

Some biological aspects of 9 fish species from the Mediterranean coast, North Sinai, Egypt, with special reference to Grey mullet, *Mugil cephalus* (Linnaeus, 1758)

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ABSTRACT

Evaluating the recent status of 9 fish species; with a detailed review of Grey mullet; from the Mediterranean coast of North Sinai and exploring the impact of fishing practices on them, is the main objective of the present study. Fish Samples were collected by four major fishing gears in the study area. Concerning length-weight relationship, *Euthynnus affine*, *Diplodus sargus*, and *Dicentrarchus labrax* shows an isometric growth pattern, where the values of dependence length upon weight (b) were equal or closed to 3. The other six species exhibit an allometric growth pattern (either positive or negative), where (b) values ranged between 2.3 and 3.5. Fully studied species were found to be in good conditions, where the values of condition factor (K) were noticed to be around “1” and ranged from 0.8 to 1.23. Length at first capture (L_c) values according to length at first maturity (L_m), confirmed the occurrence of overfishing for many species, where they have been caught at a size less than or approximately equal to the size at first maturation. Concerning *Mugil cephalus*, Sex ratio was 1:1.77 for males and females respectively. Gonado-Somatic Index (GSI) values revealed that *M. cephalus* has a long spawning season extending from August to December with one peak in September and October for males and females respectively. The current status suggests a future decline in production and fish stocks. Immediate adjustments to fishing laws and strict enforcement, with a suitable minimum catch size of each species, is a goal to be achieved.

INTRODUCTION

The Mediterranean coast of Egypt extends for about 950 km, of which north Sinai's share about 200 km (Bride, 2010). The Mediterranean coast facing Sinai Peninsula is a distinguished area for the Egyptian fisheries sector, due to its distance from dense urban and pollution sources, as well as considering this border area of special nature in terms of strict control on fishing vessels and the work regulating laws, which gave opportunity for the availability of high quality and valuable fishes in this region. The main issue in the Egyptian fisheries sector was the absence of monitoring the discard fractions of catches. Recently, the Egyptian government has established a modern fishing fleet for the Mediterranean, consisting of 100 modern vessels called "Watanya", 34 of which already operating in the North Sinai region. There are planned amendments to be implemented in

the Egyptian fishing law, which will set a minimum size for the caught species. Species composition of this area was studied and found to be greatly varied according to domestic consumer demand and economic value (EL-Aiatt, 2004).

On the other hand, biological studies are the backbone of managing any aquatic ecosystem; this is for sure, where good biological indicators of aquatic species are the greatest evidence of the ecosystem balancing, as well as its suitability for life and growth.

To preserving fish stocks from depletion, as well as taking the appropriate decision to set the minimum size of the caught species, maturation studies were carried out in addition to many biological aspects related to growth performance; length weight relationship and condition factor; (Shabana *et al.*, 2013; Omar, 2018; Sayf Al-Din, 2018 and Shalloof and El-Aiatt, 2019).

On this context, *Mugil cephalus* (Linnaeus, 1758) is a species of Mugilidae found in freshwater, brackish, hypo saline lagoons, and coastal marine areas with a depth of less than 20 meters (FAO, 1990). Mulletts are successful teleost fishes which make up an important and probably the most widely distributed commercial fishes in the coastal waters of tropical and subtropical regions of the world (Wijeyaratne and Costa 1968; Koutrakis and Sinis, 1994 and Morey *et al.*, 2003). With a production exceed 180,000 tonnes/ year; Egypt is the world's first producer of mullet (FAO, 2017). Mullet is the second; Nile Tilapia is the first; popular species for the Egyptian consumer and is considered the main species for the local population in the North Sinai region, due to its good price and also the lack of tilapia species in this region.

Evaluating the current biological status of 9 fish species in the Mediterranean coast of North Sinai, will provide databases for decision makers in developing and protecting this vital sector of Egyptian fisheries, which is the main objective of the present study.

MATERIALS AND METHODS

Sampling and study area

Monthly random samples of 9 fish species {grey mullet (*Mugil cephalus*), cattle fish (*Sepia officinalis*), grouper (*Epinephelus marginatus*), Spanish mackerel (*Scomberomorus commerson*), kawakawa (*Euthynnus affinis*), white seabream (*Diplodus sargus*), Atlantic mackerel (*Scomber scombrus*), European seabass (*Dicentrarchus labrax*) and meager (*Argyrosomus regius*)} were collected from El-Arish port, North Sinai coast (Fig. 1) from January to December 2017. Samples were collected by the major four fishing gears (Trammel net, purse seine, trawl net and long lines) in the study area.

Biological measurements

The total number of fish individuals was 2927 from the previous species. For each individual, total length was measured to the nearest 0.1 cm and weighed to the nearest 0.1 g. The condition factor (K) was determined using the equation: $K = 100 * W / L^3$ (Ricker, 1975)

Where: W= weight of fish in (g) and L= standard length of fish (cm).

