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Growth and mortality rates for management of the common smooth-hound shark, *Mustelus mustelus* in the Egyptian Mediterranean waters

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ABSTRACT

The present study aimed to provide information on growth and mortality rates for the management of the common smooth-hound shark, *Mustelus mustelus* in the Egyptian Mediterranean waters at Alexandria. The study was based on a total of 311 specimens of *M. mustellus* which were monthly collected from the commercial catch at Alexandria coast of the Mediterranean Sea, during the period from June 2020 to May 2021. Results showed that the total length of male *M. mustellus* ranged from 38.6 to 106.8 cm for males and from 38.6 to 117.5 cm for females. The total weight varied from 155.9 to 3611.7 g for males and from 157.3 to 2828 g for females. The b value (2.88, 2.74, and 2.8 for male, female and whole population, respectively) is slightly lower than the ideal, indicating a tendency towards slightly negative allometric growth. Results showed that the present levels of exploitation represented 0.407, 0.417 and 0.42 for males, females, and the whole population, respectively which were higher than that of $E_{0.5}$= as 0.30, 0.295, and 0.297 for males, females, and the whole population, respectively. It gives the maximum (Y/R), which means that the stock of *M. mustellus* is highly overexploited, which is needed to maintain 50% of the stock biomass. For management purposes, the exploitation rate of *M. mustellus* should be reduced to be < $E_{0.5}$ i.e., the fishing mortality should be reduced to lower than the current fishing mortality (F=0.39, 0.42 and 0.45 y^{-1} for male, female, and the whole population respectively) to maintain sufficient spawning biomass for sustainability. Finally, this study concluded that the length of the first capture of *M. mustellus* was calculated at 33.8 cm, while *M. mustellus* doesn't reach maturity unless reaches 83 cm at least. These indicated that *M. mustellus* in Egyptian Mediterranean waters was captured way before it reached its maturity stage.

INTRODUCTION

The Egyptian Mediterranean Sea coast attained about 1100 km. It extends from El-Salloum in the West to El-Arish in the East **(Mehanna *et al*., 2005)**. The width of the Eastern continental shelf was greater than that in the West, except in Salloum Bay **(Abu-Hatab, 2005).**

FAO (2005) designed the field identification guide to the sharks of the Mediterranean Sea and mentioned that 49 species of sharks belong to 17 families and 5 orders: Hexanchiformes, Squaliformes, Squatiniformes, Lamniformes, and Carcharhiniformes. **El-Tabakh (2019)** mentioned that 21 species of sharks collected from Alexandria, Mediterranean Sea; belongs to 9 families and 5 orders; Hexanchiformes, Squaliformes, Squatiniformes, Lamniformes and Carcharhiniformes. The Smooth-hound sharks belong to the genus Mustelus (family Triakidae), which includes 34 valid species occurring in all major oceans. Five of those species can be found in the Mediterranean. *M. Mustelus* (Linnaeus, 1758) is a demersal species inhabiting sandy or muddy bottom down to the depths of 150 m **(Golani *et al*., 2006** and **Özcan &Başusta, 2016).**

Elasmobranch fish species are exploited for their fins, skin, jaws, or meat. Shark fins were the most valuable of shark products and used to make traditional shark fin soup, a delicacy in the Chinese culture **(Clarke *et al*., 2006)**.

Sharks are known as animals that are long-lived, slow growing, late maturing and producing few offspring. Overall, sharks have a low productivity that tends to be lower than that of other vertebrate groups of teleosts **(Walker, 1998).** Although, the decline of smooth hounds in the Mediterranean was acknowledged by IUCN and also confirmed by fishers, the rate of reduction in the different sectors of the Mediterranean is unclear **(Stevens, *et al*., 2000; Barker & Schluessel, 2005; Maynou *et al*., 2011; Nieto *et al*., 2015** and **Colloca *et al*., 2017)**. Although this makes sharks vulnerable to overfishing, a larger problem is, however, the lack of management of shark catches. The management of shark fishing has proven problematic due to a lack of co-ordinated research relating to the biology and stock assessment of commercially valuable sharks. Accurate stock assessment is made difficult by the large amount of illegal fishing and discards because sharks are largely taken as by-catch. The quantity of demersal sharks caught as by-catch in inshore trawl fisheries is higher than sharks caught by the directed demersal shark longline fishery **(MCM, 2010).**

The catch of elasmobranchs was recorded every year by the general authority for fish resources development in Mediterranean coast, it has been reduced from 3450 Tons during 2006 to 1292 Tons during 2018 **(GAFRD, 2018)** and reduced to 881 Tones during 2020 **(GAFRD, 2020)** with no reference to sharks or other elasmobranchs and the identification to the lowest species taxa.

Therefore, the present study aimed to provide the basic information required for the managing the common smoothhound shark (*M. mustelus*) in the Egyptian Mediterranean waters, at Alexandria, such as growth, mortality and exploitation rates.

MATERIALS AND METHODS

1. Samples collection:

A total of 311 specimens of the common smoothhound shark, *Mustelus mustelus* **(Fig. 1)** were monthly collected from the commercial catch at the fish land markets in Alexandria of the Mediterranean Sea, during the period from June 2020 to May 2021. Samples were kept in 10% formalin solution before transporting to the Marine Biology Laboratory, Zoology Department, Faculty of Science, Al-Azhar University, Nasr City, Cairo, Egypt, for further study. Sharks were identified in the laboratory using **FAO (2005)**, fork and total lengths were measured to the nearest millimetres. Sharks were also wet weighted in grams and the following studies were carried out.

Fig. (1): Picture of common smoothhound shark, *M. mustelus*, collected from the commercial catch at the land fish market in Alexandria of Mediterranean Sea, during the period from June 2020 to May 2021.

2. Length - weight relationship:

Length-weight relationship was determined according to **Le Cren (1951)** for males and females separately and for the whole populations of each species according to the following equation:

$$W = a * L^{b}$$

The length-weight relationship was transformed to logarithmic modification according to the following equation:

$$\text{Log } W = a \pm b \log L$$

Where: **W**= Total weight of fish (g); **L**= Total fish length (cm); a&b= Constants, whose values are estimated by the least square method.

3. Condition factors:

Condition factor (**K**) is given by the following formula:

$$K = 100\ W/{+}L^{3} \qquad \text{(Le Cren, 1951):}$$

Where: **W**= Total weight of fish (g); **L**= Total fish length (cm).

The relative condition coefficient factor (Kn) was determined by the following equation:

$$Kn = W/W' \qquad \text{(Hile, 1936)}$$

Where: W= Observed fish weight (g) and W`= Calculated weight estimated from the length-weight relationship.

4. Fishery and stock assessment studies:

4.1. Estimation of the theoretical growth in length:

The **Von Bertalanffy (1938)** for growth model was applied to describe the theoretical growth in length and weight.

- Von Bertalanffy growth in length equation can be expressed as follows:

$$L_t = L_\infty [1 - e - k (t - t_o)]$$

Where: L_t= Mean length at age t; L_∞= Asymptotic length, i.e. the (mean) length of a given stock would reach if they were left to grow forever; **k**= Growth coefficient that determines the rate at which L_∞ is attained; **t**= Age at length L_t; $\mathbf{t_0}$= Age at which the length is theoretically equals zero.

4.2. Von Bertalanffy growth parameters:

The values of L∞ and k were estimated from the linear regression between (L_t) and (L_t+1) using the **Ford (1933)** and **Walford (1946)** method as the following:

$$L_t+1 = L_\infty (1\text{-}e\text{-}k) + e\text{-}k * L_t$$

$$L_\infty = a / (1- b); \qquad K = - \ln b$$

Where: **a** & **b** are the intercept and the slope of the regression, respectively.

This method was applied by plotting (L_t+1) against (L_t) which gives a straight line with a slope (b) equals to (e-k) and an intercept (a) equals to [L_∞ (1-e-k)]. The constants (a) and (b) of this linear relationship were estimated by using the least square method.

5. Estimation of growth performance index (Φ):

For comparing the growth performance of the species with that of the same species in other region, the growth performance index (Φ) was estimated according the formula of **Pauly (1984)** as follows:

$$\Phi = \text{Log } K + 2 \text{ Log } L\infty$$

Where: **Φ**= Phi-prime, i.e., a length-based index of growth performance; **K** and $\mathbf{L_\infty}$ are von Bertalanffy growth parameters.

