standard error of the total length (TL), total weight (TW) and Fulton index (K) by sex

Sex		TL (cm)		TW (g)		K	
	N	Mean	SE	Mean	SE	Mean	SE
Males	392	11.7	1.8 ^{ab}	11.5	7.8 ^{ab}	0.84	0.11 ^{a}
Females	368	12.0	1.9 ^{a}	15.6	8.4 ^{a}	0.84	0.11 ^{a}
Juveniles	57	7.6	1.0 ^{b}	3.6	1.0 ^{b}	0.83	0.43 ^{b}

The captured individuals were smaller than those identified on the Bulgarian Black Sea coast, up to 19 cm (Yankova, 2013). The horse mackerel samples from the Romanian Black

Sea coast have a growth rate different from those in other areas of the sea, most likely due to different living conditions and availability of food (Bănaru et al., 2009). Inter annual variation may be related to differences in recruitment but also to migrations and common studies should be make in the Black Sea in order to cover the entire migration area of this species.

Total weight

The mean of the weight of the analyzed individuals was 14.3 ± 8.3 g. The highest weight was registered in 2018 (18.3 ± 6.1 g), and the lowest ones in 2020 (11.9 ± 4.2 g) (Table 1). Similarly, to the total length, the highest values were recorded in May, July and October and the lowest ones in August, September and November (Table 2) and significant different values were found only between females and juveniles (Table 3). Studies conducted for horse mackerel taken from the Turkish Black Sea region revealed a spectrum of weight between 3.32 g and 59.98 g (Aydin & Karadurmuş, 2012); so, hight weight were register than those from this study. The length-weight relationship was established using the equation $W = 0.0073 \times L3.0546$ ($R^2 = 0.8726$) (Figure 2). The mean value of *b* (3.0546) did not significantly differ ($P<0.05$) from the standard value of 3.0, implying that the "cube law" could be applied for this species (Ricker, 1973). When the weigh-length exponent *b* is equal to 3.0, the body form maintains a constant proportion to the length and the fish grows isometrically, resulting in an ideal shape (Pauly, 1983). However, when *b* is less than 3.0, the fish shows negative allometric growth, and when the *b* value is greater than 3.0, the fish shows positive allometric growth (Weatherley and Gill, 1987). Thus, the fish are expected to grow proportionally in all directions. Changes in fish weight are generally greater than those in fish length (Ahmed et al., 2011). In general, when the value of *b* exceeds 3.0, fish become fatter, and when the value falls below 3.0, fish become leaner. The value of *b* found in the present study is within the interval of 3 to 3.5 recorded for many fish species by (Froese, 2006). As shown in several studies, when the size of fish increase, more fat is deposited than the formation of other tissues (Salam and Davies, 1994; Salam et al., 2001).

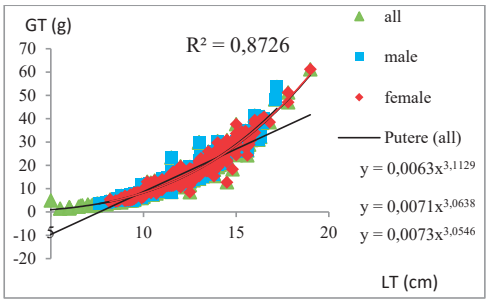

Figure 2. Length - weight relationship of the horse mackerel during the analysed period 2018-2020

Fulton Index

The mean value of the Fulton index of all the analyzed individuals was 0.84 ± 0.15. Higher the Fulton coefficient is and better the relative body condition is. Higher relative body conditions were shown in 2018 and 2019 (0.91 ± 0.1) compared to 2020 (Table 1). Seasonal variations of the relative body condition were highlighted with the lowest values in August and the highest ones in May and July (Table 2). These variations may be related to the life history traits and their environmental condition and diet during the previous months. All, male, female and juveniles have approximately the same body condition (Table 3).

Age

Determining the age of fish is an important element for the study of the population dynamics. Analyzed horse mackerel individuals age varied between 0 and 5 years. The mean age was 1.19 ± 1.2. Seasonal differences were highlighted with the oldest individuals were found in May (1.8 ± 0.8 years) and the youngest in September (0.6 ± 0.9 years) (Table 2).

Individuals with 0+ age predominated in length classes between 51-110 mm, 1 age individuals at 111-120 mm, 2+ age individuals at 121-130 mm, 3+ age individuals at 131-150 mm, 4+ age individuals at 151-170 mm and 5+ age individuals at 171-180 mm (Figure 3).

The mean length and mean weight increased with age from 9.5 + 1.2 cm and respectively 7.4 + 2.9 cm for 0+ age individuals to 17.8 + 1.1 cm and respectively 54.5 + 6.5 g for 5 years individuals (Table 4). Relative body condition factor decreases from 0+ (0.83) to 5 years (0.97), while the degree of maturity increases with age from 1.7 ± 0.7 for 0+ year individuals

to 5.2 ± 0.3 for 5 years individuals. This inverse relation may be related to higher energetic investment for reproduction in larger and older individuals.

