SCRS/1992/061 Col.Vol.Sci.Pap. ICCAT, 41 : 354-362 (1994)

SAILFISH LENGTHS, WEIGHTS, AND SEX DATA FROM THE SENEGALESE SPORT FISHERY IN 1980 AND 1982

C. Limouzy-Paris[1] and M. F. McGowan[1]

ABSTRACT

Data on length, weight, sex, and gonad stage were obtained for 832 sailfish captured by the recreational fishery in Senegal during 1980 and 1982. Sex was recorded for 426 males and for 325 females. Gonad stage was recorded for approximately two-thirds of the males and females. The length range for males was 136-174 cm eye orbit fork length. The length range for females was 140-179 cm. A linear regression was fitted to predict lower jaw fork length from eye orbit fork length for 280 specimens (R^2 = 0.85). The weight range for males was 13.0-36.5 kg and for females was 17.0-45.0 kg. Analysis of covariance indicated that mean weight differed between males and females but did not differ statistically between years. Weight was linearly related to length for both males (R^2 = 0.49) and females (R^2 = 0.54) over the range of observed sizes in this study. Females increased faster in weight with increasing length than males did. The sex ratio was significantly different from 1:1 in 1980 (1.28 male /female) and in 1982 (1.38 male /female). Using discriminant function analysis to predict sex based on length and weight data correctly classified only 68% of males and 60% of females. However, the predicted sex ratio (255:205) was very close to the true ratio (251:209) suggesting potential application of this method to other landings data which lack sex information.

RESUME

Des données sur la taille, le poids, le sexe et l'état des gonades ont été obtenues pour 832 voiliers capturés par la pêche sportive au Sénégal en 1980 et 1982. Le sexe de 426 mâles et de 325 femelles a été enregistré. L'état des gonades a été examiné chez les deux-tiers environ des mâles et des femelles. Les mâles mesuraient de 136 cm à 174 cm de longueur orbitaire. Les femelles mesuraient de 140 cm à 179 cm. Une régression linéaire a été ajustée pour déterminer la longueur maxillaire à partir de la longueur orbitaire pour 280 individus (R^2 = 0.85). Les mâles pesaient de 13,0 kg à 36,5 kg et les femelles de 17,0 kg à 45,0 kg. L'analyse de la covariance indiquait que le poids moyen différait entre mâles et femelles, mais ne différait pas statistiquement d'une année sur l'autre. Le poids était en relation linéaire avec la taille pour les mâles (R^2 = 0.49) comme pour les femelles (R^2 = 0.54) pour la gamme de tailles sous étude. Les femelles prenaient plus rapidement du poids en grandissant que les mâles. Le sex ratio était sensiblement différent de 1:1 en 1980 (1.28 mâles /femelles) et en 1982 (1.38 mâles /femelles). L'analyse de la fonction discriminante pour déterminer le sexe à partir des données sur la taille et le poids n'a permis de classer correctement que 68 % des mâles et 60 % des femelles. Néanmoins, le sex-ratio établi (255:205) était très proche du ratio réel (251:209), ce qui suggère que cette méthode pourrait être appliquée à d'autres données de débarquement pour lesquelles l'information manque sur le sexe.

RESUMEN

Se obtuvieron datos de talla, peso, sexo y estado de las gónadas de 832 peces vela capturados por la pesquería de recreo en Senegal en 1980 y 1982. Se tomó nota del sexo de 426 machos y 325 hembras. Se registró el estado de las gónadas de aproximadamente dos tercios de los machos y hembras. La gama de tallas de los machos estaba en 136-174 cm desde la órbita del ojo a la horquilla. La gama de tallas de las hembras estaba en 140-179 cm. Se ajustó una regresión lineal para estimar la longitud mandibula inferior-horquilla, desde la órbita del ojo a la horquilla, en 280 ejemplares (R^2 = 0.85). La gama de pesos

---

[1] Rosentiel School of Marine and Atmospheric Science, University of Miami, 4600 Rickenbacker Causeway, Miami, FL 33149, U.S.A.