Length-weight relationship was obtained according to the allometric equation:

$$W = a L^b \quad (\text{Sparre } et al., 1989)$$

Where: W= total body weight (g), L= total length (cm), a= constant and b= exponent value.

Gonado-Somatic Index (GSI) was calculated for each specimen by the following equation:

$$GSI (\%) = GW/W * 100 \quad (\text{Render } et al., 1995)$$

Where: GW= gonad weight (g) and W= weight of specimen (g).

The length at first capture (L_c) was estimated by Pauly (1984) and the length at first maturity (L_m) was determined by having the point on x-axis corresponding to 50% on y-axis according to Pitt (1970).

Statistical Analysis

The descriptive statistics, one-way ANOVA (for GSI and K values) and Chi-square test were applied by using SPSS program version 16.0, with a significant level of 0.05.

Ethical Statements

No live fish were used in an experimental form. Samples were collected from commercial catches of non-living fish. Authors have not violated the directives of the NIOF Committee for Ethical Care of Marine Organisms and Experimental Animals, Egypt (NIOF - IACUC) in any way.



Fig. (1): Map of the Mediterranean coast of Sinai- Egypt

RESULTS

Catch production in the study area:

From the obtained field data, it was found that the descending order of the Catch production of different fish species from El-Arish Port during fishing season 2017 was as follow; Crabs, *Sardinella*, and *Sigans* production were 364.4, 336.8 and 241.1 tons, respectively followed by shrimp, scad, grey mullet, shrimp, cattle fish and Spanish mackerel (99.2, 72.3, 68.8, 66.7 and 46.7 tons, respectively) and European seabass, Kawakawa, groper, Atlantic mackerel, meager and white seabream, which constituting about 15.7, 15.3, 10.3, 8.5, 8.5 and 1.3 tons, respectively (Fig. 2).

Length–weight relationship:

Length-weight relationships of 9 studied fish species were shown in Table (1). It's clear that, *E. affinis*, *D. sargus* and *D. labrax* showed an isometric growth pattern, where (b) values of dependence length upon weight were 3.057; 2.9996 and 2.954 for the previous species, respectively. The growth of *Scomber scombrus* has taken a positive allometric pattern, where (b) value found to be 3.50. The other five species exhibit a negative allometric growth pattern, where (b) value ranged between 2.13 and 2.76. Concerning *M. cephalus*, 371 individuals were collected during the period of study from the Mediterranean coast of Sinai; ranged from 20.8 to 49.4 cm for total length and 86.5 to 915.1 g for total weight; where the length – weight relationship was described by the equation: $W = 0.0233 L^{2.7397}$ ($R^2 = 0.949$), $W = 0.0289 L^{2.6749}$ ($R^2 = 0.960$) and $W = 0.0273 L^{2.6921}$ ($R^2 = 0.960$) for males, females and combined sexes respectively and shows a negative allometric growth pattern (Fig. 3).

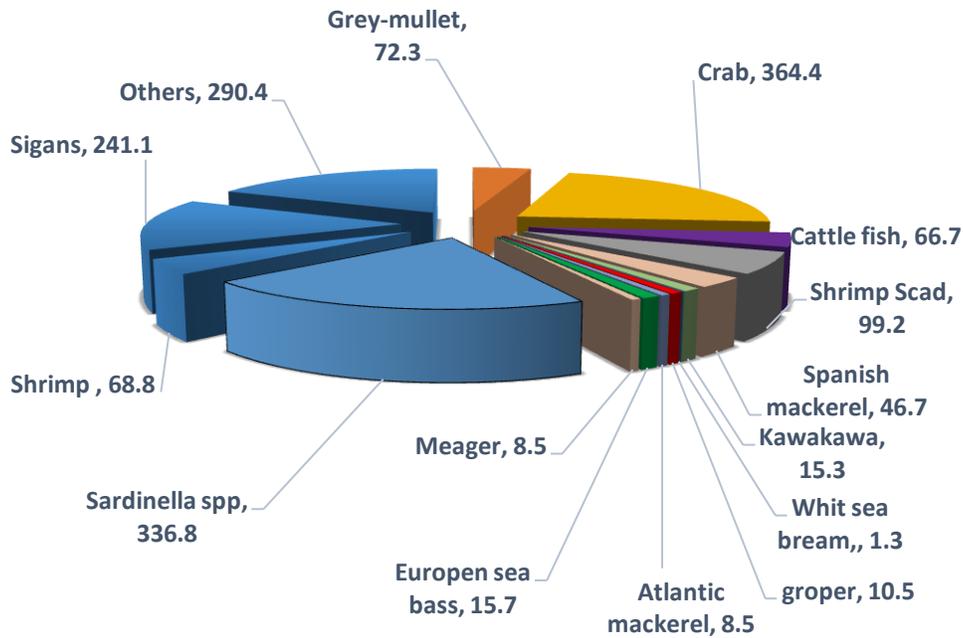


Fig. (2): Total production (tons) of different fish species from El-Arish Port during 2017 (AFO, 2018)

Table (1): Length -weight relationship (L-W), Length and weight profile and the mean Values of condition factor (K) of fish species from the Mediterranean coast of Sinai.

