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The Growth Parameters of the Mako Shark *Isurus Oxyrinchus* (Rafinesque, 1810) in the Moroccan Central Atlantic Coast

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ABSTRACT

The present study was carried out through regular biological sampling operations of the mako shark during a period of 24 months (October 2017 - August 2019). Specimens were collected from the commercial catches of artisanal boats operating in the Moroccan Central Atlantic Coast and landing at Sidi Ifni Port. A total of 1088 individuals were examined, including 567 females and 521 males. The total length (TL) of both sexes combined ranged from 60 to 317cm, with an average of 150.83 ± 41.51cm (mean±sd). Dominant sizes varied between 105 and 195 cm (TL). The linear regression equations showed a good positive correlation between the different body lengths (0. 983 <R <0.997). The allometric equations between the two variables of weight W(t) and length L(t), where $W(t) = 7\ E^{-05} * L^{2.6092}$, showed significantly lower allometry for the two sexes combined. The parameters of the Von Bertalanffy linear growth equation for both sexes combined were estimated as $L_\infty = 313.24$ cm, K=0.15 $year^{-1}$ and $t_0 = -0.68$. For the same age, the sizes of males were recorded larger than those of females. Moreover, results showed that the determined longevity (tmax) was 24.75 years for males and 26.65 years for females.

INTRODUCTION

The mako shark or shortfin mako shark *Isurus Oxyrinchus* (Rafinesque, 1810) is one of the five species belonging to the Lamnidae family. This species is widely distributed in the world, especially in populating the temperate and tropical regions of the oceans. It is often associated with the Gulf Stream **(Compagno, 2001)**. It is found in the same waters as other pelagic sharks and tuna (blue skin, swordfish and tuna,...etc) **(Cortés *et al.*, 2010)**. In Morocco, the mako shark landed by the active flotilla along the Moroccan coast. It is caught, incidentally, by the longline fleet targeting swordfish **(Baibbat *et al.*, 2017)**. **Serghini *et al.* (2018)** reported that, the national average catch of mako shark reached 680 tonnes / year for the period that extended from 2012 to 2016. This national production increased from 607 tonnes in 2016 to 622 tonnes in 2017, with an increase of around 2.5%. For a rational management of this specific species, basic scientific data are essential, which unfortunately are not yet available in Morocco, while the assessment of its stock using the analytical models is based on a structured and detailed description of size and age. Such models require knowledge on the growth parameters biology of the species being exploited.

The current work targeted the study of the growth parameters of the mako shark through biological sampling carried out regularly, during a period of 24 months (October 2017-August 2019). Samples were collected from the commercial catches of artisanal boats operating in the Moroccan Atlantic Center and landing at Sidi Ifni Port. This study facilitated the estimation of growth parameters, beside recording linear growth, height-weight relationship, morphometry and longevity. Those parameters, in combination with the combined data on the catch and fishing effort, would make it possible to get a comprehensive idea of the population dynamics of *Isurus Oxyrinchus* in the Moroccan central Atlantic. In addition, their use in analytical assessment models would enable those in charge to know the state of exploitation of the stock of this species, and hence, propose the appropriate and useful measures to manage a sustainable development for its management plan.

MATERIALS AND METHODS

Sampling Strategy

The sampling area is located in the Moroccan Central Atlantic area, precisely at Sidi Ifni port (latitude: 29°21'N-longitude: 10°11'W) about 170 km south of Agadir. The fishing area is between -10°N and -12°N latitude, and between 29°W and 31°W longitude. The aforementioned fishing area is bounded to the north by the "Aglou" coast and to the south by a beach commonly known by "Plage blanche" (Fig.1).This area is subjected to a subtropical climate where the surface water temperature varies between 14 ° C and 22.1 ° C (seasonal acoustic surveys carried out in spring and autumn by the R/V Al Amir Moulay Abdallah during the period 2017 -2019).

A total of 1088 specimens of mako shark were sampled during the study period (October 2017-August 2019). Those specimens were gathered from the catches of artisanal boats operating in Sidi Ifni.

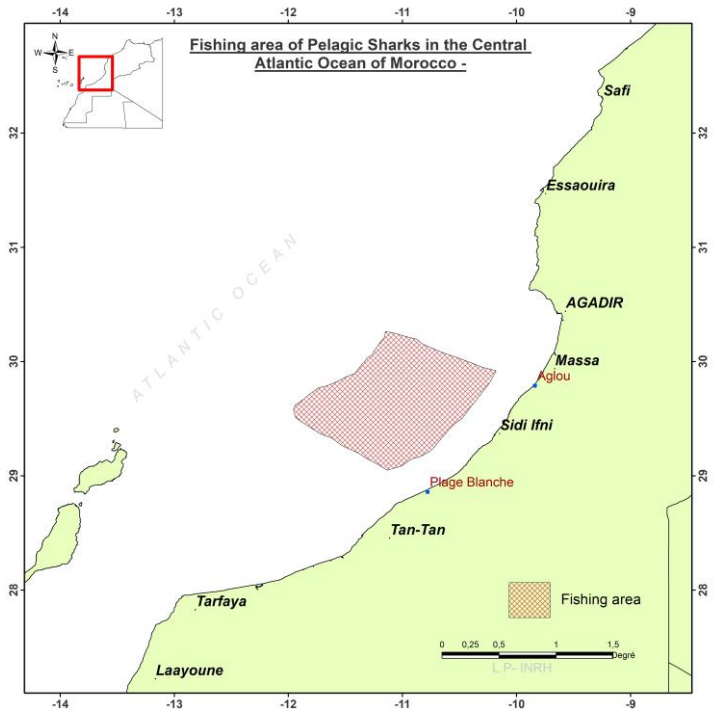

Fig. 1 : The Geographic Location of the Mako Shark in the Study Area of the Moroccan Central Atlantic Coast.

Morphometric Study

Mako sharks are not eviscerated on board. Fish traders stated that, those sharks are mainly destined for international markets and availableonly in small quantities for national ones. For each specimen, measures of the total length (TL) with caudal fin in natural position, the size at the fork of the tail (FL), the standard precaudal length (PRC or SL), the distance between the tip of the snout and the origin of the first dorsal (D1L) and the distance between the end of the muzzle and the origin of the pelvic fin (PvL) were recorded to the nearest centimetre with a tape measure (Fig. 2). Whereas, body weight was determined to the nearest Kg using an electronic scale. The data were expressed as means ± standard deviations (mean ±SD).