para los machos era 13.0-36.5 kg y en el caso de las hembras 17.0-45.0 kg. El análisis de la covarianza indicaba que el peso medio difería entre machos y hembras, pero no difería estadísticamente de un año a otro. El peso estaba relacionado de forma lineal con la talla, tanto en los machos ($R^2 = 0.49$) como en las hembras ($R^2 = 0.54$) en toda la gama de tamaños observados en este estudio. Las hembras aumentaban de peso, al aumentar de talla, mas rápidamente que los machos. La sex ratio era muy diferente de 1:1 en 1980 (1.28 macho /hembra) y en 1982 (1.38 macho /hembra). Al usar un análisis de función discriminatoria para predecir el sexo, basada en datos de talla y peso, se clasificaba correctamente sólo el 68% de los machos y el 60% de las hembras. Sin embargo, la predicción respecto a sex ratio (255:205) estaba muy próxima al sex ratio auténtico (251:209), lo cual sugiere que este método es aplicable en potencia a otros datos de desembarques en los que falta información sobre el sexo.

1. INTRODUCTION

Frequency distributions of length and weight for sailfish landings are useful to model growth and mortality and thus to manage exploitation of the stocks. Sexual dimorphism has been reported for blue marlin *Makaira nigricans* (Wilson et al. 1991), swordfish *Xiphias gladius* (Palko et al. 1981), and white marlin *Tetrapturus albidus* (de Sylva and Davis 1963). Therefore, information about sexual dimorphism is germane to interpreting size frequencies of sailfish. The purpose of this study is to describe size frequencies of sailfish sampled in Senegal in 1980 and 1982 and to determine whether sex related differences in length, weight, or weight at length exist in the fraction of the landings for which sex information was available. The data were also analyzed to provide, if possible, a basis for assigning sex to sailfish size frequency data where sex was not recorded.

2. METHODS

Data were collected from recreational fishery landings in Dakar Senegal by Claire Limouzy Paris during July, August, and September 1980, and July and August 1982. Sex was determined by visual examination of gonads in the peritoneal cavity through a small incision in the rectal region for 751 of 832 fish. Length was measured to the nearest cm and weight was measured to the nearest 0.5 kg. Sex was determined for 731 of 802 fish (91%) for which length was measured. This was not a random sample, rather, as many fish as possible were examined and the fraction examined was approximately equal for all length classes. Gonads were examined to determine sex and stage of maturation following the maturity scale from 0 (unidentified sex) to 5 (post spawning) for skipjack (Katsuwonus pelamis) adapted according to P. Cayre (personal communication, ORSTOM, Dakar), and weighed to the nearest 0.1 g. Data were entered into a spreadsheet (Quattro Pro 4.0). Frequency distributions and scatterplots were examined, and the statistical program SYSTAT was used to test for normality of length and weight frequencies by the Kolmogorov-Smirnov one sample test, for length and weight differences between sex by T-test, for differences in weight-length relationship by analysis of covariance, and to objectively classify fish to sex based on length and weight by discriminant analysis. Observed sex ratios were tested against 1:1 by Chi-square tests. The Chi-square test was also used to test the male:female ratio predicted by discriminant analysis against the empirically observed sex ratio.

3. RESULTS

Data for eye orbit fork length (EOFL), weight, maturity stage and gonad weight are summarized in Table 1. Females were on average slightly longer and heavier than males. Mean maturity stage for both females and males was 3: the maturation stage just prior to being ripe.

For the 280 fish with measurements of both lower jaw fork length (LJFL) and eye orbit fork length (EOFL) LJFL was linearly related to EOFL by the regression model:

$$\mathrm{LJFL} = 16.44 + 1.05\ \mathrm{EOFL} \quad (R^2 = 0.85)$$

This relationship can be used to convert the other EOFL measurements to the LJFL standard if desired (Table 2, Fig. 1). However, analyses reported here used EOFL in order to present the original measured data. Results of statistical comparisons should be the same after linear transformation but statistical error would not be reflected in the length frequencies so we left them in the original metric.