Species	L-W	Total length (cm)			Total weight (g)			K
		L(min)	L(max)	L̄	W(min)	W(max)	W̄	
Grey-mullet	0.0273L ^{2.6921}	20.8	49.4	31	86.5	915.1	301.9	0.93
Cattle fish	0.2203L ^{2.7655}	6.1	20.3	13.8	35.2	870	353.8	-
Spanish mackerel	0.0151L ^{2.7598}	12.3	137	34.1	30.4	14880	410.9	0.8
Kawa kawa	0.0090L ^{3.057}	21.5	105	41.5	90	13600	1328	1.12
White seabream,	0.0178L ^{2.9996}	10.6	40.7	19.5	23.5	1115	156.8	1.18
Grouper	0.0415L ^{2.6407}	16	44	28.1	60.5	988	321.3	1.23
Atlantic mackerel	0.0064L ^{3.1174}	8	28.5	19.4	6	226.2	79.1	0.93
European seabass	0.0100L ^{2.9540}	25.6	58.3	37	146.4	1658	587.5	0.90
Meager	0.2712L ^{2.1331}	24.5	80	38.2	257	4391	635.2	1.20

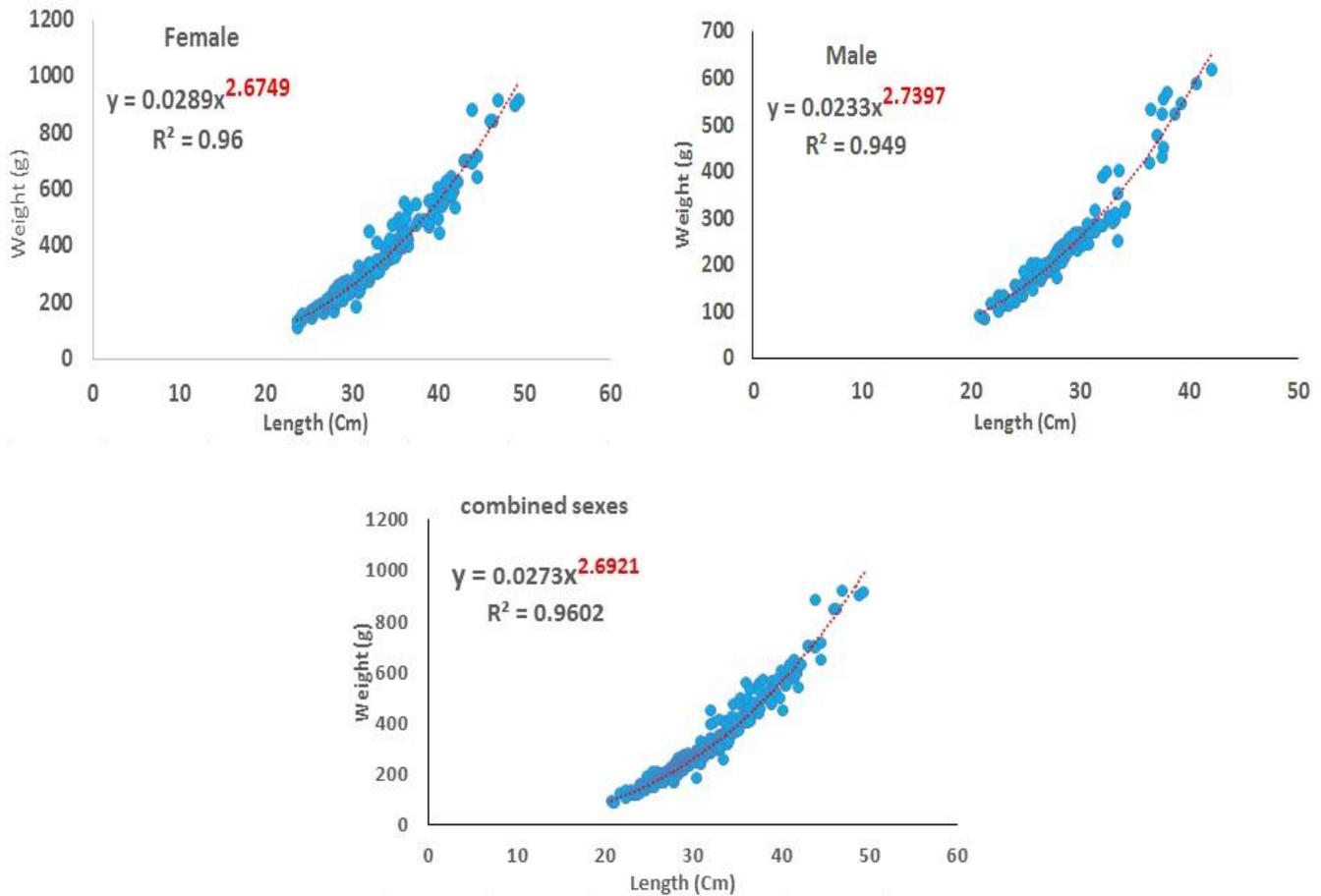


Fig. (3): Length weight relationship of males, females and combined sexes of *Mugil cephalus* from the Mediterranean coast of Sinai