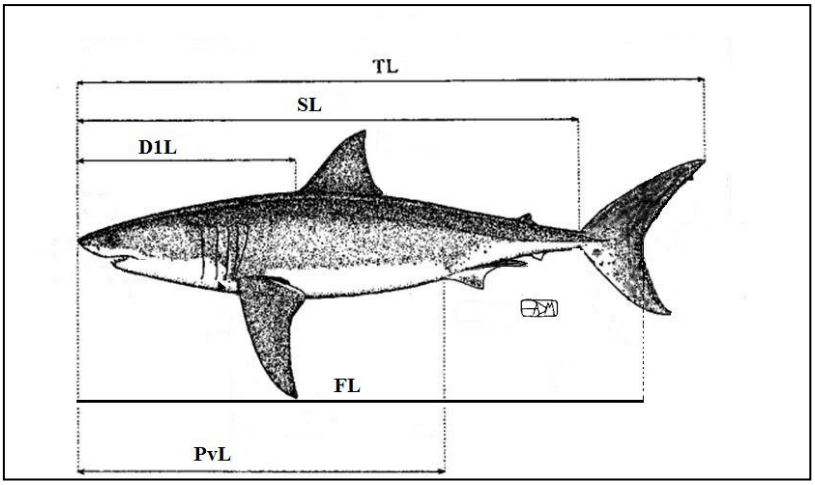

Fig. 2 : The Different Measurements of a Marko Shark. (**De Maddalena *et al*., 2001**)

Linear Regression (Length - Length Relationships)

The relationships between the different measured body lengths were determined using the method of least squares to fit a simple linear regression model as follows **(Alam *et al*., 2012)**:

$$Y = a + b * X$$

Where:

Y and X = different body lengths (cm),
a = constant of proportionality, and
b = regression coefficient.

Relative Growth (Length-Weight Relationship)

The relation between the total length of the fish and their total weight was estimated according to **Le Cren (1951)** and **Ricker (1975)** as follows:

$$W(t) = a.L^{\wedge}b$$

Where:

W(t): the total mass of the fish in (Kg).

L: the total length of the fish in centimetre (cm).
a: constant.
b: the rate of allometry.

The allometric coefficient b provides information on the proportionality of weight and linear growth **(Hil, 1936).** Three cases can arise:

- b <3, the length increases faster than the weight: the allometry is lower;
- b = 3, the growth in length is proportional to the weight: there is isometry;
- b> 3, the weight increases faster than the length: the allometry is major.

Linear Growth: Determining the parameters of the Von-Bertalenffy equation.

The parameters L∞, k and t0 of the Von-Bertalenffy equation for linear growth are determined from the size frequency distribution using the LFDA (length frequency distribution analysis) software sub-program of ELEFAN (electronic length frequency analysis) **(kirkwood *et al.*, 2003).**

The length growth of fish as a function of age is expressed according to the mathematical model of Von-Bertalenffy by the equation:

$$L(t) = L\infty\ (1\text{-}e\ \hat{}\ (-\ k\ (t\text{-}t0)))$$

Where :

Lt : length of fish at time t.

L∞: asymptotic length or maximum average length of the population assuming that the fish continue to grow indefinitely.

K: growth coefficient that characterizes the speed with which the fish grows towards the asymptotic length.

t0: the theoretical age for which the fish has zero length. It designates the starting point of the growth curve on the time axis if the fish had grown according to the Von-Bertalanffy growth model.

Growth Performance Index

Pauly and Munro (1984) showed that, for species whose growth follows the Von-Bertalanffy equation, the growth parameters k, L∞ are related by the relationship:

$$Ø' = \log k + 2 \log L\infty$$

Where:

Ø' is the size growth performance index.

Longevity

Longevity (t_{max}) indicates the age of the fish that attained 95% of the asymptotic size, of which L∞. t_{max} is estimated by the following equation **(Cailleit *et al.*, 1992**):

$$t_{max} = \frac{5(ln2)}{k}$$

The results are verified by a statistical chi-square compliance test (X^2).

RESULTS

Size frequency distribution

A total of 1088 shortfin mako sharks were examined, including 567 females and 521 males. The total length in both sexes combined ranged from 60 to 317 cm, with an average of 150.83 ± 41.51 cm (mean ± sd) . For females, the total length varied from 60 to 317 cm with an average of 152.86 ± 43.26 cm while for males, it was recorded between 63 and 305 cm with an average of 148.48 ± 40.03 cm.

The distribution of the measured size frequencies indicates that the total exploited population, for both sexes combined and separate sexes of mako shark species, is composed of seven distinct modes: 95 cm – 115 cm -145 cm – 165 cm – 215 cm – 245 cm and 285 cm (Figs.3a,b&c).