More fish were sampled in 1980 than in 1982 (457 vs. 375). The sex ratio in 1980 was 1.26 male/female (statistically different than 1:1, $P < 0.02$, Chi-square = 5.72, df = 1) and in 1982 it was 1.37 male/female ($P < 0.01$, Chi-Square = 9.0, df = 1). Distributions of length frequencies by 5 cm interval (Fig. 2) and weight frequencies by 5 kg interval (Fig 3) were not different from normal distributions based on the Kolmogorov-Smirnov test (Table 3). For each sex, mean lengths and weights did not differ between years (Table 4). Differences between males and females for both mean length (Fig. 4a) and mean weight (Fig. 4b) combined over both years were statistically significant at the 0.05 level (Table 5).

The length-weight relationships by sex and by year were linear over the range of data sampled (Figs. 5 and 6). Modelling the data by analysis of covariance indicated no effect of year on weight but significant effects of sex and the covariate length (Tables 6-8). Therefore, separate regressions by sex were plotted combining the years (Fig. 7).

Discriminant analysis of the discrete variable sex using the continuous variables length and weight correctly classified 68% of males as males and correctly classified 60% of females as females (Table 9). The sex ratio of the discriminant function classified fish was 255:205 male:female while the actual sex ratio was 251:209 male:female (Table 9). These two proportions were nearly identical and did not differ statistically from each other ($P > 0.8$, Chi-square = 0.14, df = 1). Fish classified incorrectly tended to be the large males and the small females which is consistent with the observed sexual dimorphism of this species with females larger than males in these landings.

The longest male in these landings was 174 cm EOFL in length (Table 1). For the observed mean length (152.5 cm) and standard deviation (6.7 cm) of males, the standardized z-score, (length - mean length)/standard deviation length = 3.223 (n=426). Therefore based on these data the probability of observing a male sailfish 174 cm or longer in this fishery is less than 0.001. The heaviest male in these landings was 36.5 kg (Table 1). The z-score for this weight is 3.333 (n=426). From this we infer that males heavier than 36.5 kg are likely to be extremely rare in this fishery. Combined length-weight plots with separate linear regressions (Fig. 7) show the exclusive limits for weight and length by sex in these landings.

4. DISCUSSION

Linear regression of lower jaw fork length and eye orbit fork length was computed for males and females combined, but can be done separately, according to Lee and Prince (1990) who developed separate regressions of lower jaw fork length to total length (TL) for males and females.

Ueyanagi et al. (1970) reported the highest density of sailfish in waters close to land masses in the tropical and subtropical areas, where spawning activity is also likely to be higher. Many males and females in our landings data were in advanced stages of maturity. Our observations suggest that the presence of sailfish off the Senegalese coast coincides with a period of reproduction, however, no juvenile fish were caught. Individuals smaller than the observed minimum size of our sampling may not yet be vulnerable to the recreational and artisanal fisheries which are both using trolling lines and rather large baits (*Sardinella eba, S. maderensis, Trachurus trachuru*, and *T. tracae*). Alternatively, juveniles may occupy different habitats than mature fish during the spawning season.

Females were slightly longer and heavier on average than males. We determined that these slight differences were statistically significant due to our large sample size. The longest and the heaviest fish in our data were females. In addition, the weight increased faster with increasing length for females than with males. This could be due to higher growth rates or to the additional weight of ripe gonads in females, or to both growth and gonad weight differences. Over the range of lengths and weights in these landings, the relationship was adequately described by a linear model: $W = a + bL$. We also fitted the model $W = aL^b$ but this only improved the R^2 slightly so it is not reported further. The analysis of covariance (Table 6) showed that the length weight relationships differed highly significantly (P = 0.002) between sexes. The difference between years was not significant at the 0.05 level (P = 0.094), but interannual differences should not be ruled out in the future.