Condition factor (K):

The data obtained in Table (1) indicated that, values of condition factor of the studied fish species were varied significantly (ANOVA, $P < 0.05$), where (K) ranged from 0.8 for Spanish mackerel to 1.23 for Grouper. Concerning *M. cephalus*, monthly mean condition factor for males, females and combined sexes were nearly similar in the trend line for both sexes and were generally low in March, September, and December. The highest values of (K) were recorded in January, February, October and November (ranged from 0.99 to 1.07) (Fig. 4). A decline in (K) was observed during July for females accompanied by a slight increase for males in the same month. Also, the overall mean values of males, females and combined sexes according to size groups of *M. cephalus* were nearly equal (Table, 2).

Table (2): Variation in condition factor (K) according to length groups of combined sexes (F&M), females (F) and males (M) of *M. cephalus*

Length groups (cm)	Combined sex		Female		Male	
	No.	k	No.	k	No.	k
20-20.9	1	1.0	--	--	1	1.0
21-21.9	3	1.0	--	--	3	1.0
22-22.9	2	1.0	--	--	2	1.0
23-23.9	7	1.0	2	0.9	5	1.0
24-24.9	14	1.0	5	1.0	10	1.0
25-25.9	11	1.0	4	1.0	7	1.0
26-26.9	27	1.0	14	1.0	13	1.0
27-27.9	31	1.0	16	1.0	15	1.0
28-28.9	50	1.0	32	1.0	18	1.0
29-29.9	49	1.0	32	1.0	17	1.0
30-30.9	30	0.9	20	0.9	10	0.9
31-31.9	26	0.9	19	0.9	7	0.9
32-32.9	19	1.0	13	1.0	6	1.0
33-33.9	22	0.9	16	0.9	6	0.9
34-34.9	8	0.9	6	1.0	2	0.8
35-35.9	7	0.9	7	0.9	0	--
36-36.9	17	0.9	15	0.9	2	1.0
37-37.9	8	0.9	3	0.9	5	0.9
38-38.9	3	0.9	1	0.9	2	1.0
39-39.9	7	0.9	6	0.9	1	0.9
40-40.9	8	0.8	7	0.8	1	0.9
41-41.9	5	0.8	5	0.8	--	--
42-42.9	4	0.8	3	0.8	1	0.8
43-43.9	3	0.9	3	0.9	--	--
44-44.9	4	0.8	4	0.8	--	--
46-46.9	2	0.9	2	0.9	--	--
47-47.9	1	0.9	1	0.9	--	--
48-48.9	1	0.8	1	0.8	--	--
49-49.9	1	0.8	1	0.8	--	--
Mean (K)	0.92		0.91		0.91	

Length at first sexual maturity (L_m):

The data of length at first sexual maturity of the studied species were shown in Table (3). Concerning *M. cephalus*, the results showed that mullet in the Mediterranean coast facing Sinai attained the first sexual maturity at length 29.8 and 30 cm for males and females respectively, as well as all males in the population become sexually mature at 44 cm compared to 48 cm in females (Fig.5).

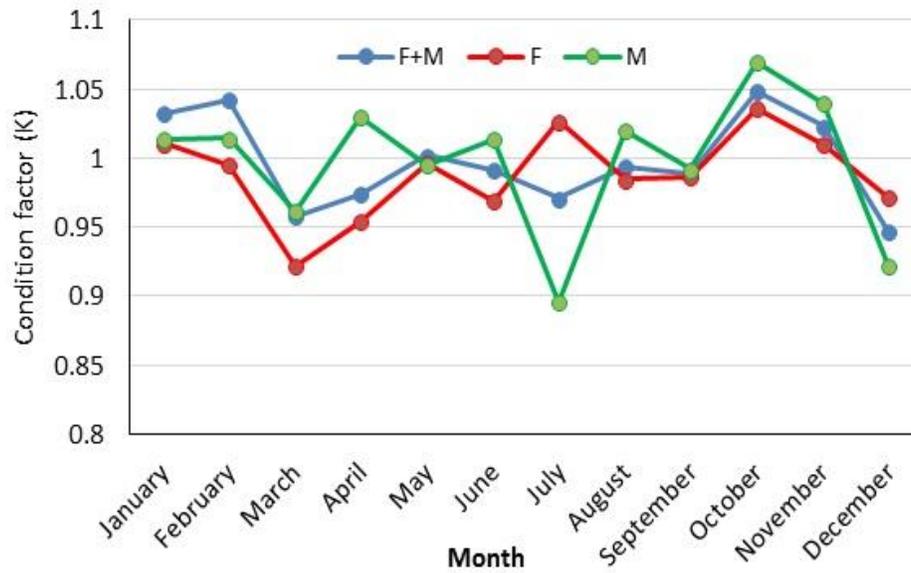


Fig. (4): Monthly variations in condition factor (K) of combined sexes (F&M), females (F) and males (M) of *M. cephalus* during 2017