6. Population dynamics:

6.1. Total mortality (Z):

It was estimated by **Pauly's method (1983):** This method is based on the analysis of catch curve using length frequency data. The catch curve is constructed through the conversion of length to age by using the growth parameters of the Von Bertalanffy growth model. The total mortality coefficient was estimated through the following relationship:

$$\ln (N/\Delta t) = a + b*t$$

Where: **N**= Frequency of each length class; **Δt**= Time needed to grow from t_1 to t_2 of a given length class; **t**= Relative age corresponding to the mid-point of the length class; **a** & **b** are constants. This is a linear relationship, where: **Y= ln (N/Δt)** and $\mathbf{X= (t_1 + t_2)/2}$

The constants (**a**) and (**b**) can be calculated by linear regression between ln (N/Δt) and X= $(t_1 + t_2)/2$. The slope (b) of this regression is equal to (-Z) and estimated by **Beverton & Holt (1956)** model. This method is based on the analysis of catch curve using length frequency data. The total mortality coefficient was estimated using the following relationship:

$$Z= K (L_\infty - L_{mean}) / (L_{mean} - L')$$

Where: **K**= curvature parameter of the VBGF; $\mathbf{L_\infty}$= Asymptotic length, i.e., the (mean) length of a given stock would reach if they were left to grow forever.

$\mathbf{L_{mean}}$ = Mean length of fish in a sample representing a steady-state population.

L`= Cut-off length or the lower limit of the smallest length class included in the computation, and estimated by Beverton and Holt model, in the Ault and Ehrhardt model, Z from mean length, is: The total mortality coefficient was estimated through the following relationship:

$$\left[\frac{Loo - Lmax}{Loo - L'}\right]^{Z/K} = \frac{Z(L' - Lmean) + K(Loo - Lmean)}{Z(Lmax - Lmean) + K(Loo - Lmean)}$$

Where: $\mathbf{L_\infty}$ = Asymptotic length, i.e., the (mean) length of a given stock would reach if they were left to grow forever; **K** = curvature parameter of the VBGF; $\mathbf{L_{mean}}$ = the mean length of the fish in a sample representing a steady-state population; **L`**= cut-off length or the lower limit of smallest length class included in the computation; $\mathbf{L_{max}}$ = largest fish in the sample.

6.2 Natural mortality (M):

The coefficient rate of natural mortality (M) refers to the natural decrease in late juvenile and adult phases of a population. It was calculated from **Pauly (1980)** based on the parameters (L_∞ and K) of the von Bertalanffy growth function and average temperature (T) according to Pauly's Empirical Equation (1980) as following:

$$\mathbf{Log\ M = - 0.0066 - 0.279\ log\ L_\infty + 0.6543\ Log\ k + 0.4634\ log\ T}$$

Where: $\mathbf{L_\infty}$ = Asymptotic length; **k** = Growth coefficient; **T** = Average annual temperature (°C) of stock's habitat.

6.3. Fishing mortality (F):

The instantaneous mortality rate is caused by the fishing operations. According to **Beverton and Holt (1957**), the total mortality rate (**Z**) is sum of fishing (**F**) and natural (**M**) mortalities (Z = F + M). With the values of (Z) and (M) are available, the coefficient of fishing mortality could be calculated by simple subtraction:

$$\mathbf{F = Z - M}$$

6.4. Rate of exploitation (E):

It is calculated from the fishing mortality (F) during some specified period when all causes of the death are affecting the population by the following relationship:

$$\mathbf{E = F / Z}$$ **Gulland (1971**)

Where: Z is the total mortality.

6.5. Length at first capture (Lc):

The length at the first capture ($\mathbf{L_c}$) is the length at which 50% of the catch retains in the gear. It was estimated by plotting the curve for probability of capture by length using the method of **Pauly (1984),** while the first capture was obtained by using the length at first capture ($\mathbf{L_c}$) and Von Bertalanffy growth parameters (**k**, $\mathbf{L_\infty}$ and $\mathbf{t_0}$) from growth in length equation as follows:

$$\mathbf{T_c = - 1/k * ln\ [1- (L_c/L_\infty)] + t_0}$$

6.6. Relative yield per Recruit(Y'/R):

The relative yield per recruit and relative biomass per recruit were estimated according to the **Beverton & Holt model (1966)** as incorporated in FiSAT software.

7. Statistical data analysis:

Statistical analysis and graphics of data was conducted by using Microsoft Excel and FiSAT software, under windows programs.

RESULTS

1. Length - weight relationship:

Results showed that the total length of male *M. mustellus* ranges from 38.6 to 106.8 cm, while the total weight varied from 155.88 to 3611.66 g. The weight of the fish increases with the increasing length of the fish **(Table 1** and **Fig. 2)**. The length-weight relationship of this fish is represented by the following equation:

$$\textbf{Log (W) = 2.8826* Log L - 2.336}$$
$$\mathbf{W = 2.336\ L^{2.88}\ (R^2 = 0.8683)}\ \text{for male}$$

Consequently, the values of "a" and "b" in male *M. mustellus* were 2.34 and 2.88 respectively. From the above findings, it is clear that the b value (2.88) is slightly lower than the ideal, thus indicating a tendency towards slightly negative allometric growth. The correlation coefficient "R^2" was highly correlated (0.87) **(Table 1** and **Fig. 2).**

On the other hand, the total length of female *M. mustellus* ranges from 38.6 to 117.5 cm, while the total weight varied from 157.28 to 2828.02 g. The weight of the fish increases with the increasing length of the fish **(Table, 1** and **Fig. 2)**. The length-weight relationship of this fish is represented by the following equation:

$$\textbf{Log (W) = 2.7364* Log L - 2.0901}$$
$$\mathbf{W = 2.0901\ L^{2.7364}\ (R^2 = 0.8268)}\ \text{for female}$$

Consequently, the values of "a" and "b" in female *M. mustellus* were 2.09 and 2.74 respectively. From the above findings, it is clear that the b value (2.74) is slightly decreased than the ideal, thus indicating a tendency towards slightly negative allometric growth. The correlation coefficient "R^2" was highly correlated (0.8268) **(Table 1** and **Fig. 2).**

In the same manner, the present data showed that the total length of the whole population of *M. mustellus* ranges from 38.6 to 117.5 cm, while the total weight varied from 157.28 to 2828.02 g **(Table, 1** and **Fig. 2)**. Fish weight increases with the increasing length of the fish. The length-weight relationship of this fish is represented by the following equation:

$$\textbf{Log (W) = 2.8025* Log L - 2.2014}$$
$$\mathbf{W = 2.20L2.80\ (R^2 = 0.8464)\ for\ combined\ sexes}$$

Consequently, the values of "a" and "b" for whole population of *M. mustellus* were 2.20 and 2.80 respectively. From the above findings, it is clear that the b value (2.80) is slightly lower than the ideal, thus indicating a tendency towards slightly negative allometric growth. The correlation coefficient “R^2” was highly correlated (0.85) **(Table 1** and **Fig. 2)**

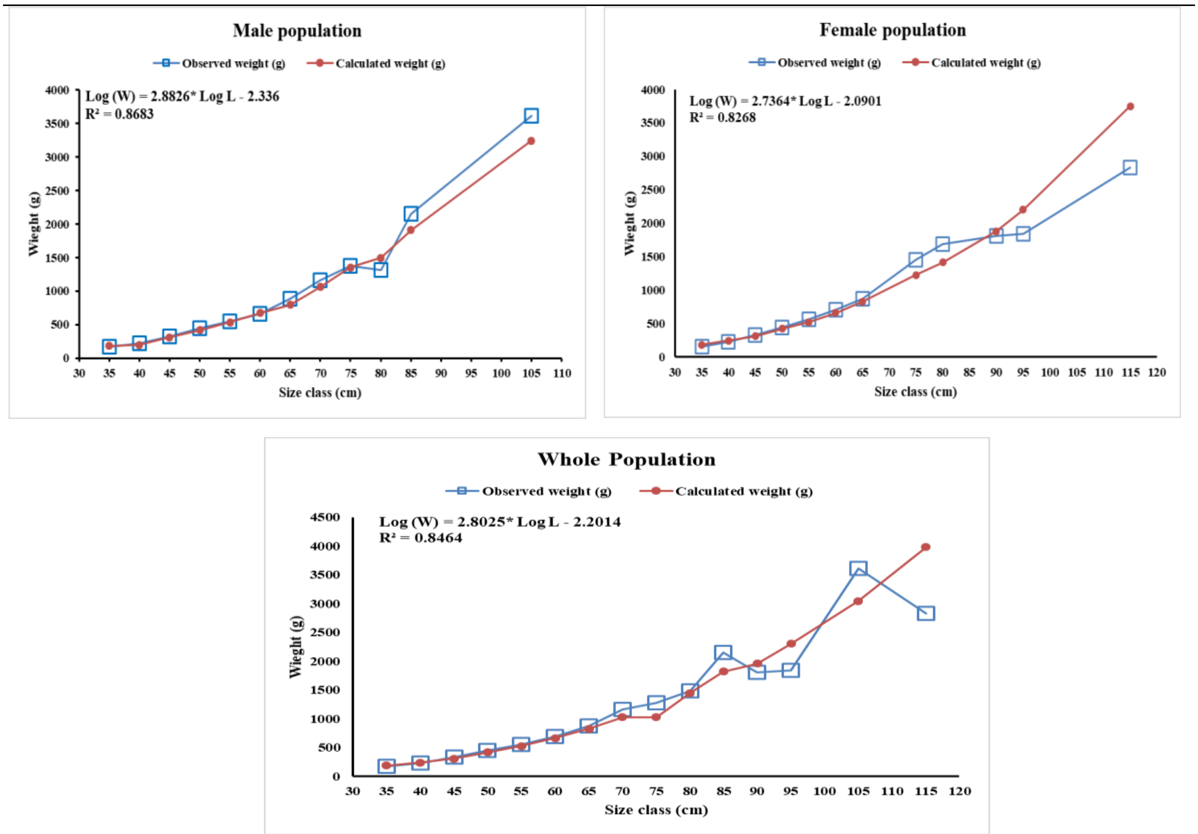


Fig. (2): Length-weight relationship of *M. mustellus* (male, female and whole population), collected from Alexandria, Mediterranean Sea, during the period from June 2020 to May 2021.