Jolley (1972) noted a significant difference in the length-weight relationship between sexes for the Florida east coast Atlantic sailfish. The partitioning of western Atlantic data by sex was shown to be necessary for further analyses, such as yield per recruit, because of sex related growth and mortality rates (Conser, 1984). Sexual dimorphism for the eastern Atlantic sailfish was also demonstrated in our data by the steeper slope for females than males in the curves of weight vs. length. Therefore, we recommend that samples from the eastern Atlantic should include sex identification so these data also can be partitioned for further analyses.

Based on these data, males longer than 174 cm or heavier than 36.5 kg will occur in this fishery very rarely. These upper limits could be used to assign larger individuals exclusively to female. Again, based on the normal probability distribution, approximately 1% of females would exceed 174 cm in length and 15% of females would weigh 36.5 kg or more.

The assignment to sex by discriminant analysis using length and weight predicted a sex ratio statistically indistinguishable from the observed sex ratio. This could be very useful in segregating other landings data by sex for the length and weight ranges included in this analysis. However, due to the large overlap in length and weight the accuracy of the discriminant analysis classification was only 68% for males and 60% for females. If animals which are statistically similar morphometrically can be treated the same in further analyses (e.g., Conser 1984), then accuracy in sex identification may not be as important as accuracy in determining sex ratio, which appears to be predicted well by the morphometric analysis. Making a few more selected morphometric measurements would be likely to enhance the statistical separation of the sexes. However, direct examination of the gonads to determine sex is preferred, and this could be done with very little more effort and training than is needed to take accurate morphometric data.

5. LITERATURE CITED

CONSER, R.J. 1983. Yield per recruit analysis of sailfish, *Istiophorus platypterus*, in the Western Atlantic Ocean. ICCAT, SCRS/83/66, Vol.30:448-464.

JOLLEY, J.W. Jr. 1972. On the biology of Florida East coast Atlantic sailfish (*Istiophorus platypterus*). NOAA Tech. Report. NMFS SSRF-675. Proceeding of the Intl. Billfish Symp. Kailua-Kona, Hawai, 9-12. Aug. 1972. Part 2.

LEE, D.W. and E.D. PRINCE. 1990. Further development of length and weight regression parameters for Atlantic blue marlin, white marlin and sailfish. ICCAT, SCRS/89/70, Vol.32:418-425.

DE SYLVA, D. P., and W. P. DAVIS. 1963. White marlin, *Tetrapturus albidus*, in the middle Atlantic Bight, with observations on the hydrography of the fishing grounds. Copeia 1963:81-99.

PALKO, J. B., G. L. BEARDSLEY, and W. J. RICHARDS. 1981. Synopsis of the biology of the swordfish, *Xiphias gladius* Linnaaeus. U. S. Dept. Commerce Tech. Rept. NMFS Circ., No. 441. 21p.

UEYANAGI, S., S.K. KAWA, M. UTO and Y. NISHIKAWA. 1970. Distribution, spawning and relative abundance of billfishes in the Atlantic Ocean. Kenyu Hokoku Bull. Bull. Far Seas Fish. Res. Lab. (Shimizu) 3:15-55.

WILSON, C. A., J. M. DEAN, E. D. PRINCE, and D. W. LEE. 1991. An examination of sexual dimorphism in Atlantic and Pacific blue marlin using body weight, sagittae weight, and age estimates. J. Exp. Mar. Biol. Ecol. 151:209-225.

Table 1. Sample size (n), mean (x), standard deviation (SD), and range of length (EOFL), weight (WT), maturity stage, and gonad weight (G-WT) of sailfish from Dakar, Senegal in 1980 and 1982.

	n	x	SD	Range
FEMALE	325			
EOFL(cm)	314	157.4	7.3	140-179
WT (kg)	220	28.1	5.6	17-45
Stage	277	2.8	0.8	1-5
G-WT (g)	130	698.6	753.7	35.9-3832.9
MALE	426			
EOFL(cm)	417	152.5	6.7	136-174
WT (kg)	260	24.5	3.6	13-36.5
Stage	350	3.2	0.9	2-5
G-WT (g)	141	100.2	54	11-523

Table 2. Conversion of eye orbit fork length (EOFL) to lower jaw fork length (LJFL).