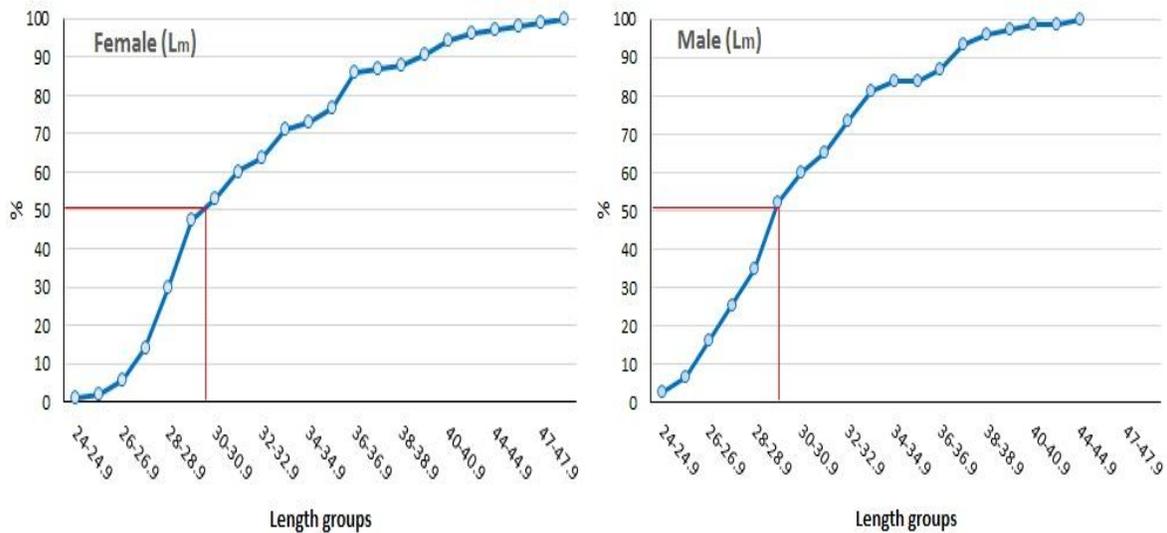


Fig. (5): Length at first sexual maturity of *M. cephalus* in the Mediterranean coast of Sinai

Length at first capture (L_c):

The length at first capture (L_c); the length at which 50 % of the population at that size are vulnerable to capture. In the present study, length at first capture for 9 studied fish species were estimated and reported in Table (3), where the minimum (L_c) was 14 cm for Cattle fish (*Sepia officinalis*) and the maximum was 35.5 cm for Kawa kawa, in

addition to 29.7 cm for *M. cephalus* (Fig. 6). Length at first capture (L_c) compared to the length at first sexual maturity (L_m) was shown in Fig. (7).

Table (3): Length at first sexual maturity (L_m) of different species (collected from published papers for each studied species in the same area or different areas) and Length at first capture (L_c) (Estimated during the present study)

English name	Scientific name	L_c (cm)	L_m (cm)	References of (L_m)
Grey-mullet	<i>Mugil cephalus</i>	29.7	31.1	Omar (2013)
Cattle fish	<i>Sepia officinalis</i>	14	13	Manmeet <i>et al.</i> (2005)
Spanish mackerel	<i>Scomberomorus commerson</i>	30.3	43	Mehdi <i>et al.</i> (2007)
Kawa kawa	<i>Euthynnus affinis</i>	35.5	43	Sallehudin (2016)
White seabream,	<i>Diplodus sargus</i>	19.5	23	Al-Beak <i>et al.</i> (2015)
Grouper	<i>Epinephelus marginatus</i>	28.8	47.1	Rafail <i>et al.</i> (1969)
Atlantic mackerel	<i>Scomber scombrus</i>	20	18	Omar (2018)
European seabass	<i>Dicentrarchus labrax</i>	32	31	Salem (2004)
Meager	<i>Argyrosomus regius</i>	35.4	46	Shabana <i>et al.</i> (2013)