2. Condition factors according to size class:

Data revealed that the composite coefficient “K” and the relative condition factor “Kn” of male *M. mustellus* varied significantly with the fish size. Values of composite coefficient of condition “K” fluctuated between 0.26 and 0.4; values of relative condition factor “Kn” varied from 0.66 to 1.12 for different length groups (**Table 1** and **Fig. 3).**

On the other hand, the composite coefficient “K” and the relative condition factor “Kn” of female *M. mustellus* varied significantly with the fish size. Values of composite coefficient of condition “K” fluctuated between 0.19 and 0.36; values of relative condition factor “Kn” varied from 0.75 to 1.2 for the different length groups (**Table 1** and **Fig. 3**).

At the same manner, composite coefficient “K” and relative condition factor “Kn” of whole population of *M. mustellus* varied significantly with the fish size. Values of composite coefficient of condition “K” fluctuated between 0.19 and 0.39. Values of relative condition factor “Kn” varied from 0.71 to 1.19 for different length groups **(Table 1** and **Fig. 3)**.

Table (1): Length-weight relationship and condition factors of *M. mustellus* (male, female and whole population), collected from Alexandria, Mediterranean Sea, during the period from June 2020 to May 2021.

	Size class	No.	Observed weight (g)		Calculated weight	Condition factor	
			Range	Mean ± S.D.		K	Kn
Female	**35**	4	154.62-200.22	170.10±21.21	182.38±7.79	0.40±0.03	0.93±0.09
	40	30	154.01-385.17	218.42±44.58	199.87±265.44	0.34±0.51	0.66±1.72
	45	39	217.12-550.19	325.24±70.43	307.72±25.79	0.36±0.06	1.05±0.20
	50	30	344.51-679.9	450.63±78.64	416.98±31.27	0.36±0.06	1.08±0.18
	55	24	411.66-702.59	546.92±71.21	533.85±42.18	0.33±0.03	1.02±0.20
	60	9	530.46-798.18	662.69±88.09	673.26±54.25	0.31±0.03	0.98±0.11
	65	3	819.97-923.8	888.92±59.71	794.58±5.34	0.32±0.02	1.12±0.07
	70	6	976.8-1301.2	1156.8±149.6	1060.64±1.96	0.34±0.03	1.09±0.10
	75	1	-	1375.84	1351.84	0.33	1.02
	80	6	352.5-1713.4	1316.3±489.6	1495.3±106.9	0.26±0.08	0.87±0.31
	85	4	530.4-3215.2	2155.5±1307.8	1911.0±46.6	0.35±0.18	1.11±0.68
	105	1	-	3611.66	3247.57727	0.31	1.112109
Female	**35**	1	-	157.28	178.42	0.37	0.88
	40	36	167.36-395.86	228.28±43.55	241.98±19.80	0.36±0.04	0.94±0.14
	45	30	221.06-964.1	329.47±26.70	309.77±26.70	0.36±0.12	1.06±0.41
	50	21	179.52-612.2	442.49±105.61	420.61±32.76	0.35±0.07	1.05±0.24
	55	25	422.34-841.8	557.49±101.80	520.68±31.20	0.34±0.04	1.06±0.16
	60	18	564.11-799.94	706.66±65.75	656.99±54.46	0.33±0.03	1.08±0.11
	65	8	791.11-996.81	869.25±80.30	827.69±40.27	0.32±0.02	1.05±0.07
	75	3	1259.98-1673	1456.7±207.21	1225.2±66.61	0.35±0.04	1.19±0.16
	80	5	1322.71-2660	1691.06±550.73	1413.82± 80.45	0.33±0.10	1.20±.400
	90	4	412.78-2375	1806.55±932.42	1879.05±44.12	0.25±.12	0.97±.50
	95	2	427.78±3260	1843.89±2002.68	2202.11±35.25	0.22±0.23	0.84±0.92
	115	1	-	2828.02	3752.77	0.19	0.754
Whole population	**35**	5	154.62-200.22	167.53±19.24	183.39±7.90	0.39±0.02	0.91±0.08
	40	66	154.01-395.86	223.80±43.96	238.50±19.86	0.35±0.05	0.94±0.16
	45	69	217.12-964.1	327.08±103.744	308.629±25.89	0.36±0.09	1.06±0.31
	50	51	179.52-679.9	447.28±89.80	417.74±31.69	0.36±0.06	1.07±0.21
	55	49	411.66-841.8	552.32±87.41	526.43±36.18	0.33±0.04	1.05±0.13
	60	27	530.46-799.94	692±75.24	665.24±48.00	0.32±0.03	1.04±0.11
	65	11	791.11-996.81	874.61±72.87	826.86±48.64	0.32±0.03	1.06±0.09
	70	6	976.84-1301.18	1156.78±149.63	1026.05±57.50	0.34±0.03	1.12±0.10
	75	4	1259.89-1673	1436.48±173.95	1273.31±60.00	0.34±0.04	1.13±0.13
	80	11	352.45-2660	1486.65±528.68	1447.18±90.26	0.29±0.09	1.02±0.36
	85	4	530.39-3215.22	2155.49±1307.76	1818.74±43.09	0.35±0.18	1.18±0.71
	90	4	412.78-2375	1806.55±932.42	1959.81±47.13	0.25±0.05	0.93±0.48

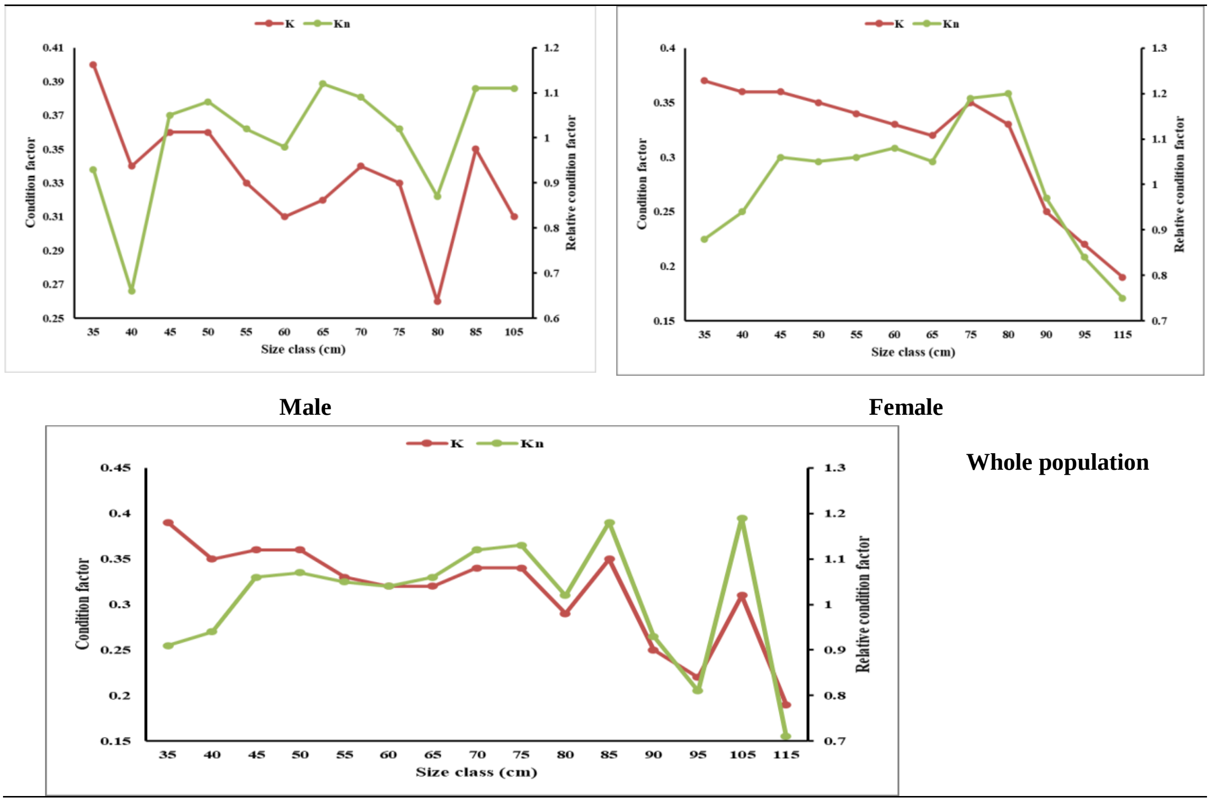


Fig. (3): Condition factors of *M. mustellus* (male, female and whole population), collected from Alexandria, Mediterranean Sea, during the period from June 2020 to May 2021.