Regression output:	
Constant	16.444
Std error of Y estimates	3.4558
R squared	0.8459
No. of observations	280
Degree of freedom	278
X coefficient	1.0512
Std error of coefficient	0.0269

LJFL = 16.44 + 1.05 EOFL (EOFL and LJFL in cm)

Table 3. Comparisons of weight and length frequency distributions against the standard normal distribution with the Kolmogorov-Smirnov one-sample test.

Variable	N	Maxdif	2-tail probability
F80L	9	0.18	0.65
F80WT	6	0.26	0.25
F82L	8	0.19	0.62
F82WT	6	0.22	0.67
M80L	8	0.21	0.39
M80WT	5	0.25	0.47
M82L	8	0.21	0.40
M82WT	5	0.29	0.21

Variable names are coded: M=male, F=female, L=EOFL, WT=weight, 80=1980, 82=1982.
For example, F80L=female length frequencies in 1980.
N=number of frequency classes; Maxdif=the maximum difference between observed and expected cumulative frequency.

Table 4. Sample size (N OF CASES), range (MINIMUM, MAXIMUM), mean and standard deviation (SD) of length frequencies and weight composition by sex for sailfish from Dakar in 1980 and 1982.

	M80L	M82L	M80WT	M82WT	F80L	F82L	F80WT	F82WT
N OF CASES	208	209	212	47	162	152	168	52
MINIMUM	136	138	13	18	140	141	18	17
MAXIMUM	172	174	35	36.5	178	179	44	45
MEAN	152.2	152.9	24.4	25	157.3	157.5	27.8	29
SD	6.415	7.059	3.559	3.95	7.4	7.286	5.292	6.555

F80L & F82L = Length frequency for female in 1980 and 1982.
F80WT & F82WT= Weight frequency for female in 1980 and 1982.
M80L & M82L = Length frequency for male in 1980 and 1982.
M80WT & M82WT= Weight frequency for male in 1980 and 1982.

Table 5. T-test on length (EOFL) and weight (WT) by sex for 1980 and 1982 combined.

Independent sample T-test on EOFL grouped by sex

Group	N	Mean	SD
M	251	152.216	6.431
F	201	157.376	7.716

Separate variances T= -7.695, DF= 405.4, Prob= 0
Pooled variances T= -7.823, DF= 458, Prob= 0

Independent sample T-test on WT grouped by sex

Group	N	Mean	SD
M	251	24.483	3.596
F	201	27.933	5.584

Separate variances T= -7.7, DF= 342.5, Prob= 0
Pooled variances T= -7.997, DF= 458, Prob= 0

Table 6. Analysis of variance of the length-weight relationship.

Dep var: WT N: 460 Multiple R: 0.758
Squared multiple R: 0.575

Source	SS	DF	MS	F	P
Sex	97.154	1	97.154	9.382	0.002
Year	29.252	1	29.252	2.825	0.094
Sex*year	7.002	1	7.002	0.676	0.411
EOFL	4946.3	1	4946.3	477.643	0
Error	4711.8	455	10.356		

Table 7. Length-Weight Relationship for Males in 1980 and 1982.

Regression Output:		
Constant		-35.36
Std Err of Y Est		2.5622
R Squared		0.4944
No. of Observations		251
Degrees of Freedom		249
X Coefficient	0.3932	
Std Err of Coef.	0.0252	

WT = -35.36 + 0.393 EOFL

Table 8. Length-Weight Relationship for Females in 1980 and 1982

Regression Output:		
Constant		-55.47
Std Err of Y Est		3.8121
R Squared		0.5362
No. of Observations		209
Degrees of Freedom		207
X Coefficient	0.5300	
Std Err of Coef.	0.0343	

WT = -55.47 + 0.53 EOFL

Table 9. Discriminant analysis of sex on length at weight.