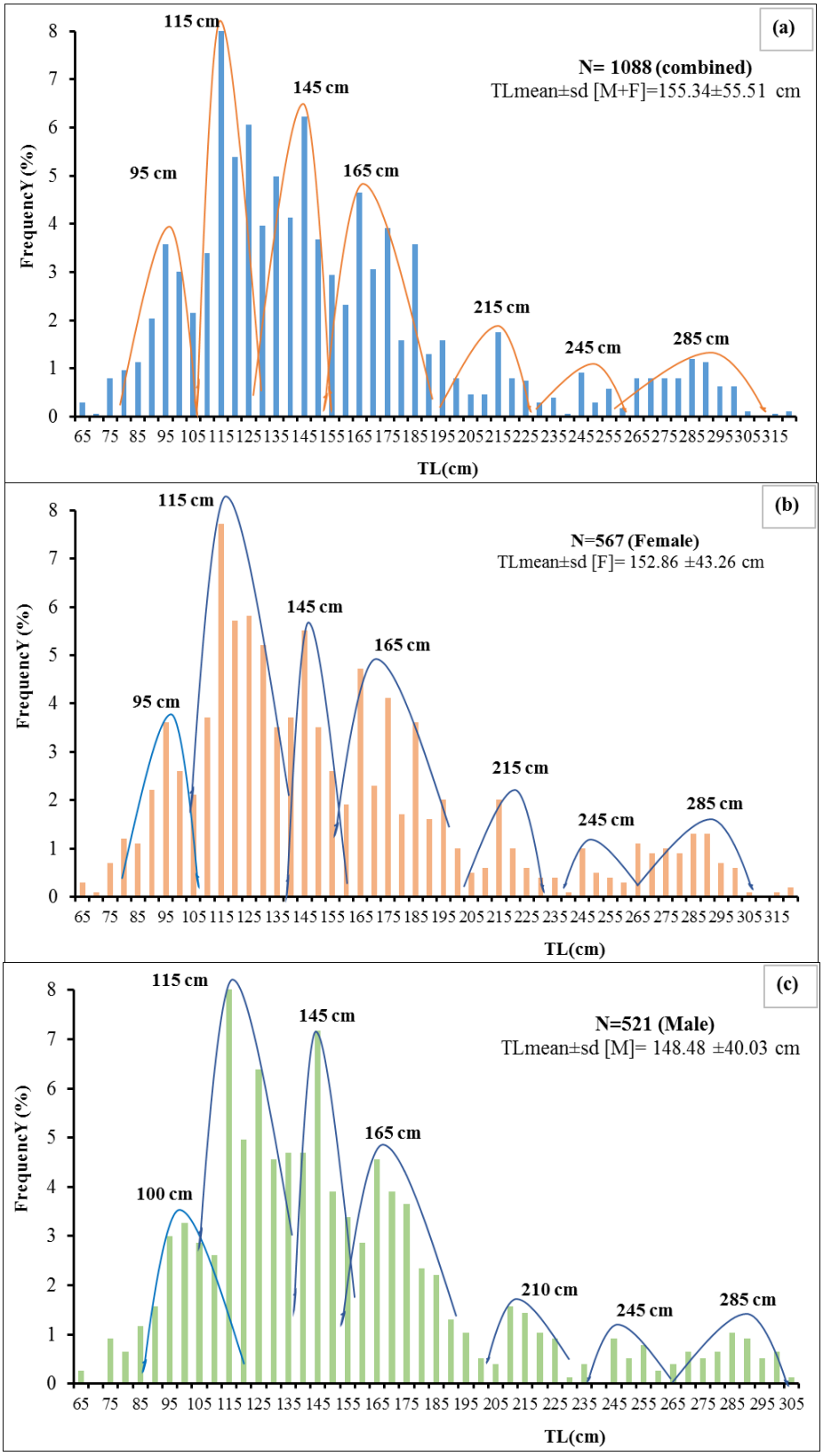

Fig. 3 : The Distribution of Measured Size Frequencies of the Mako Shark for (a) Both Sexes Combined, (b) Females and (c) Males.

Results of the monthly distribution of sizes showed that there was a variation in the number and the average value of the mode per month during the year (Table 1). For the two months of January and February, the catch was very low and the number of individuals sampled was not representative to determine size modes.

Table 1 : Monthly Distribution of Size Classes.

Year	Month	(n) mode	Size (cm)	Mean (cm)	Sd
2017	October	2	116.79 _ 170.56	154.17	±43.82
	November	2	117.99 _ 166.99	143.95	±52.27
	December	2	121.82 _ 176.67	170.79	±56.49
2018	March	1	138.27	180.11	±55
	April	3	132.58 _ 170.44 _ 216.26	165.77	±68.09
	May	3	148.79 _ 204.27 _ 233.33	205.94	±64.32
	June	7	85 _ 124.13 _ 170.94 _ 215.57 _ 264.26 _ 281.72 _ 290.17	168.88	±69.25
	July	4	90 _ 153.32 _ 213.49 _ 277.68	146.41	±53.97
	August	2	89.13 _ 157.86	133.08	±31.58

As shown in Fig. (4), the most dominant sizes vary between 105 and 195 cm (TL). Large sizes are observed during the months of November, December, January, February, April and May. The largest observed size of 317 cm (TL) is recorded in December, 2018. The monthly evolution of the average sizes of the mako shark is shown in the Fig.(4).

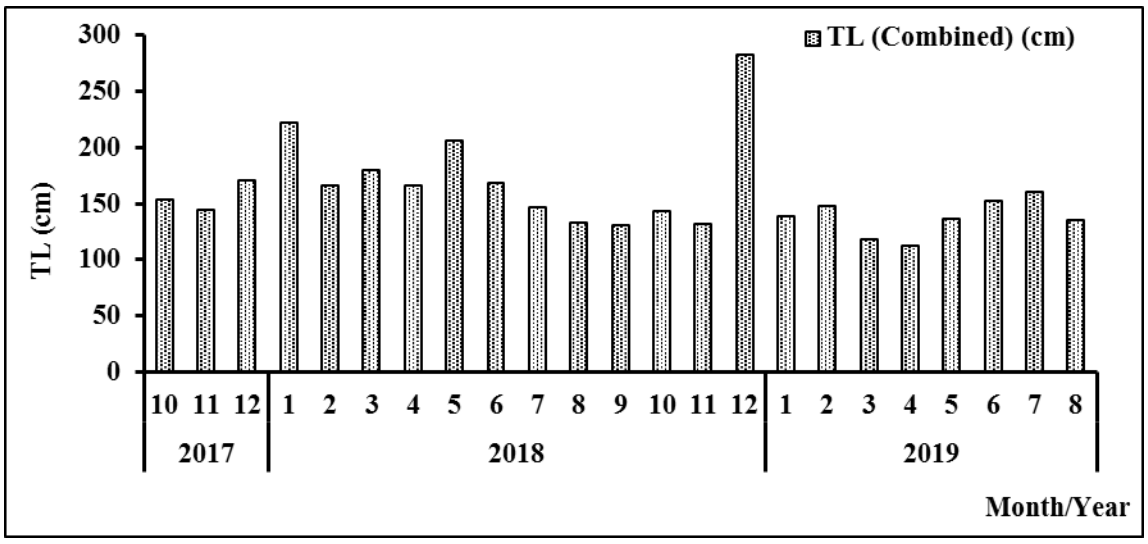

Fig. 4 : The Monthly Evolution of the Medium Size of the Mako Shark that Landed at the Port of Sidi Ifni During the Period of October 2017 - August 2019.