3. Condition factors according to months:

Data in **Table (2)** showed that the highest value of condition factor “Kc” of male *M. mustellus* was recorded in July (0.34) and the lowest one (0.27) occurred in December and January. The maximum value of relative condition factor “Kn” was recorded during July (1.18) and the minimum value (0.91) occurred during December.

In the same manner, data in **Table (2)** showed that the highest value of condition factor “Kc” of female *M. mustellus* was recorded in July (0.33) and the lowest one (0.26) occurred in December and January. The maximum value of relative condition factor “Kn” was recorded during November (1.18) and the minimum value (0.89) occurred during January.

Finally, data represented in **Table (2)** showed that the highest value of condition factor “Kc” of whole population of *M. mustellus* was recorded in July (0.34) and the lowest one (0.27) occurred in December, January, April and May. The maximum value of relative condition factor “Kn” was recorded during July (1.18) and the minimum value (0.90) occurred during December and January.

Table (2): Monthly condition factors of male, female and whole population *M. mustellus*, collected from Alexandria, Mediterranean Sea, during the period from June 2020 to May 2021.

Months	Male			Female			Whole population		
	No	K	Kn	No	K	Kn	No	K	Kn
Jun-20	17	0.28±0.07	1±0.23	9	0.31±0.02	1.11±0.08	26	0.3±0.06	1.04±0.19
Jul-20	22	0.34±0.06	1.18±0.22	14	0.33±0.08	0.92±0.26	36	0.34±0.07	1.18±0.23
Aug-20	13	0.3±0.04	1.03±0.13	17	0.31±0.17	1.1±0.55	30	0.3±0.13	1.07±0.42
Sep-20	14	0.29±0.03	1.01±0.11	18	0.29±0.04	1.03±0.14	32	0.29±0.04	1.02±0.13
Oct-20	18	0.31±0.03	1.09±0.10	13	0.31±0.03	1.11±0.10	31	0.31±0.03	1.1±0.11
Nov-20	12	0.3±0.03	1.04±0.09	11	0.32±0.04	1.18±0.14	23	0.31±0.03	1.11±0.12
Dec-20	13	0.27±0.02	0.91±0.07	10	0.26±0.03	0.91±0.11	23	0.27±0.03	0.9±0.09
Jan-21	9	0.27±0.08	0.92±0.29	12	0.26±0.07	0.89±0.24	21	0.27±0.08	0.9±0.25
Feb-21	7	0.30±0.10	1.01±0.32	13	0.28±0.03	0.97±0.97	20	0.29±0.06	0.98±0.22
Mar-21	8	0.28±0.08	0.98±0.30	11	0.29±0.08	0.99±0.35	19	0.28±0.08	0.99±0.32
Apr-21	8	0.27±0.03	0.91±0.10	12	0.28±0.04	0.96±0.15	20	0.27±0.03	0.94±0.13
May-21	16	0.28±0.06	0.97±0.22	14	0.27±0.05	0.94±0.17	30	0.27±0.05	0.95±0.21

4. Fishery and stock assessment studies:

4.1. Fishery statistics:

The catch is sorted out before landing by species group. The fishing catch composite of many fish catch (cartilaginous fish, bogue, sole common, shrimp, jack, European seabass, octopus, striped piggy, common cuttlefish, little tunny, spine feet, bluefish, white seabream, groupers nei, large head hairtail, gray mullets, marine mollusks nei, sardinellas nei, and sigan). Cartilaginous fish was represented in the catch by 2.16% of the total catch in the Egyptian Mediterranean water in 2019 and 1.77 % in 2020 **(GAFRD, 2020)**.

Results showed that annual total fish catch in the Egyptian Mediterranean waters during the period from 2010 to 2020 was fluctuated between 77799 tons during the fishing season in 2011 and 48018 tons during the fishing season of 2019, with a total value of 625532 tons throughout the whole period. The annual cartilaginous fish catch caught from the Egyptian Mediterranean waters fluctuated between 3333 tons (representing 4.28 % of the total catch) in 2011 and 881 tons (representing 1.77%) during 2020 with a total value of 18827 tons (representing 3.01 %) throughout the 10 years of fishery statics **(Table, 3)**.

Finally, results showed monthly variations in cartilaginous fish catch as a percentage of total catch in Egyptian Mediterranean waters. It was varied during the fishing seasons 2019 and 2020 with 3.48 % and 2.91 % of the total catch, during February 2019 and January 2020, respectively. While the minimum catches of cartilaginous fish (1.48 % and 1.22 %) was recorded during September 2019 and October 2020, respectively **(Table, 4)**.

Table (3): Annual total catch (tons) of cartilaginous fish from the Egyptian Mediterranean waters, during the period from 2010 to 2020 (as mentioned in GAFRD, 2020).

Year	Total Catch	Cartilaginous fish catch	%
2010	77388	3056	3.95
2011	77799	3333	4.28
2012	69332	2338	3.37
2013	63027	2112	3.35
2014	62746	1843	2.94
2015	57602	1141	1.98
2016	53964	1300	2.41
2017	58926	1375	2.33
2018	56730	1292	2.28
2019	48018	1037	2.16
2020	49896	881	1.77
Total	625532	18827	3.01

Table (4): Monthly variations in cartilaginous fish catch (tons) in the Egyptian Mediterranean waters during the fishing seasons 2019- 2020.

Months	2019 Catch			2020 Catch		
	Total catch	Cartilaginous catch		Total catch	Cartilaginous catch	
	Tons	Tons	%	Tons	Tons	%
January	1909	60	3.14	1957	57	2.91
February	1494	52	3.48	1827	33	1.81
March	2326	71	3.05	2372	65	2.74
April	3307	112	3.39	3320	73	2.20
May	4313	111	2.57	4660	104	2.23
June	5295	113	2.13	5535	107	1.93
July	5585	113	2.02	5856	111	1.90
August	5595	91	1.63	5383	76	1.41
September	5469	81	1.48	6180	79	1.28
October	4796	73	1.52	5503	67	1.22
November	4245	71	1.67	4471	64	1.43
December	3684	89	2.42	2832	45	1.59
Total	48018	1073	28.51	49896	881	1.77

5. Growth performance:

5.1. Growth estimation:

For growth curves, parameters of Von Bertalanffy were estimated according to **Ford (1933)** and **Wallford (1946).** Asymptotic length (L_∞) and growth coefficient (k), of *M. mustellus* were theoretical lengths at each year (L_{25}= 20.57, L_{50}= 32.80, L_{75}= 34.49 cm) for Male, (L_{25}= 20.66, L_{50}= 33.73, L_{75}= 35.67 cm) for Female and (L_{25}= 20.93, L_{50}= 33.80, L_{75}= 35.70 cm) for whole population.

L_∞ and k were estimated in *M. mustellus* from the Ford-Walford plot, and they were 110.25 cm and 0.30 year $^{-1}$, respectively for males. While, it is estimated to be 120.75 cm and 0.14 year $^{-1}$, respectively for females. In the same manner, it's calculated to be 120.75 cm and 0.24 year $^{-1}$ respectively for the whole population.

5.2. Growth performance index (Φ):

Growth performance indices are used as an indicator of the growth of fish and for comparing its growth with the same species in other sites or with other fish populations. The value of the growth performance index of *M. mustellus* according to L_∞ (Φ) was 3.562 for males, while it was estimated to be 3.311 for females and calculated to be 3.544 for the whole population.

5.3. Mortality rates:

The determination of mortality is essential as it is considered one of the basic input parameters for population dynamic models used in fishery analysiss and management. The total mortality coefficient is defined as the total loss by death of individuals from a population during a certain time interval.

The total mortality coefficient (Z) is composed of two components namely fishing mortality (F) by man and natural mortality (M) by all other causes other than fishing, such as predation, ecological conditions, and diseases.