Table of GROUP (rows) by PREDICT (columns)

	M	F	TOTAL	CORRECT
M	172	79	251	0.685
F	83	126	209	0.603
TOTAL	255	205	460	0.648

M = male
F = female
GROUP = observed sex, M:F = 251:209
PREDICT = predicted sex by statistical classification, M:F = 255:205
CORRECT = % of correct prediction of sex

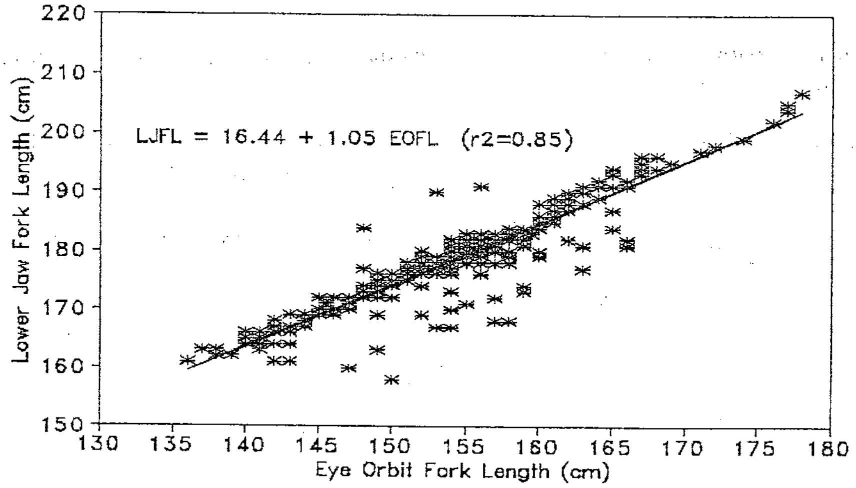

Fig. 1. Plot of linear regression of lower jaw fork length (LJFL) on eye orbit fork length (EOFL) for 1980 and 1982.

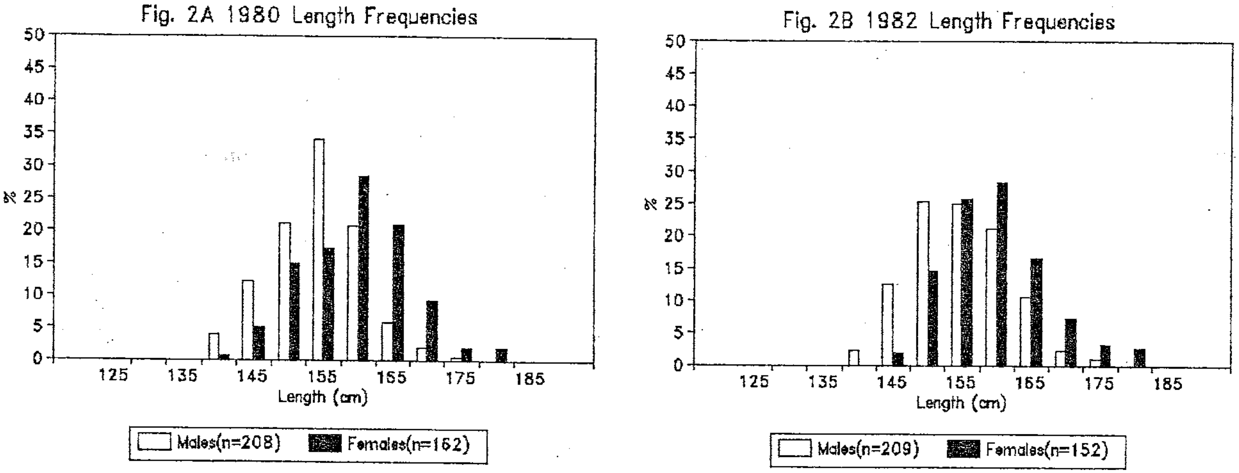

Fig. 2. Comparison of EOFL frequencies of male and female sailfish from Dakar, Senegal for 1980 (A) and 1982 (B).