Linear Regression of sizes

The dependency relationship of the total size (TL) with the different body sizes of individuals is established by linear regression using the least squares method. It makes it possible to correct missing data and to easily interpret the results expressed in either of these lengths. The regression equations and their graphical representations are in Table (2) and Fig. (2).

Table 2 : Relationships Between Different Body Sizes of the Mako Shark Species.

N	The Relations of the parameters	Size (cm)	Regression equation : Y= a + b.X	R^2
314	TL/SL	[50 - 256]	TL= -2.2203+0.8114 * SL	0.9855
314	TL/LD1	[30 - 117]	TL = 0.442+0.375 * LD1	0.9676
314	TL/LPv	[35 - 185]	TL = -7.3408+0.6022 * LPv	0.9796
106	TL/FL	[70 - 300]	TL= -6.2238+0.9865 * FL	0.9917
89	FL/SL	[50 -256]	FL= -1.2397+1.21 * SL	0.9879
106	FL/TL	[74 -310]	FL= -6.6299+0.9994 * TL	0.9953

The linear regression equations shows a good positive correlation between the different lengths with TL and FL. Apparently, the values obtained for the correlation coefficient "R^2" vary from 0.983 to 0.997.

Relative Growth (Size-Weight Relationship)

The relationship between the total size in (cm) and the total weight in (Kg) was studied for the two separate and combined sexes of the mako shark using Ricker's equation $W(t)=a*TL^b$. The parameters of the equation **(Ricker, 1975)** have been described in Table (3).

Table 3 : Size-Weight Relationship Settings of Atlantic Mako Shark (Males(M), Females(F) and Combined(Comb)) in the Moroccan Central Coast.

Sex	**N**	**TL / FL (cm)** [Min-Max]	**W(t) (kg)** [Min-Max]	**$W(t)=aTL^b$**	**R^2**	**Allometry**
M	110	TL ; [63-303]	[5 - 212]	$W(t)=8*10^{-5}TL^{2.594}$	0.969	Minor
F	151	TL ; [60-317]	[5 - 230]	$W(t)=2*10^{-4}TL^{2.4275}$	0.9367	Minor
Comb	961	TL ; [60-317]	[5 - 230]	$W(t)=7*10^{-5}TL^{2.6092}$	0.944	Minor
	63	FL ; [53-296]	[5 - 212]	$W(t)=9*10^{-4}FL^{2.1385}$	0.9487	Minor

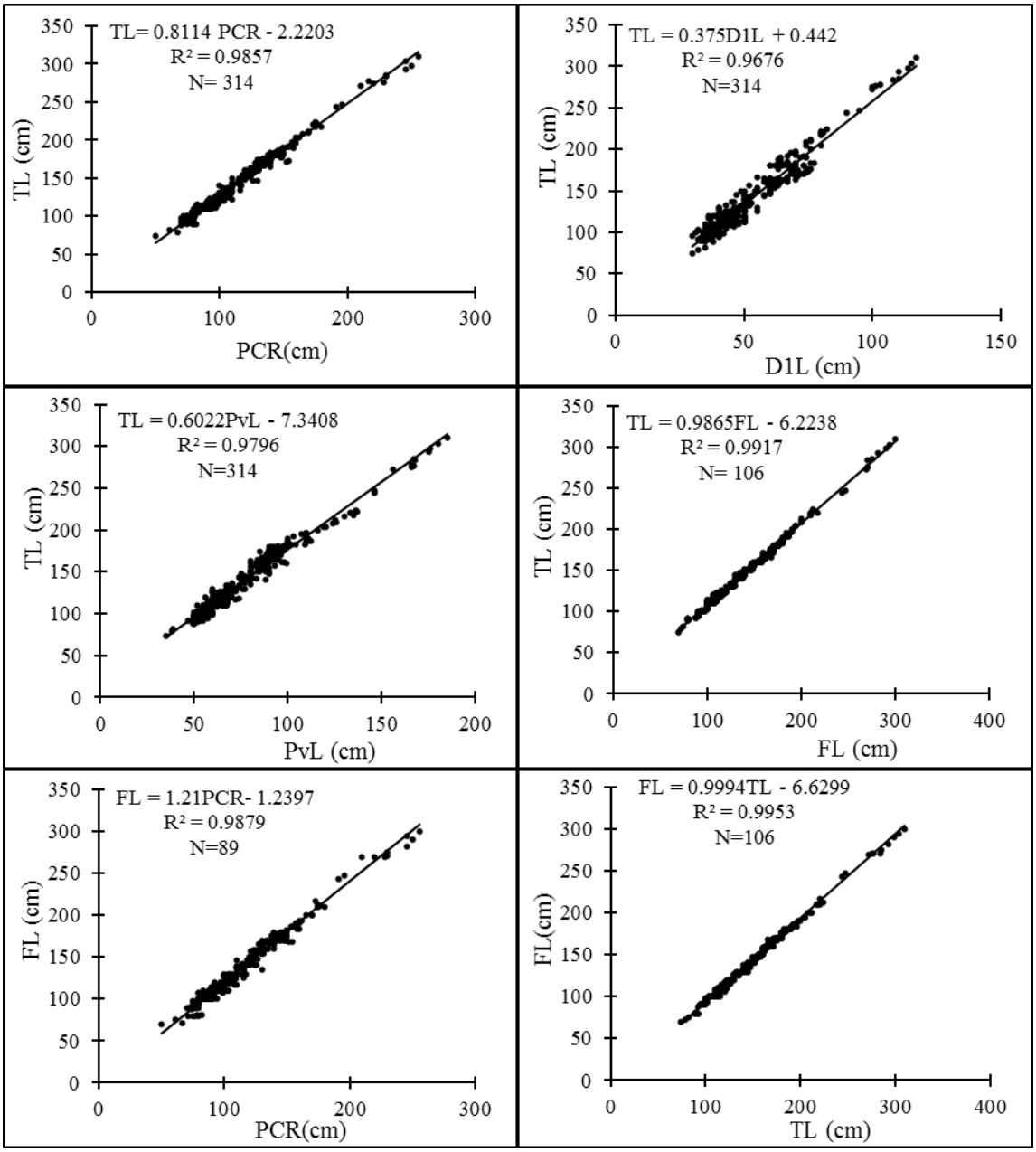

Fig. 5 : Relationship Between TL and FL with the Different Lengths of the Landed Mako Sharks at the Port of Sidi Ifni During the Period of October 2017-August 2019.