5.4. Total mortality ccoefficient (Z):

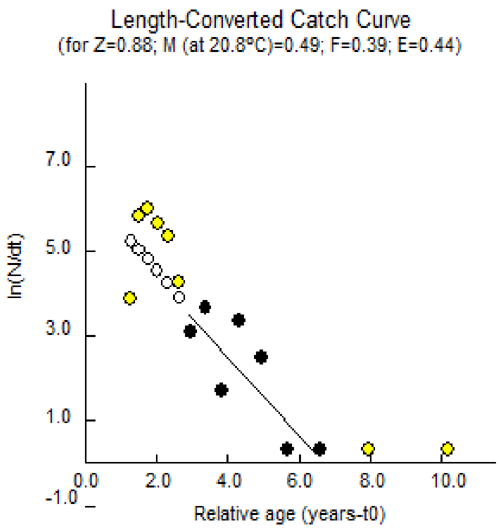
The values of total mortality coefficients for *M. mustellus* were estimated from the length converted catch curve of **Pauly (1983)** to be 0.88, 0.45, and 0.86 for male, female, and whole populations, respectively, it has been calculated by **Ault & Ehrhardt** model and valued at 0.891 y^{-1}, 0.424 y^{-1}, and 0.836 y^{-1} for male, female, and whole population respectively **(Fig. 4)**. While it is estimated to be 0.90 y^{-1}, 0.451 y^{-1}, and 0.846 y^{-1} for male, female, and whole population respectively according to **Beverton & Holt model (1957).**

5.5. Natural mortality (M):

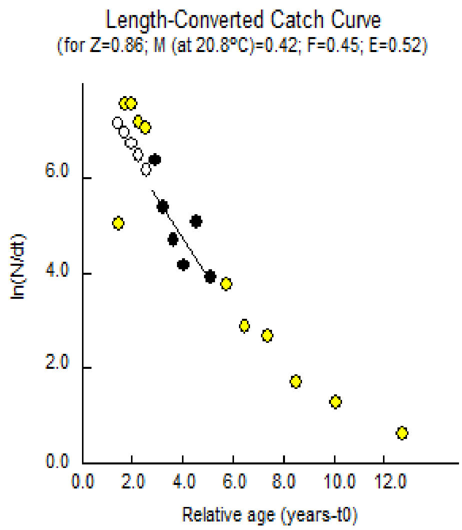
The value of the natural mortality coefficient was 0.49 y^{-1}, 0.29 y^{-1}, and 0.42 y^{-1} for male and female and whole population *M. mustellus* estimated from the length converted catch curve of **Pauly (1983) (Fig. 4)**.

5.6. Fishing mortality (F):

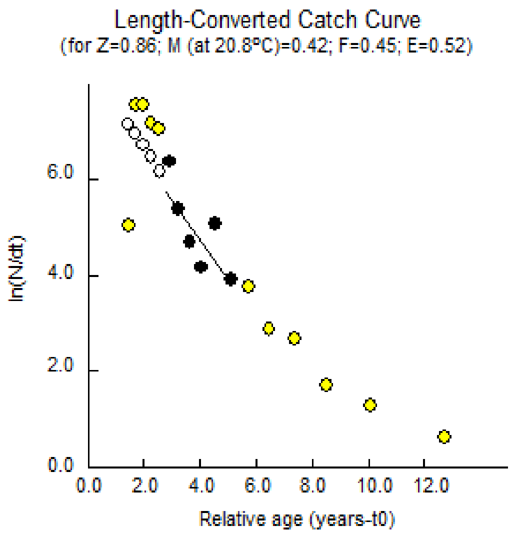
The mean value of fishing mortality was 0.39 y^{-1} for males while it has been calculated to be 0.42 y^{-1} for females and estimated to be 0.42 y^{-1} for the whole population of *M. mustellus* (**Fig. 4**). This fishing mortality is indicating a high level of exploitation.



Male



Female



Whole population

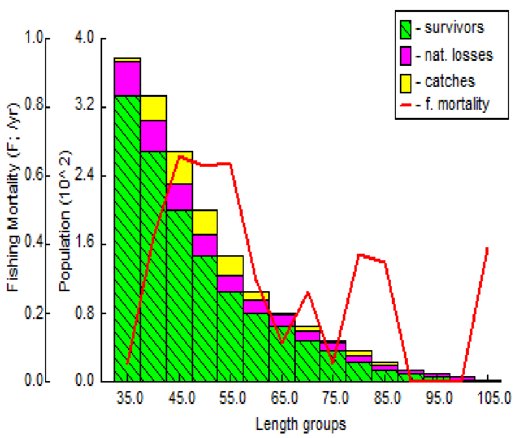
Fig. (4): Length–converted catch curve for estimation of total mortality of male, female and whole population of *M. mustellus*, collected from Alexandria, Mediterranean Sea, during the period from June 2020 to May 2021

5.5. Exploitation ratio (E):

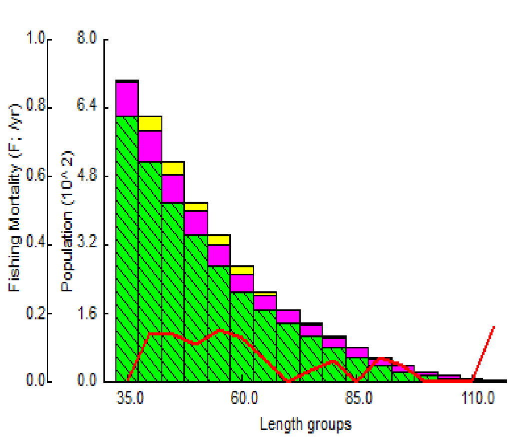
The exploitation ratio is very important to estimate the state of the stock, which is optimum, underexploited, and overexploited. The values of exploited rates were 0.44, 0.35, and 0.52 for males, females, and the whole population of *M. mustellus*. From this result, the exploitation level is very high and exceeds the optimum one (E0.5 = 0.30, 0.295, 0.297) for the male, female, and whole population of *M. mustellus* respectively.

5.6. Length at first capture (L_c):

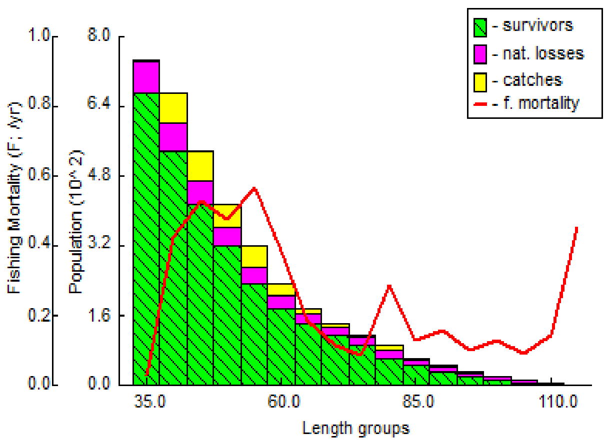
The length group frequency percentage of samples was cumulated separately, and a cumulative curve was drawn to estimate the length at 50 % (Lc) as shown in **Figure (13)**. From this figure, the length at first capture was (32.8, 33.73, and 33.8 cm) for male, female, and whole population of *M. mustellus* respectively **(Fig. 5)**.



Male



Female



Whole population

Fig. (5). Capture probability of *M. mustellus*, collected from Alexandria, Mediterranean Sea, during the period from June 2020 to May

5.7. Relative yield per recruit (Y/R)' and relative biomass/recruit (B/R):

Relative yield per recruit for *M. mustellus* was estimated based on the model of **Beverton & Holt (1966)**. This model describes the exploited population in terms of growth and natural mortality and allows a relative prediction of the long-term catch weights and stock biomass under different exploitation rates. It expresses the yield on a per recruit basis, and hence the yield is relative to recruitment. (Y/R) can be calculated for given input values of M/K, Lc, and L_∞ for values of E.

The maximum (Y/R)' was obtained at (E_{max} = 0.518, 0.513, and 0.506) for male, female, and whole populations respectively, as the exploitation rate increases beyond this value, the relative yield per recruit decreases **(Fig. 6)**.

$E_{0.1}$: is estimated as 0.407, 0.417, and 0.42 for male, female and whole population *M. mustellus*, respectively. **$E_{0.5}$:** is estimated as 0.30, 0.295, and 0.297 for male, female, and whole population respectively.