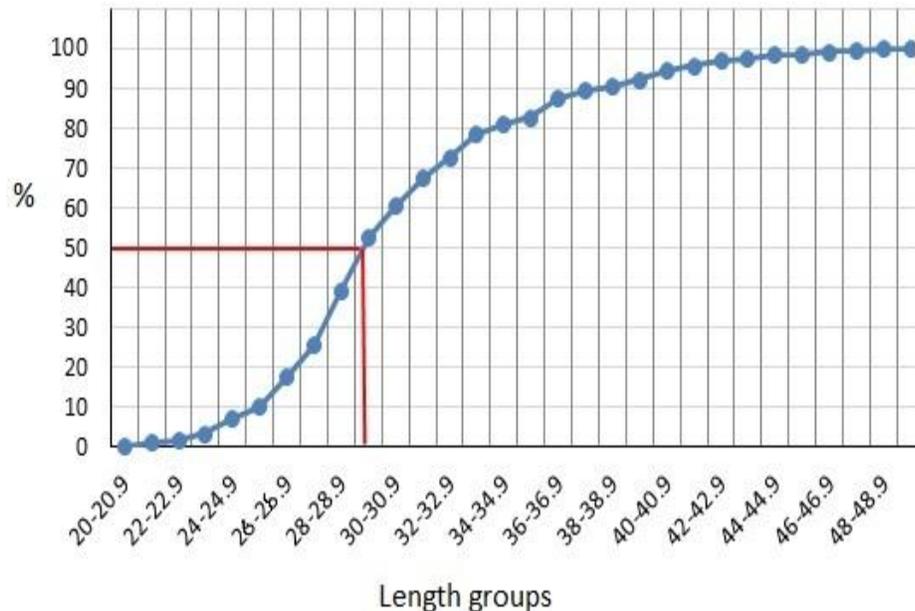


Fig. (6): Length at first capture of *M. cephalus* in the Mediterranean coast of Sinai during 2017

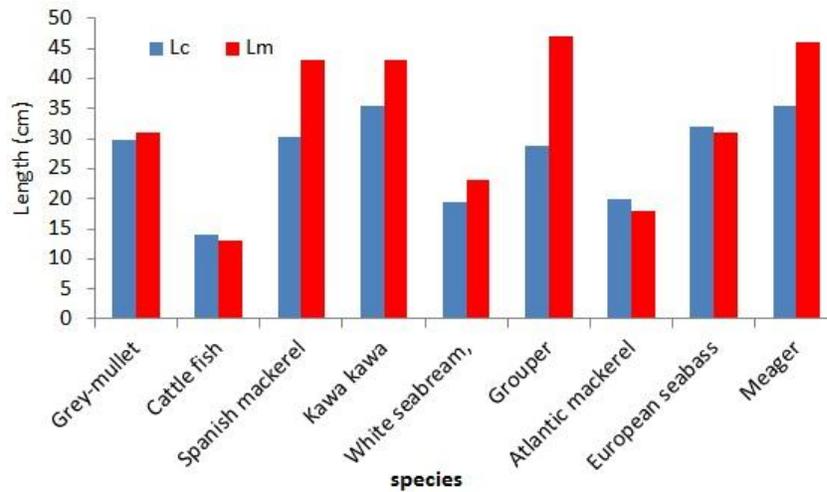


Fig. (7): Length at first capture (L_c) compared to length at first sexual maturity (L_m) of studied fish species

Sex ratio of *M. cephalus*:

According to months, grey mullet showed an inconsistent pattern in the monthly distribution of sex ratio. Although the dominant feature in most months was the numerical predominance of females, except in February, July and December, where the ratio of males to females was equal (Fig. 8). The overall ratio of males to females was 1:1.8, which provided a significant variation from the expected ratio 1:1 (X^2 , $P < 0.05$).

Gonado- Somatic Index (GSI) of *M. cephalus*:

Figure (9) presents the monthly values of (GSI) and showed that, *M. cephalus* has a long spawning season extends from August to December with one peak in September (2.81) and October (3.67) for males and females respectively. A sharp decrease in GSI values were detected during the period from January to July expressing the rest period, where the minimum values were detected in May (0.20) and June (0.33) for males and females respectively.

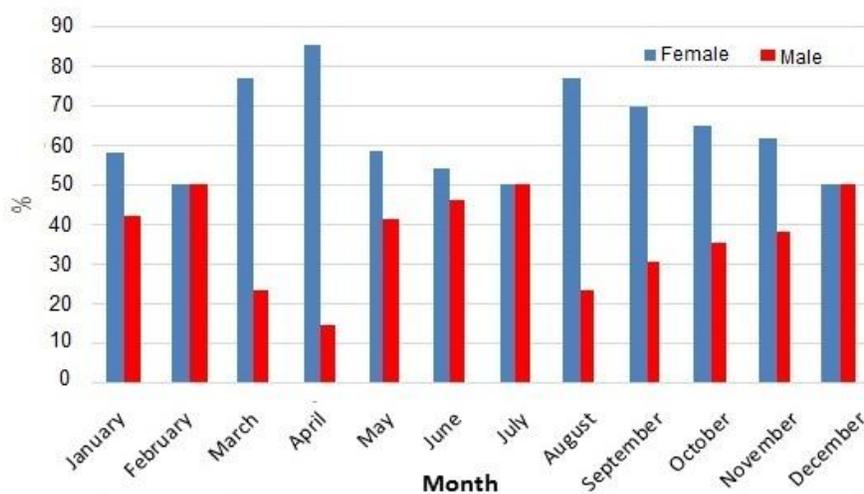


Fig. (8): Monthly variations in sex ratio of *M. cephalus* in the Mediterranean coast of Sinai