The allometric equations between the two variables W (t) and L (t) show a significantly lower allometry for the two separate sexes as well as for the combined sexes. The mako shark size- weight equations are graphed for males, females and both sexes combined in Fig. (6).

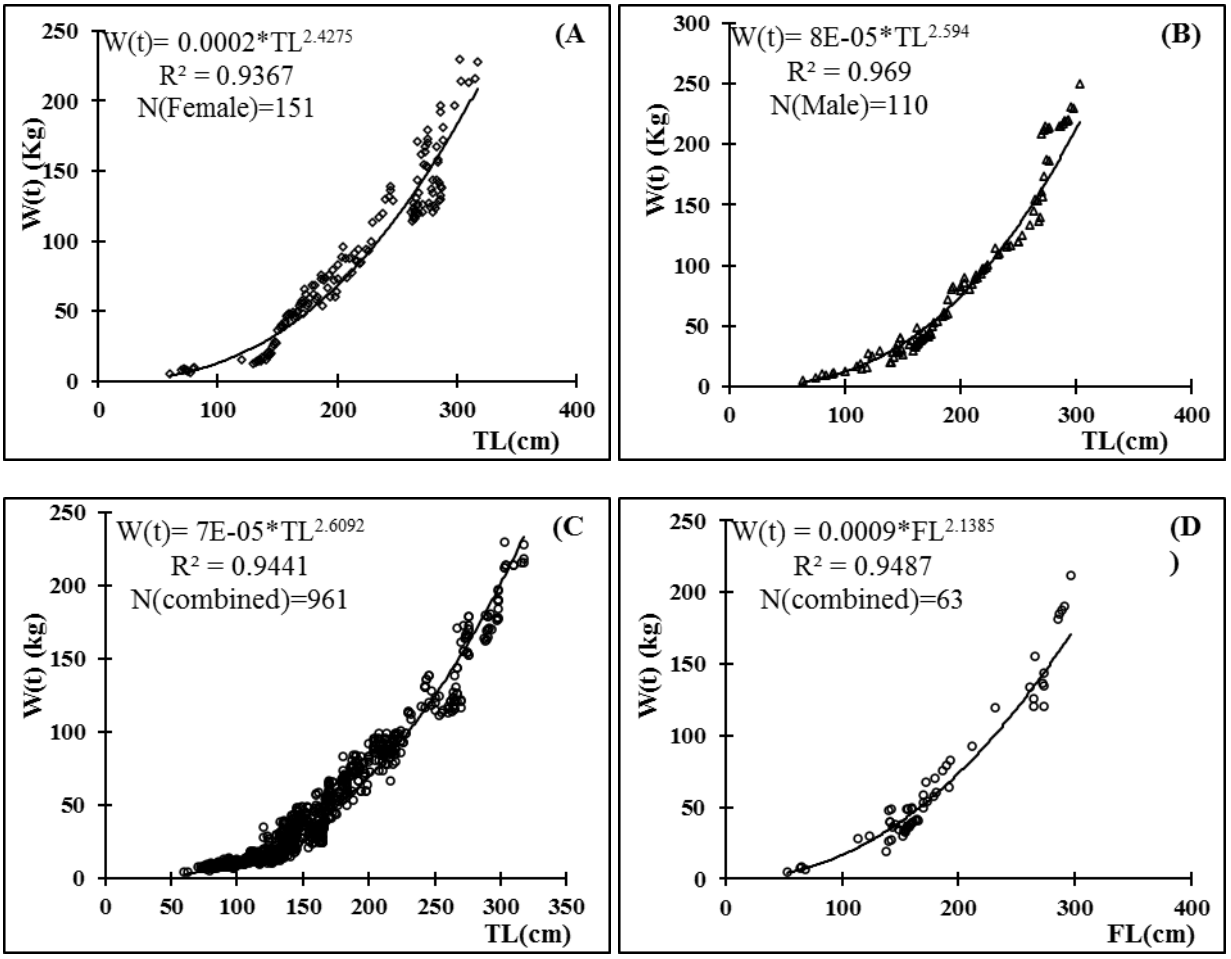

Fig. 6 : Size(cm) - weight (kg) Relationship of *Isurus oxyrinchus* from the Moroccan Central Atlantic Coast for Females (**A**), Males (**B**) and Both Sexes Combined (**C-D**).

The representation of the equations of the total length-total weight relationship of the mako shark of both sexes(Fig. 7) shows that for the same size, the two sexes have similar weights. Likewise, the comparison of the size-weight of both sexes by the chi-square test using the contingency tables with 61 size classes (n = 61 and ddl = 60) shows that there is no significant difference between the size-weight relationship of both sexes (X^2=6.77<79.019 at ddl=60 and p=0.05).

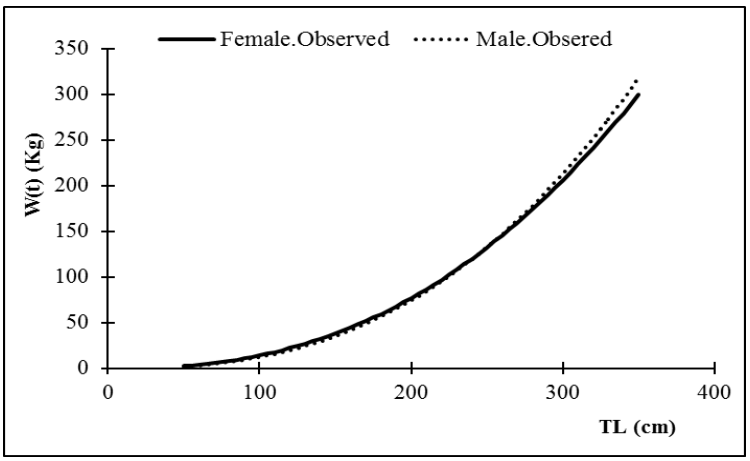

Fig. 7 : The Size (cm) - Weight (kg) Relationship of the *Isurus oxyrinchus* in the Moroccan Atlantic Center Coast.