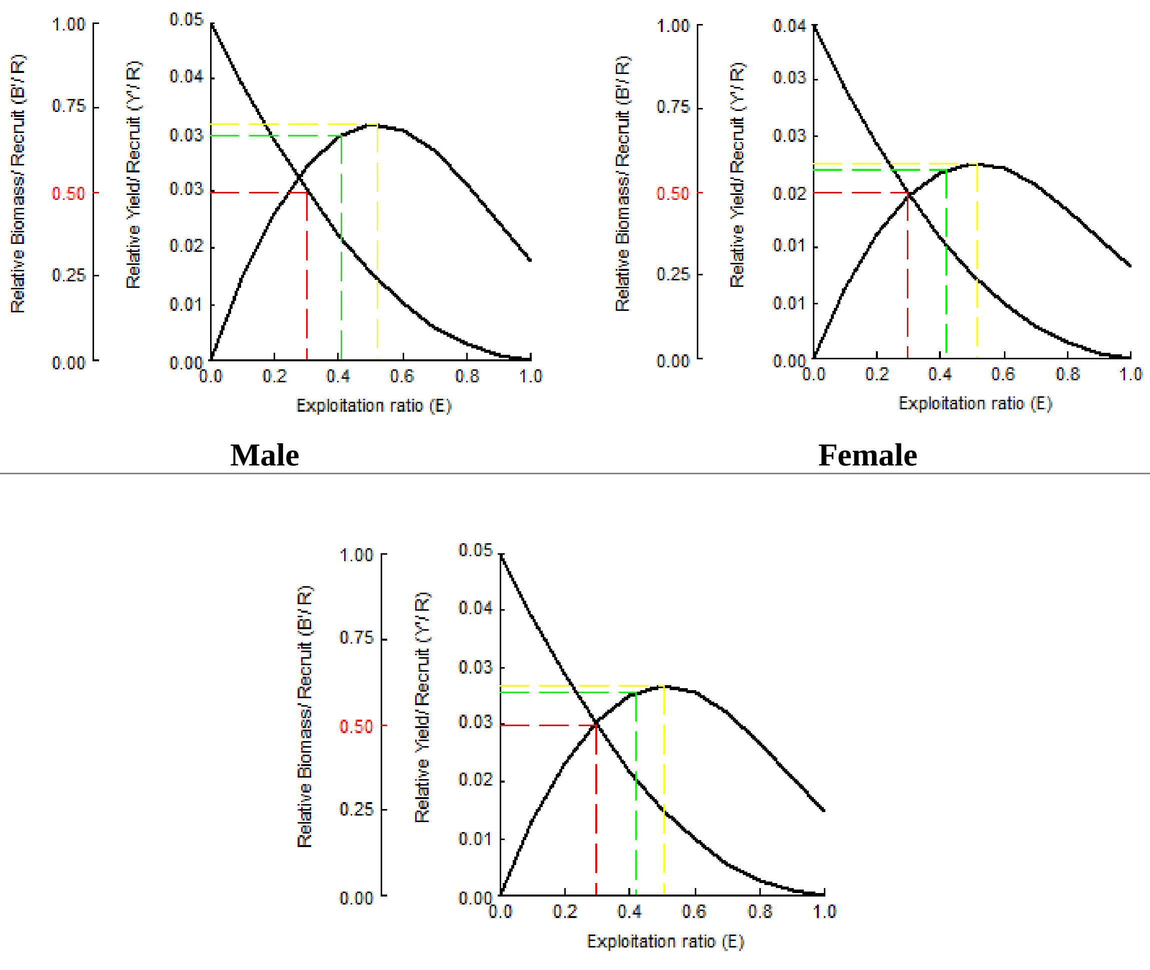


Fig. (6). Relative yield and biomass per recruit (below) and virtual population analysis (above) of male, female, and whole population *M. mustellus*, collected from Alexandria, Mediterranean Sea, during the period from June 2020 to May 2021

These results indicated that the present levels of E (0.407, 0.417 and 0.42 for male, female, and whole population, respectively) are higher than that ($E_{0.5}$= as 0.30, 0.295, and 0.297 for male, female and whole population, respectively). It gives the maximum (Y/R), which means that the stock of *M. mustellus* is highly overexploited, which is needed to maintain 50% of the stock biomass.

For management purposes, the exploitation rate of *M. mustellus* should be reduced to be < $E_{0.5}$ i.e., the fishing mortality should be reduced to lower than the current fishing mortality

(F=0.39, 0.42 and 0.45 y-1 for male, female, and the whole population respectively) to maintain sufficient spawning biomass for sustainability.

Therefore, for management purposes and to maintain the stocks of *M. mustellus* in the Egyptian Mediterranean Sea, the fishing mortality should be decreased by at least 31.81, 43.27 and 42.88% of male, female and the whole population respectively of its current level to maintain a healthy population structure. In addition, the length of first capture of *M. mustellus* calculated at 33.8 cm, while *M. mustellus* doesn't reach maturity unless reach 83 cm at least. These indicate that *M. mustellus* at Egyptian Mediterranean waters captured way before its reach its maturity stage. Therefore, for management purposes and to maintain the stocks of *M. mustellus* in the Egyptian Mediterranean Sea, a regulation must be obtained to prevent the early capture of *M. mustellus* population.

DISCUSSION

In the present study, the maximum total length of *M. mustellus* (male, female and whole population) was 106.8, 117.6 and 117.6 cm, respectively. It was lower than that observed for the same species which recorded by **Goosen & Smale (1997)** at South Africa; **Smale & Compango (1997)** at South Africa; **Capape (2006**) at the Coast of Senegal; **Saidi *et al.* (2008)** at South central Mediterranean Sea; and **Da Silva (2018)** at South Africa and **Ozcan & Basusta (2018**) at North eastern Mediterranean Sea. It was higher than that recorded by **Morte *et al*. (1997**) at Gulf of Valencia, Spain and **Filiz & Mater (2002)** at North Aegean Sea.

In the present study, the "b" value found to be 2.80 for *M. mustellus* and showed a slightly negative allometric growth. It was close to which reported by **Dulcic & Kraljevic (1996)** at Eastern Adriatic; **Ozaydin *et al*. (2007)** at Gulf of Izmir, Aegean Sea; **Guven *et al.* (2012)** at Gulf of Antalya in Mediterranean Sea and **Bilge *et al.* (2014)** at southern Aegean Sea. While it was lower than which estimated by **Filiz & Mater (2002)** at Nort Aegean Sea; **Filiz & Bilge (2004)** at Northern Aegean Sea; **Capape *et al*. (2006)** at Eastern Tropical Atlantic, Senegalese coast; **Ismen *et al*. (2009)** at Gulf of Saros, North Aegean Sea; **Pereira *et al*. (2012)** at North Atlantic; **Wilhelms (2013)** at north-eastern Atlantic; **Eronat & Ozaydin (2014)** at sigacik Bay, Aegean and **Ozcan & Basusta (2018)** at Turkey coasts.

The highest values of condition factor "K" of *M. mustellus* (male, female and whole population) were recorded in July and the lowest values were recorded in December and January. It was higher than which estimated by **Goosen & Smale (1997**) at South Africa; **Yamaguchi *et al*. (ۨ999)** at Japan; **Malcolm (2015**) at South Africa; **Ozcan & Basusta (2018**) at Turkey, Mediterranean Sea (0.14) and **Da Silva (2018)** at South Africa.

In the present study, the average relative condition factor (Kn) in male, female and combined sexes of *M. mustellus* are nearly equal one, indicating that the ecological conditions at the Egyptian Mediterranean waters are nearly suitable for the growth of these fishes.

For the last 10 years, Cartilaginous fish catch decreased from 3333 tons (representing 4.28 % of the total sea catch) during 2011 to be only 881 tons (representing 1.77%) in 2020 (**GAFRD, 2020**).

In the present study, the growth performance index value was estimated to be Φ= 3.56, 3.311 and 3.544 for *M. mustellus* (male, female and whole population, respectively) at Mediterranean Sea, Egypt. This value was higher than that estimated by **Da Silva (20٠٧)** in South Africa (0.062).

For growth curves, parameters of Von Bertalanffy were estimated according to **Ford (1933)** and **Wallford (1946)**. Asymptotic length (L∞) and growth coefficient (k), of *M. mustellus* were theoretical lengths at each year (L_{25}= 20.57, L_{50}= 32.80, L_{75}= 34.49 cm) for Male, (L_{25}= 20.66, L_{50}= 33.73, L_{75}= 35.67 cm) for Female and (L_{25}= 20.93, L_{50}= 33.80, L_{75}= 35.70 cm) for whole population.

From the Ford-Walford plot L_∞ was estimated, and it was 110.25, 120.75 and 120.75 cm for *M. mustellus* (male, female and whole population). It was lower than that recorded by **Francis (1981)**; **Yamaguchi *et al*. (1996**) at Japan; **Goosen & Smale (1997)** at South Africa; **Da Silva (2007)** at South Africa and **Da Silva & Bürgener (2007)** at South Africa; **Ozcan & Basusta (2018)** at Turkey, Mediterranean Sea. It was higher than that estimated by **Yamaguchi *et al.* (1999)** at Japan.

The present study recorded that growth coefficient (K) estimated from length frequency analysis (ELEFAN I) was 0.30 and 0.24 y^{-1}, for male and whole population of *M. mustellus*. It was higher than that recorded by **Francis (1981)**; **Yamaguchi *et al*. (1996 & 1999)** at Japan; **Goosen & Smale (1997)** at South Africa; **Da Silva & Bürgener (20٠٧)** at South Africa (0.08 year-1) and **Ozcan & Basusta (2018)** at Turkey, Mediterranean Sea. While, growth coefficient (K) estimated from length frequency analysis (ELEFAN I) was 0.14 y^{-1} for female of *M. mustellus*. It was higher than that recorded by **Goosen & Smale (1997)** at Mediterranean Sea; **Da Silva (20٠٧**) at South Africa and it was lower than which estimated by **Francis (1981)** at Mediterranean Sea; **Ozcan & Basusta (2018)** at Turkey, Mediterranean Sea and **Yamaguchi *et al.* (1999)** at Japan.