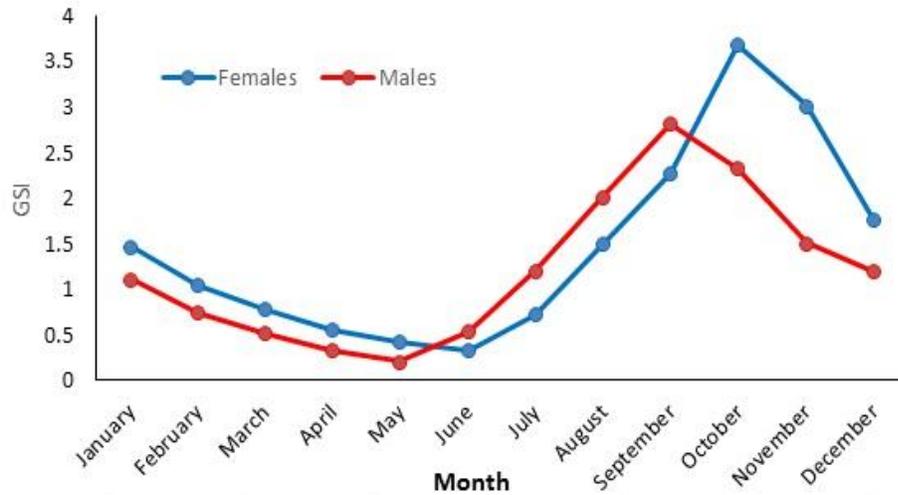


Fig. (9): Monthly variations in Gonado Somatic Index (GSI) of *M. cephalus* in the Mediterranean coast of Sinai

DISCUSSION

The main objective of fishery management is to maximize the yield taken from a fishery without compromising future catches (**Kar and Matsuda, 2006**). The present field study in Mediterranean coast in north Sinai of Egypt indicated that (except Sardines) 9 fish species; Grey-mullet, Cattle fish, Spanish mackerel, Kawa kawa, White seabream, grouper, Atlantic mackerel, European seabass and Meager; represented the majority of the total production from different fish species. These fish species were greatly varied according to their economic value. The previous results were consistent with **El-Aiatt (2004)** who found that the catch of Mediterranean coast of Sinai fishery during the period from 1989 to 2001 was composed of Sardines (86.51%), Shrimp scad (1.81%), Cattle fish (1.33%), Spanish mackerel (0.68%), Groupers (0.66%), Crabs (0.28%), White seabream (0.19%), Meager (0.11%), Kawa kawa (0.21%) and others (8.22%).

Length-weight relationship is used for converting weight data to length and vice-versa. Length-weight relationship is very important for fisheries biologists, where the differences in length-weight relationship might be interpreted as being due to differences in growth and morphometry between regions (**Barnabè, 1976**). In the present study, *E. affinis*; *D. sargus*; and *D. labrax* shows an isometric growth pattern, where (b) value of dependence length upon weight = 3.057, 2.9996 and 2.954 for the previous species respectively. The other six species exhibit an allometric growth pattern (either positive or negative), where (b) value ranged between 2.3 and 3.5. **Bagenal and Tesch (1978)** reported that growth is isometric when the length exponent is equal to 3 and allometric when length exponent is greater or less than 3.

Concerning *M. cephalus* in the present study, the length – weight relationship of male, female and combined sexes shows a negative allometric growth pattern. The (b) value in present study may be greater or lower than other studies in the same lagoon or other regions as shown in Table (4), where a positive allometric and isometric growth patterns were reported. Variation in growth pattern may be attributed to fish size and maturation, where the present study obtained large sizes of *M. cephalus* compared to some other studies. Fishes can change its growth pattern during the life time, this could sign-out the beginning of the reproduction engagement (**Fontoura *et al.*, 2010**).

Generally, the difference in "b" values can be due to the combination of various factors such as number of specimens, habitat, stomach fullness, gonadal maturity, sex, and the overall fish condition (**Abowei *et al.*, 2009**).

Table (4): Values of (b) of *M. cephalus* in different regions

References	Regions	Values of (b)
Durairaja, <i>et al.</i> (2020)	pulicat lake, Tiruvallur	2.77
Reis and Ateş (2019)	Köyceğiz Lagoon in Turkey	2.95
Ogunola and Onada (2017)	Okrika Gulfs	2.86
EL Aiatt and Salem (2017)	Bardawil lagoon	2.96
Espino-Barr <i>et al.</i> (2015)	Mexican Central Pacific	2.95
Ezekiel and Abowei (2014)	Nigeria	2.73
Huseyn Khayyami <i>et al.</i> (2014)	Qeshm Island	2.90
Omar (2013)	Bardawil lagoon	2.67
Kurma and Ramesh (2013)	India	2.74
Sahoo <i>et al.</i> (2012)	Chilika lagoon India	2.98
Emmanuel <i>et al.</i> (2010)	Lagos lagoon, Nigeria	2.99
Dulcic and Glamuzina (2006)	Croatia	3.23
El Ganainy <i>et al.</i> (2002)	Bardawil lagoon	2.86
Wokoma <i>et al.</i> (2001)	Nigeria	2.88
Bebars (1986)	Bardawil lagoon	2.81
EI Maghraby <i>et al.</i> (1973)	Borullus, Egypt	2.81
Rangaswamy (1973)	Pulicat lake India	2.91
The present study	Mediterranean coast of Sinai	2.69