Linear Growth

The study of the linear growth of the mako shark by the size frequency distribution method, using the LFDA (length frequency distribution analysis) program, made it possible to estimate the parameters of the Von Bertalanffy linear growth equation for the two sexes combined and separated. The obtained results are described in Table (4).

Table 4 : Parameters of the Von-Bertalanffy Equation of the Linear Growth of the Mako Shark.

Sex	L_∞ (cm)	K ($year^{-1}$)	$t_0(year)$	Number
Combined	313.24	0.15	-0.68	1116
Female	322.14	0.13	- 0.79	599
Male	349.40	0.14	- 0.34	517

The linear growth curves of females, males and both sexes combined of the mako shark are presented in a graph (Fig. 8).

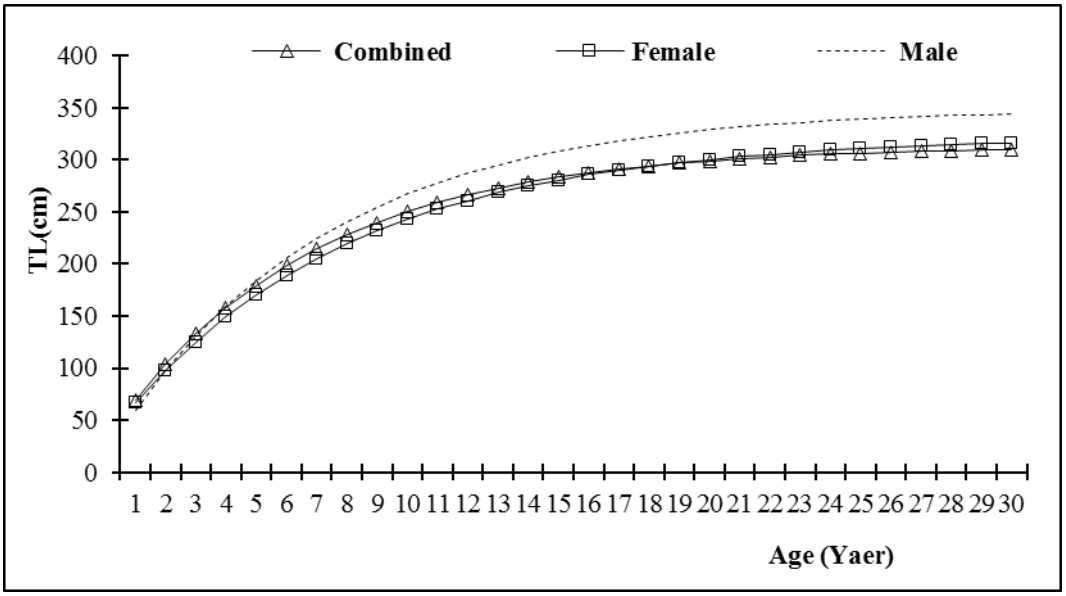

Fig. 8 : Von-Bertalanffy Curves of Mako Shark Linear Growth in the Moroccan Central Atlantic Coast.

The representation of the Von Bertalanffy equations for the linear growth of males and females of the mako shark (Fig. 8) shows that the growth in length for males is faster than females starting from the third year of life. For the same age, the sizes of males are larger than females.

The Chi-square test (X^2) used contingency tables with 30 size classes (n = 30 and ddl = 29); the calculated value of X^2 was of the order of 1.9496 which remains much lower than 42.5570 encountered on the X^2 table for ddl = 29 and p = 0.05. This means that no big

difference in growth was recorded between females and males. It is considered to be almost a similar growth between the two sexes.

The size growth performance index was calculated to be Φ ’= 4.16 for both sexes combined. While it was in the order of Φ ’= 4.23, and Φ’ = 4.13 for males and females, respectively.

The determined longevity (t_{max}) was 23.10 years for both sexes combined, while it was 24.75 years for males and 26.65 years for females. Those results show that females have a greater longevity compared to males (table. 5).

Table 5 : Results of Growth Parameters (Growth Performance Index and Longevity) of Both Sexes of *I.Oxyrinchus*.

Sex	**Φ’**	t_{max} **(Longevity)**
Combined	4.16	23.10 years
Male	4.23	24.75 years
Female	4.13	26.65 years

DISCUSSION

Distribution of size frequencies

Mako sharks caught with surface drifting longlines in the coastal waters of the central Moroccan Atlantic area, particularly at Sidi-Ifni port, had sizes between 60 to 317 cm (TL). The sizes of females varied between 60 and 317 cm, while the sizes of males were between 63 and 305 cm.

The most dominant sizes varied between 105 and 195 cm, and large individuals were observed during the months of November, December, January, February, April and May. However, the largest observed size (317 cm) was detected in December 2018. The measured sizes distribution showed that the total exploited population was made up of five to seven modes. However, the size composition of the mako shark seems to vary in terms of space and time.

Baibbat *et al*. (2017) performed two studies in 2015 and 2016 for the same species and at the same location; the Moroccan South Atlantic Coast. In 2015, the results showed that the sizes measured ranged between 60 and 290 cm, with a dominance for sizes between 135 and 200 cm, and a distinct mode with average value of the order of 190 cm **(Baibbat *et al*., 2017).** Whereas in 2016, the sizes measurements showed a single mode of 125 cm with a dominance of sizes between 100 cm and 180 cm. Large individuals were observed in the same year, during the months of December, January, February and March **(Baibbat *et al.*, 2017).**

In addition, **Bustamante *et al.* (2013)** stated that in the Southeastern Pacific Ocean, the body sizes of the females captured in 2005 ranged from 76 to 213 cm, and from 75.5 to 240 cm for males. While in 2010, those sizes varied from 80-338 cm and from 66 to 267 cm, respectively for females and males.

Linear Regression of Sizes

Morphometric studies are essential for rational exploitation and good population management of a species. For the mako shark, the different regression equations showed that the lengths of the body parts are proportional and in perfect positive correlation with the total

length (TL). This result is confirmed by other studies **(Kohler *et al.*, 1996, Francis *et al.*, 2005, Campana *et al.*, 2005, Natansson Lj, 2002, Joung Sj *et al.*, 2005)** (table. 6).

Table 6 : Relationships Between Different Body Sizes of Mako Shark.