The total mortality coefficients (Z) for of *M. mustellus* (male, female and whole population) in Egyptian Mediterranean Sea were estimated from the length converted catch curve of **Pauly (1983)** to be 0.88, 0.45 and 0.86 respectively according to Ault & Ehrhardt model. While, it is estimated to be 0.90, 0.45 and 0.85 y^{-1} respectively, according to **Beverton & Holt model (1957)**. It was higher than that estimated by **Da Silva & Bürgener (2007)** at South Africa.

Natural mortality is defined as the death created by all causes other than fishing such as disease, predation, competition, starvation, spawning stress and salinity. Since a direct measurement of natural mortality coefficient is often impossible to obtain. It has been attempted to identify values which can be assumed proportional to natural mortality **(Mehanna, 1996)**.

The natural mortality coefficient in the present study was 0.49 y^{-1}, 0.29 and 0.42 for male and female and whole population respectively of *M. mustellus* estimated from the length converted catch curve of **Pauly (1983)**. It was higher than that estimated by **Da Silva & Bürgener (2007)** at South Africa (M= 0.05 y^{-1}).

The fishing mortality in the present study was 0.39, 0.16 and 0.45 y^{-1} for *M. mustellus* (male, female and whole population respectively). This fishing mortality is indicating a high level of exploitation. It was higher than that recorded by **Da Silva & Bürgener (2007)** at South Africa (F = 0.08 y^{-1}).

The need for management is acute with evidence of serious overexploitation widespread (**Sadovy, 1989**). Use of marine reserves (areas protected from fishing) has been proposed as a management approach which can overcome the above difficulties. Among the most important advantages claimed for them are: (1) protection of spawning stock biomass, (2) supply of recruits to fished areas, (3) enhancement of catches in adjacent areas through emigration, (4) insurance against stock collapse due to successive years of poor recruitment, (5) reduced data collection needs and (6) simplified enforcement **(Roberts & Polunin, 1991**). Several of these advantages stem from the prediction that under zero fishing, target species will increase in abundance and average size. It is well known that management strategies and techniques are usually classified into two distinct categories namely: the regulation of catch-age composition and the regulation of the fishing effort (**Mehanna, 1996)**.

For the regulation of catch-age composition, several analytical models have been developed. These models are based on the estimation of the yield per recruit under a particular set of fishing conditions. In the present study, estimation of the parameters of recruitment, yield per recruit and yield is very essential in fisheries management. These parameters with that of growth and mortality are widely used in assessment of the states of the fish stocks.

Practically, fisheries are dealing with the data collected to answer two main questions: "How much fish is there in the area that is intended to fish; and 'what is the maximum number of fishes which can be caught annually without affecting the ability of the stock to produce that yield" (**Holden & William, 1974**).

If the number of fishes a single year-class entering the exploitable phase of a stock in given period by growth of smaller individuals (i.e., recruit) is known, it will be possible to predict the yield throughout the life span of this cohort and known its growth and morality. The yield-per-recruit (YPR) pattern eliminates the uncertain recruitment number from calculate and provides a mean to assess the status of the stock (**Sparre & Venema, 1998**).

In the present study, the fishing mortality of *M. mustellus* (F= 0.45) showed an over exploitation of this species (E= 0.52). The exploitation rate is very important to estimate the state of the stock which optimum, underexploited, and overexploited. The obtained results showed that *M. mustellus* was overexploited where the estimated E value was 0.52 in the Egyptian Mediterranean Sea. **Gulland (1971)** suggested that a fish stock is optimally exploited at a level of fishing mortality that generates E = 0.50, where optimum fishing mortality equal the natural mortality (F= M). **Pauly (1980)** proposed a lower optimum fishing mortality (E = 0.40).

Therefore, for management purposes and to maintain the stocks of *M. mustellus* in the Egyptian Mediterranean Sea, the fishing mortality should be decreased by at least 31.81, 43.27 and 42.88% of male, female, and the whole population respectively of its current level to maintain a healthy population structure.

In addition, the length at first capture of *M. mustellus* was calculated as 33.8 cm, while the *M. mustellus* doesn't reach maturity unless reach 83 cm at least. These indicated that *M. mustellus* at Egyptian Mediterranean waters captured before its reach its maturity stage. Therefore, for management purposes and to maintain the stocks of *M. mustellus* in the Egyptian Mediterranean Sea, a regulation must be obtained to prevent the early capture of *M. mustellus* population.

The relative yield per recruit (Y/R)' model has the great advantage of requiring fewer parameters allowing the authors to calculated (Y/R)' for different values of E and L_c/L_∞. Mortality, exploitation, and yield per recruit are essential in order to reveal the effect of fishing on the present stock of *M. mustellus* in the Egyptian Mediterranean Sea to contribution of their fishing management. It is well known that effective management of a fish stock is important for the sustainable of that stock (**Beverton & Holt, 1957** and **Sparre & Venema, 1992**).

REFERENCES

Abu Hatab, H.G. (2005): Stock assessment and fishery management of *Boops boops* in Mediterranean waters of Gaza Strip, Alexandria and Saloum. Egypt. Ph.D. Thesis, Arab Academy for Science and Technology and Maritime Transport., Pp: 189.

Barker, M.J. and **Schluessel, V. (2005):** Managing global shark fisheries: Suggestions for prioritizing management strategies. Aquatic Conservation: Marine and Freshwater Ecosystems, **15**: 325 – 347.

Beverton, R.J.H. and **Holt, S.J. (1956)**: A review of methods of estimating mortality rates in exploited fish population, with special reference to source of bias in catch sampling. Rapp. P. V. Reun. CIEM, **140** (1):67 – 83.

Beverton, R.J.H. and **Holt, S.J. (1957):** On the dynamics of exploited fish population. U. K. Min. Agr. Fish. Invest. Ser., **19**: 533 pp.

Beverton, R.J.H. and **Holt S.J. (1966):** Manual of methods for fish stock assessment. Part 2.Tables of yield functions. FAO Fish. Tech. Pap., **38** (1): Pp: 67.

Bilge, G.; Yapici, S.; Filiz, H. and **Cerim H. (2014):** Weight– length relations for 103 fish species from the southern Aegean Sea, Turkey. Acta Ichthyologica et Piscatoria, **44** (3): 263–269.

Capape, C.; Diatta, Y.; Diop, M.; Vergne, Y. and **Guelorget, O. (2006):** Reproductive biology of the smooth hound, *Mustelus mustelus* (Chondrichthyes: Triakidae) from the coast of Senegal (eastern tropical Atlantic). Cybium, **30**: 273 – 282**.**

Clarke, S.; Magnusson, J.E.; Abercrombie, D.L.; McAllister M. and **Shivji, M.S. (2006):** Identification of shark species composition and proportion in the Hong Kong shark fin market based on molecular genetics and trade records. Cons. Biol., **20**: 201- 211.

Colloca, F.; Enea, M.; Ragonese, S. and **Di Lorenzo, M. (2017):** A century of fishery data documenting the collapse of smooth hounds (Mustelus spp.) in the Mediterranean Sea. Aquatic Conservation: Marine and Freshwater Ecosystems, **27**(6): 1145 – 1155.

Da Silva, C. (2007): The status and prognosis of the smoothhound shark (*Mustelus mustelus*) fishery in the southeastern and southwestern Cape Coasts, South Africa. M.Sc. Thesis, Rhodes University, South Africa.

Da Silva, C. (2018): Biology, movement behavior and spatial dynamics of an exploited population of smooth hound shark, *Mustelus mustelus* around a coastal marine protected area in South Africa. University of Cape Town.

Da Silva, C. and **Bürgener, M. (2007):** The status and prognosis of the smooth-hound shark (*Mustelus mustelus*) fishery in the Southeastern and Southwestern Cape Coasts, South Africa. MSc Thesis, Rhodes University, South Africa, Traffic Bulletin, **21**: 55-56.

Dulcic, J. and **Kraljevic, M. (1996):** Weight-length relationships for 40 fish species in the eastern Adriatic (Croatian waters) Fish. Res., **28**: 243 - 251.

El-Tabakh, M.A. (2019): Population biology and genetic variations of some sharks in Mediterranean Sea at Alexandria, Egypt. Ph.D. Thesis, Zool. Dept., Fac. Sci., Al-Azhar Univ., 413 pp.

Eronat, E.G.T. and **Ozaydin, O. (2014**): Length–weight relationship of cartilaginous fish species from central Aegean Sea (Izmir Bay and Sığacık Bay). Ege Journal of Fisheries and Aquatic Sciences, **31**(3): 119 – 125.

FAO (Food and Agriculture Organization of the United Nations) (2005): FAO Species Identification Guide for Fishery Purposes, Field Identification Guide to the Sharks and Rays of the Mediterranean and Black Sea. FAO United Nations, Rome, Italy, pp: 97.

Filiz, H. and **Mater, S. (2002):** A preliminary study on length– weight relationships for seven elasmobranch species from North Aegean Sea, Turkey. Egyptian Journal of Fisheries and Aquatic Sciences, **19**(3–4): 401–409.