Condition factor is a simplified relationship between length and weight, which widely used to infer to what extend the environmental conditions are appropriate for fish species to live and achieve a balance growth rate (**Bagenal and Tesch 1978**). In the present study, the condition factor was studied for 9 fish species, and it was found that there were significant differences in (K) values as they differ in their biological response towards ecological variables.

Concerning *M. cephalus*, males and females were nearly similar in the trend line for both sexes. A decline in the value of condition factor (K) was observed during July in

female, which accompanied by slight increase in males. This may attributed to gonadal development and consequently a decline in condition factors in female was occurred. Fish size and condition are key parameters to properly assess fecundity at the population level (**Murua et al., 2003**). **Vazzoler (1996)** confirmed that, lowest (K) values during the more developed gonadal stages might mean resource transfer to the gonads during the reproductive period. **Braga (1986)** showed that, values of the condition factor vary according to seasons and are influenced by environmental conditions.

It's clear that, there was a sharp variation in length at first sexual maturity (L_m) according to species, where the maximum value (47.1) for Grouper compared to 13 cm for Cattle fish. Variation in size and age during attaining the first sexual maturity according to fish species is a certain fact, which is controlled by factors specific to species itself and other ecological factors, as well as the effect of each of them on other (**Fontoura et al., 2010**).

M. cephalus attained the length at first sexual maturity (L_m) at 29.8 and 30.0 cm for males and females respectively. The present results are nearly similar to the finding of **Ibáñez and Gallardo-Cabello (2004)**, where (L_m) was 28.0 cm for males and 29.9 cm for females in the Gulf of Mexico. On the contrary, 23.6 and 25 cm for males and females respectively in east Florida USA were reported by **Oren (1981)**. The discrepancy in (L_m) may be due to the difference in location according to longitude and latitude in addition to size and characteristics of the water body (**Nikolsky, 1963**).

The length at first capture was estimated to identifying the effect of different fishing activities on the general shape of the fish communities and even for one species. In the present study, values of (L_c) were compared to the length at first sexual maturity (L_m). It was found that, Grey mullet, Spanish mackerel, Kawa kawa, White Seabream and Meager were caught before reaching the first sexual maturity. The lower value of (L_m) than (L_c), confirmed the occurrence of overfishing and the negative impact on fish stock. There were 3 species; Cattle fish, Atlantic mackerel and European seabass; in which the values of (L_m) and (L_c) were nearly equal, therefore approximately 50 percent of these species were be caught under maturation size, which makes the stock of these species threatened. The fishing effort must be reduce to preserve these species and give them the opportunity to reproduce and preserve their fish stocks.

The gonadosomatic index (GSI) is the basic indicator for gonadal conditions. For more accurate tracking of reproductive activities, GSI was investigated separately for both sexes because of GSI values were vary significantly between sexes as a result of highly variations in the weight of ovaries and testes during different maturity stages (**El-Betar, 2016**). The recorded values of GSI ranged from 0.33 to 3.67 and from 0.22 to 2.81 for females and males respectively. The highest values were recorded in September and October for males and females respectively. The pattern of GSI in *M. cephalus* indicated that, this species has a long spawning season with one peak for both sexes, as well as males preceded females at the beginning of their entry into the reproductive

season and gonadal development. **El-Betar (2009)** and **El-Boray (1993)** found the same observation and reported that, the highest GSI of females delayed one month than that of male.

Bekova and Raikova-Petrova (2017) reported that the maximum values for the ovarian GSI of *M. cephalus* from the Bulgarian Black Sea coast established in August while for the testes in July. Its values increase with the fish weight and ranged from 1.19 to 5.37 for males and females. The values of GSI may be varied according to several factors, some of which may be overlapping together to increasing or decreasing the variation.

CONCLUSION AND RECOMMENDATIONS

The present study investigate some biological characteristics of 9 fish species; especially mullet; in the Mediterranean coast of North Sinai. The study showed the good condition of fish species and the ecological suitability to achieve balanced growth performance (length weight relationship and condition factor). Length at first capture according to length at first sexual maturity confirmed the occurrence of overfishing for many species, where they have been caught at size less than or approximately equal to the size at first maturation. The current status suggests a future decline in production and a negative impact on fish stocks.

Immediate adjustments to fishing laws and strict enforcement, with suitable minimum catch size of each species, is a goal to be achieved.

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