Zone / Authors	***Number***	**Relational parameters**	**Size range (cm)**	**Regression equation Y= a*X+ b**	**R^2**
North-West Atlantic **(kohler et *al.*,1996**)	199	FL/TL	[70 - 368]	FL = -1.701+0.9286TL	0.9972
New Zealand (**Francis *et al.*,2005**)	999	FL/ SL	[61 - 346]	FL = 0.766+1.100SL	0.997
	399	FL/ TL	[70 - 346]	FL = 0.821+0.911TL	0.993
Canadian Atlantic (**Campana *et al.*,2005**)	13	FL/TL	[50 -330]	FL = -9.36+0.972TL	0.99
		TL/FL		TL = 11.75+1.02FL	
		FL/SL		FL = 6.06+1.07SL	
		FL/D1L		FL = -8.25+1.92D1L	0.98
North-West Atlantic (**Natansson *et al.*,2002**)	73	FL/TL	[70 - 400]	FL = 0.95834+0.5331TL	0.90
North-West Pacific (**Joung *et al.*,2005**)	1240	SL/TL	[80 - 375]	SL = 0.784+0.816TL	0.98
	1236	FL/TL	[72- 375]	FL = 0.952+0.890TL	0.98
Moroccan Central Atlantic Coast (Present study)	314	TL/SL	[50 - 256]	TL = -2.2203+0.8114SL	0.9855
	314	TL/D1L	[30 - 117]	TL = 0.442+0.375D1L	0.9676
	314	TL/PvL	[35 - 185]	TL = -7.3408+0.6022PvL	0.9796
	106	TL/FL	[70 - 300]	TL = -6.2238+0.9865FL	0.9917
	89	FL/SL	[50 - 256]	FL = -1.2397+1.21SL	0.9879
	106	FL/TL	[74 -310]	FL = -6.6299+0.9994TL	0.9953

Relative Growth (Size-Weight Relationship)

The results of the size- weight relationship of the mako shark, obtained by this present study, are similar to those obtained in the North-East Atlantic zone **(Biton, 2015)**, in the North-West Pacific zone **(Joung *et al.*, 2005)** and in Canada on the Atlantic side **(Companna *et al.*, 2005).**

These relationships showed a minor growth allometry for both separate and combined sexes of the mako shark, which means that the weight increases proportionally but less quickly than the size. Additionally, using the same allometry equation, it was found that, for the same size, both sexes had similar weights. On the other hand, in the North-West Atlantic area **(Kohler *et al.*, 1996)** indicated the presence of a major allometry while studying the size-weight relationship. Differences in body weight also reflect differences in body condition in which weights of individual sharks of the same length may differ depending on several factors, including the amount of stomach contents, stage of maturity, liver weight, and body condition. The comparison of the different equations is shown in Table (7).

Table 7 : Parameters of the Size- Weight Relationship for the Two Sexes of Mako Sharks Combined in Different Study Areas.

Zone/Authors	N	TL/ FL(cm) [Min-Max]	W(t) (kg) [Min-Max]	$W(t)=a*L^b$	R^2	Allometry
North-East Atlantic **(Biton 2015)**	69	LT;[99-340]	———	$W(t)= 2*10^{-5}\ TL^{2.84620}$	0.9504	Minor
Pacific North-West **(Joung *et al.*,2005)**	345	LT;[80-345]	[3.4-407]	$W(t)=1.1*10^{5}TL^{2.95}$	0.98	Minor
Atlantic in Canada **(Campanna *et al.*,2005)**	89	FL;[50-330]	———	$W(t)=0.8*10^{-4}\ TL^{2.626}$	0.86	Minor
North-West Atlantic **(Kohler *et al.*,1996)**	2081	FL;[65-338]	[2 - 531]	$W(t)=5.24*10^{6}TL^{3.1407}$	0.9587	Major
Present study	961	LT;[60-317]	[5 - 230]	$W(t)=7*10^{-5}TL^{2.6092}$	0.944	Minor
	63	FL;[53-296]	[5 - 212]	$W(t)=9*10^{-4}TL^{2.1385}$	0.9487	

Linear Growth

The study of the growth length of the mako shark *Isurus oxyrinchus* (Rafinesque, 1810) was carried out by estimating the growth parameters with techniques based mainly on the study of the length structure of the population. The use of LFDA software (ELEFAN sub-program) allowed to estimate, for the first time, the growth parameters of the targeted species on the Moroccan Central Atlantic area.

The longevity of the mako shark landed at Sidi Ifni port was calculated at 26.56 years for females and 24.75 years for males.

According to the criteria to determine the mode of growth, **Branstetter (1987)** estimated that a species grows slowly when the measured weight is $0.05 \leq K \leq 0.10$ / year, while an intermediate growth is recorded when the weight is $0.10 \leq K \leq 0.20$ / year. On the other hand,

a rapid growth is fortified if the weight is $0.2 \leq K \leq 0.50$ / year. Thus, it can be concluded that, the mako shark of the Moroccan Central Atlantic area of which K = 0.15 / year has an intermediate growth. That result is in agreement with that of the Ivorian coasts having such an intermediate growth **(Kone *et al.*, 2014).** However, several studies, in particular those of **Cerna and Licandeo (2009)** on *I. oxyrinchus* reported that those species has a slow growth. The previous authors added that the longevity calculated for those species was between 9 and 50 years (Table 8).

Table 8 : Parameters of the Von-Bertalanffy Linear Growth Equation (K, $L\infty$, and t_0) Obtained by Different Authors, for the Combined and Separate Sexes of the Mako Shark.