Filiz, H. and **Bilge, G. (2004):** Length–weight relationships of 24 fish species from the North Aegean Sea, Turkey. Journal of Applied Ichthyology, **20**(5): 431 – 432.

Ford, E. (1933): An account of the herring investigations conducted and Plymouth during the years from 1924 to1933. J. Mar. Biol. Assoc. U.K., **19**: 305 - 384.

Francis, M.P. (1981): Von Bertalanffy growth rates in species of *Mustelus* (Elasmobranchii: Triakidae). Copeia, **1**: 189. DOI: 10.2307/1444053

GAFRD (General Authority for Fish Resources Development) (2018): Book Year of Fishery Statistic. Egyptian Ministry of Agriculture, Cairo

GAFRD (General Authority for Fish Resources Development) (2020): Book Year of Fishery Statistic. Egyptian Ministry of Agriculture, Cairo

Golani, D.; Bayraam, O. and **Nuri, B. (2006):** Fishes of the Eastern Mediterranean, Turkish Marine Research Foundation. Turkish Marine Research Foundation, pp.: 260.

Goosen, A.J.J. and **Smale, M.J. (1997):** A preliminary study of age and growth of the smoothhound shark, *Mustelus mustelus* (Triakidae). South African Journal of Marine Science, **18**(1): 85–91.

Gulland, J.A. (1971): The fish resources of the oceans. Fishing News Books Ltd., England, pp.: 255.

Guven, O.; Kebapçioğlu, T. and **Deval, M.C. (2012**): Length– weight relationships of sharks in Antalya Bay, eastern Mediterranean. Journal of Applied Ichthyology, **28**(2): 278–279.

Hile, R. (1936): Age and growth of the cisco, *leucichthys artedi* (Le Sueur) in the lakes of the north eastern Highlands, Wisconsim. Bull. U. S. Bur. Fish., **19**: 211 - 317.

Holden, M.J. and **Raitt, D.F. (1974):** Manual of fisheries science. Part 2. Methods of resource investigations and their application. FAO Fish. Tech.Pap., 115 Rev., **1**: 214 pp.

Holden, M.J. and **William, T. (1974):** The biology and population structure of bass, *Dicentrarchus labrax*, in English waters. J. Mar. Biol. Assoc. UK, **54**: 91-107.

Ismen, C.; Cigdem, Y.; Altinagac, U. and **Ayaz, A. (2009):** Short communication length–weight relationships for ten shark species from Saros Bay (North Aegean Sea) By A. Department of Fishing and Processing Technology, Faculty of Fisheries, C¸ anakkale Onsekiz Mart University, C¸ anakkale, Turkey, J. Appl. Ichthyol., **25**(1): 109–112.

Le Cren, E.D. (1951): The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviattilis*). J.Anim.Ecol., **20**: 201-219.

Malcolm, P. (2015): Von Bertalanffy growth rates in species of *Mustelus* (Elasmobranchii: Triakidae) FRANC, Copeia, **1981**(1): 189 - 192.

Maynou, F.; Sbrana, M.; Sartor, P.; Maravelias, C.; Kavadas, S.; Damalas, D. and **Osio, G. (2011):** Estimating trends of population decline in long-lived marine species in the Mediterranean Sea based on fishers' perceptions. PLoS ONE, **6**, e21818.

MCM, R.R. (2010): Status of South Africa's marine living resources. Marine and Coastal Management, Pp: 55

Mehanna, S.F. (1996): A study of the biology and population dynamics of *Lethrinus mahsena* (Forsskal, 1775) in the Gulf of Suez. Ph.D. Thesis. Facul. Sci. Zagazig Univ., Pp: 230.

Mehanna, S.F.; Haggag, H.M. and **Amin, A.M. (2005):** A preliminary evaluation of the status of southeastern Mediterranean fisheries of Egypt (Port Said Region). The 9th conference about the fisheries resources in Mediterranean, Tanta University

Morte, S.; Redon, M.J. and **Sanz-Barau, A. (1997):** Feeding habits of juvenile *Mustelus mustelus* (Carcharhiniformes, Triakidae) in the western Mediterranean. Cahiers de Biologie Marine, **38**: 103-107.

Nieto, A.A.; Ralph, G.M.; Comeros-Raynal, M.T.; Kemp, J.; Garcia Criado, M.; Allen, D.J. and **Williams, J.T. (2015):** European Red List of marine fishes. Luxembourg: Publications Office of the European Union.

Ozaydin, O.; Uçkun, D.; Akalın, S.; Leblebici, S. and **Tosunoğlu, Z. (2007):** Length–weight relationships of fishes captured from Izmir Bay, central Aegean Sea. Journal of Applied Ichthyology, **23**(6): 695–696. DOI: 10.1111/j.1439-0426.2007.00853.x

Özcan, E.İ. and **Basusta, N.I. (2016):** Digestive system contents of the *Mustelus mustelus* (Linnaeus, 1758) inhabiting northeastern Mediterranean. Journal of Science, **28**(1): 7-12.

Ozcan E.I. and **Başusta, N.I. (2018):** Preliminary study on age, growth, and reproduction of *Mustelus mustelus* (Elasmobranchii: Carcharhiniformes: Triakidae) inhabiting the Gulf of Iskenderun, north-eastern Mediterranean Sea. Acta Ichthyol. Piscat., **48**(1):27-36.

Pauly, D. (1980): On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J. Cons. CIEM, **39**(3): 175-192.

Pauly, D. (1983): Some simple methods for the assessment of tropical fish stocks. FAO

Pauly, D. (1984): Fish population dynamics in tropical waters: a manual for use with programmable calculators. ICLARM Stud. Rev., **8**: Pp: 325.

Pereira, J.N.; Simas, A.; Rosa, A.; Aranha, A.; Lino, S.; Constantino, E.; Monteiro, V.; Tariche, O. and **Menezes, G. (2012):** Weight–length relationships for 27 demersal fish species caught off the Cape Verde archipelago (eastern North Atlantic). Journal of Applied Ichthyology, **28**(1): 156–159. DOI: 10.1111/j.1439- 0426.2011.01915.x

Roberts, C.M. and **Polunin, N.V.C. (1991):** Are marine reserves effective in management of reef fisheries? Rev Fish, Biol. Fish., **1**: 65-91.

Sadovy, Y. (1989): Caribbean fisheries: problems and prospects. Prog. Undenvat Sci., **13**: 169-184.

Saidi, B.; Bradai, M.N. and **Bouain, A. (2008):** Reproductive biology of the smooth-hound shark, *Mustelus mustelus* (Linnaeus, 1758), in the Gulf of Gabes (southcentral Mediterranean Sea). Journal of Fish Biology, **72**(6): 1343-1354.

Smale, M. and **Compagno, L. (1997):** Life history and diet of two southern African smoothhound sharks, *Mustelus mustelus* (Linnaeus, 1758) and *Mustelus palumbes* (Smith, 1957**)** (Pisces: Triakidae). S. Afr. J. of Mar. Sci., **18**: 229-248

Sparre, P. and **Venema, S.C. (1992):** Introduction to tropical fish stock assessment. FAO Fisheries Technical Paper, **306**/1 rev.1. Pp: 376.

Sparre, P. and **Venema, S.C. (1998):** Introduction to tropical fish stock assessment- part 1: Manual. FAO Fisheries Technical Paper, No 306/1

Stevens, J.D.; Bonfil, R.; Dulvy, N.K. and **Walker, P.A. (2000):** The effects of fishing on sharks, rays, and chimaeras (Chondrichthyans), and the implications for marine ecosystems. ICES Journal of Marine Science, **57**: 476 - 494.

Von Bertalanffy, L. (1938): A quantitative theory of organic growth Hum. Biol., **10**: 181-143.

Walford, L.A. (1946): A new graphic method of describing the growth of animals. Biol. Bull. Mar. Biol., **90**(2):141-147.

Walker, T.I. (1998): Can shark resources be harvested sustainably? A question revisited with a review of shark fisheries, Marine and Freshwater Resources Institute, PO Box 114, Queenscliff, Vic. 3225, Australia. Mar. Freshwater Res., **49**: 553 - 572.

Wilhelms, I. (2013): Atlas of length–weight relationships of 93 fish and crustacean species from the North Sea and the North-East Atlantic. Thünen Working Paper No. 12. Thünen-Institut, Bundesforschungsinstitut für Ländliche Räume, Wald und Fischerei, Braunschweig, Germany.

Yamaguchi, A.; Huang, S.Y.; Chen, C.T. and **Taniuchi, T. (1999):** Age and growth of the starspotted smoothhound, *Mustelus manazo* (Chondrichthyes: Triakidae) in the waters of north-eastern Taiwan, in Proc.

Yamaguchi, A.; Taniuchi, T. and Shimuzu, M. (1996): Age and growth of the starspotted dogfish, *Mustelus manazo* from Tokyo Bay, Japan. Fish. Sci., **62**: 919–922.