Table 4. Mean values and standard error of the total length (TL), total weight (TW), Fulton index (K) and maturity degree by age (years)

Age (y)		TL (cm)		TW (g)		K				DM	
	N	Mean	SE	Mean	SE	Mean	SE		N	Mean	SE
0+	311	9.5	1.2	7.4	2.9	0.83	0.20		311	1.7	0.7
1	209	11.5	0.7	13.6	3.5	0.87	0.11		209	2.5	0.4
2	170	12.7	0.7	17.0	3.8	0.82	0.10		70	2.9	0.5
3	91	14.3	0.6	25.1	4.8	0.85	0.13		91	4.0	0.5
4	33	16.0	0.6	35.4	5.9	0.86	0.08		33	4.7	0.5
5	3	17.8	1.1	54.4	6.5	0.97	0.08		3	5.2	0.3

N.B. N= number of analysed individuals. SE = standard error

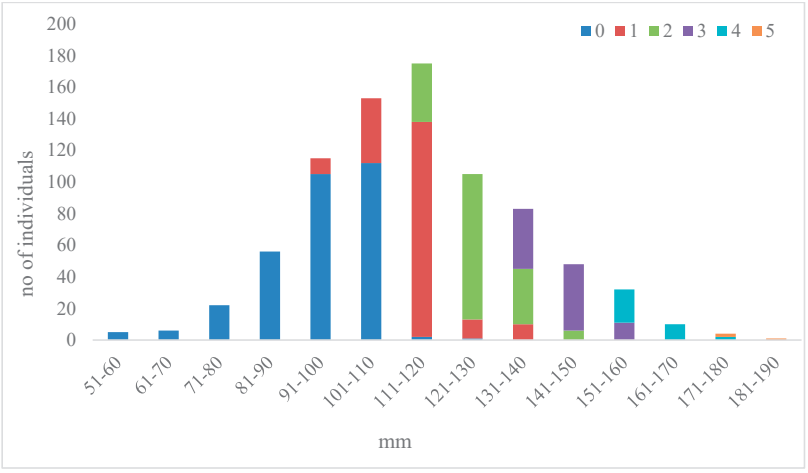

Figure 3. Distribution of *Trachurus meditteraneus* individuals by ages and length classes

Sex determination

Gonads differences between sexes appeared early, at age 1. Mean sex-ratio (males/females) over the study period was 1.06.

This ratio was variable between years (minimum 0.8 in 2018 and maximum 1.5 in 2019).

Males dominated in June, July, October and November while female dominated in May, August and September (Figure 4).

Natural variability of sex-ratio in recruitment but also fisheries pressure on young stages may be responsible of these differences.

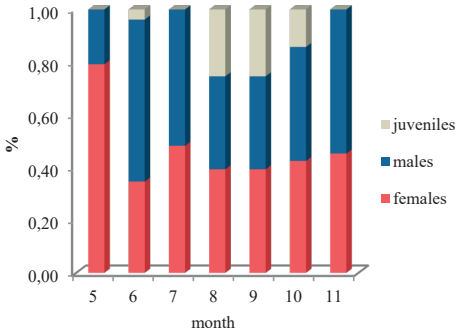

Figure 4. Sex ratio by month of *T. mediterraneus*

Gonadal maturity

Sexual maturity has a practical importance in the analysis of fish population. Generally, fish are considered to be mature when they reach the middle of their maximum size (Păun et al, 2019).

Over the whole studied period, the mean value of the gonadal maturity index of the 817 analyzed individuals was 2.6 ± 1. Significant differences were shown between months with the highest values in May (2.9 ± 0.08) and July (2.9 ± 0.6) when they also had the better relative body condition, while the lowest values were observed in August and September (Table 2).

CONCLUSIONS

In this paper variability of different biological aspects of the horse mackerel from the Romanian Black Sea coast were reported

Regarding the length, the mean of all the analyzed individuals we registered was 11.5 ± 2.1 cm. High significant differences were shown between years; the highest mean length was registered in 2018 (12.3 ± 1.3 cm), and the lowest one in 2020 (10.9 ± 1.2 cm). And significant different values were found between females and juveniles.

The mean weight of the analyzed individuals was 14.3 ± 8.3 g. The highest weight was registered in 2018 (18.3 ± 6.1 g), and the lowest ones in 2020 (11.9 ± 4.2 g).

Relative body condition values were higher in 2018 and 2019 compared to 2020. The relative body condition factor decreased from younger to older individual, while the degree of maturity increased with age. The gonadal maturity analyses showed that the reproduction occurs mainly during summer with a maximum in July. Analyzed horse mackerel individuals age varied between 0 and 5 years; the mean age was 1.19 ± 1.2.

Seasonal differences were highlighted with the oldest individuals that were found in May (1.8 ± 0.8 years) and the youngest in September (0.6 ± 0.9 years).

Mean sex-ratio over the study period was 1.06; this ratio was variable between years.

This study should continue and extended to a longer period. The horse mackerel is an economically species in Romanian waters, therefore, it is necessary to monitor and follow the changes in stock size in term of sustainable fisheries.

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