Zone / Authors	Sex	L_∞ (cm)	K ($year^{-1}$)	$t_0(yaer)$	$T_{max}(yaers)$ Longevity
California Waters **(Cailliet *et al.*, 1983)**	Combined	321 ; LT 292.8; FL	0.072	-3.75	18 – 38
Occident North Atlantic **(Pratt and casey, 1983)**	Male	302 ; FL	0.266	-1	10
Pacific Australia **(Chan, 2001)**	Male	267 ; FL	0.312	-0.95	9
	Female	349 ; FL	0.155	-1.97	17
Ivory Coast **(Kone *et al.*, 2014)**	Female	345 ; FL	0.203	-1	14
China **(Joung *et al.*, 2005)**	Male	321.8 ; FL	0.049	-6.07	-
	Female	403.62 ; FL	0.040	-5.27	-
Pacific Baja California **(Ribot *et al.*, 2005)**	Combined	375.4 ; FL	0.05	-4.7	55
Pacific. New Zealand **(Bishop *et al.*, 2006)**	Male	302.2 ; FL	0.052	-9.04	48
	Female	820.1 ; FL	0.013	-11.3	219
South Atlantic **(Natanson *et al.*, 2006, Barreto *et al.*, 2016, Doño *et al.*, 2015)** Cited by **(ICCAT 2017)**	Female	244 ; FL	0.04	-7.08	23
	Male	261 FL	0.08	-4.47	11
Present study	Combined	313.24 ; TL	0.15	-0.68	23.10
	Male	349.40 ; TL	0.14	-0.34	24.75
	Female	322.14 ; TL	0.13	-0.79	26.65

The chi-square test, used to compare linear growth for the two sexes, showed that for the same age, almost a similar growth was recorded between the two sexes of mako sharks, the result of which coincides with that in the South Atlantic **(ICCAT, 2017**). However, **Skomal and Natanson (2002**) stated that females were increasingly larger compared to males. This is due to gender-related metabolic differences. In fact, females are often quieter and consume less oxygen than males, resulting in intersex differences in the growth.

The representation of Von-Bertalanffy's equations for the linear growth of the mako shark referred to in the present study compared with other studies, are shown in the Fig. (9).

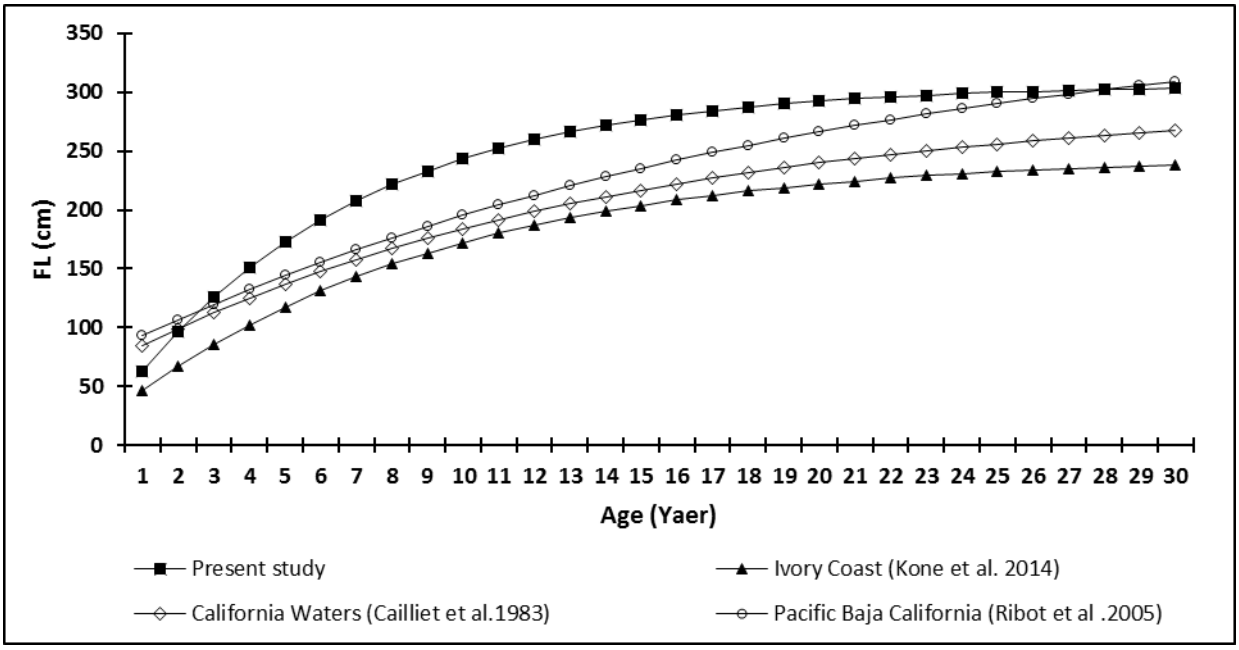

Fig. 9 : Linear Growth Curves in Both Sexes Combined in the Different Distribution Areas Where the Mako Shark Lives.

Fig. (9) shows that, for the same age and during the first two years of life, the total length of the mako shark in the Moroccan Central Atlantic Coast is between that obtained in the Ivorian coasts **(Kone *et al.*, 2014)**, in California **(Cailliet *et al.*, 1983)** and in Baja California **(Ribot *et al.*, 2005)**. Beyond two years, the lengths by age group, estimated in the Moroccan Central Atlantic, are greater than those in other study areas (Fig. 9). However, by the age of 28, the lengths became equal to or slightly shorter than those of Baja California **(Ribot *et al.*, 2005).**

CONCLUSION

In the light of this work, biological parameters relating to the growth biology of the shark mako *Isurus oxyrinchus* were studied in the Moroccan Central Atlantic zone. The current results provided information on the morphometric characters of the mako shark species in the area.

The growth measurements revealed that the measurement of the total lengths of the mako shark showed a multimodal distribution with a size range from 60 to 317 cm TL. In artisanal fishing catches, the juveniles were the most dominant. The morphometric study in the mako shark showed that the lengths of the body parts were proportional and in perfect positive correlation with the total length (TL). Furtermore, the size-weight relationship study, in both separate and combined sexes, showed a growth with minor allometry, which means that the weight increases proportionally but less quickly than the length, and for the same size the two sexes have similar weights. For the same age, the total length of the two sexes of mako sharks recorded a similar growth.

To conclude, it is important to emphasize that the results of the present study could be applied to assess rational management measures of the mako shark fishery in the Moroccan Central Atlantic. The present findings would lead to safeguard the mako shark conservation. For this reason, it is highly recommended to determine the birthing and nursing areas that must be protected in order to avoid fishing of young individuals, to fix a commercial size limit which should be greater than the size at first sexual maturity in order to give young adults the chance to reproduce before they are caught. Besides, it is highly required to use the non-destructive fishing gears that are suitable for fishing the mako shark *Isurus oxyrinchus* to ensure its sustainable exploitation.

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