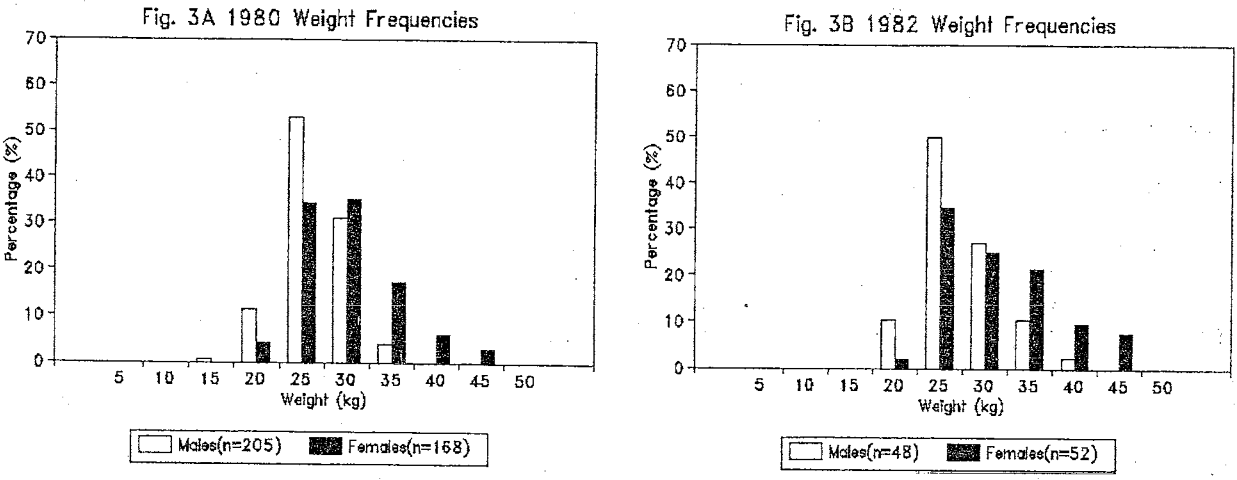

Fig. 3. Comparison of weight frequencies of male and female sailfish from Dakar, Senegal for 1980 (A) and 1982 (B).

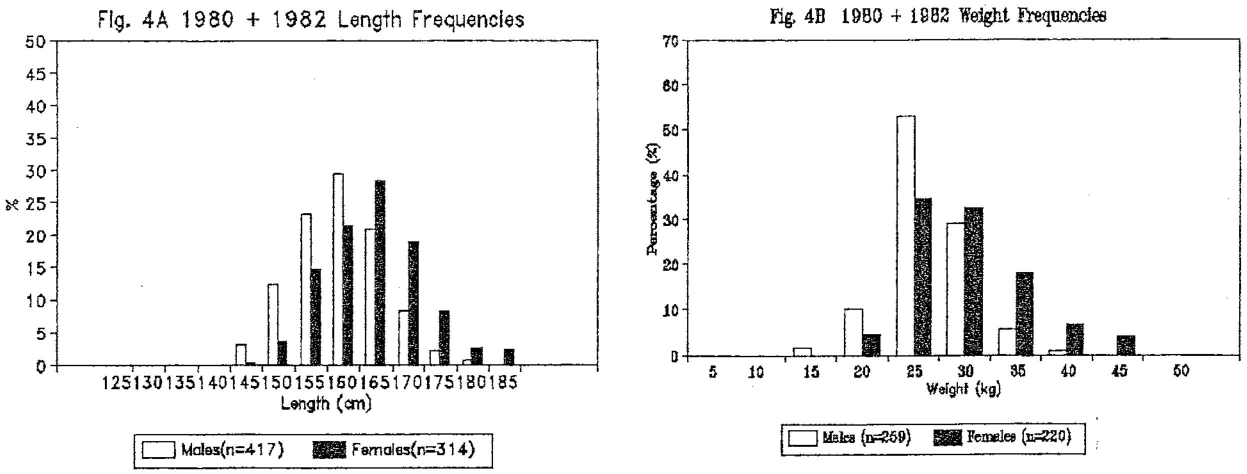

Fig. 4. Comparison of EOFL frequencies (A) and of weight frequencies (B) of male and female sailfish from Dakar, Senegal for 1980 and 1982 combined.

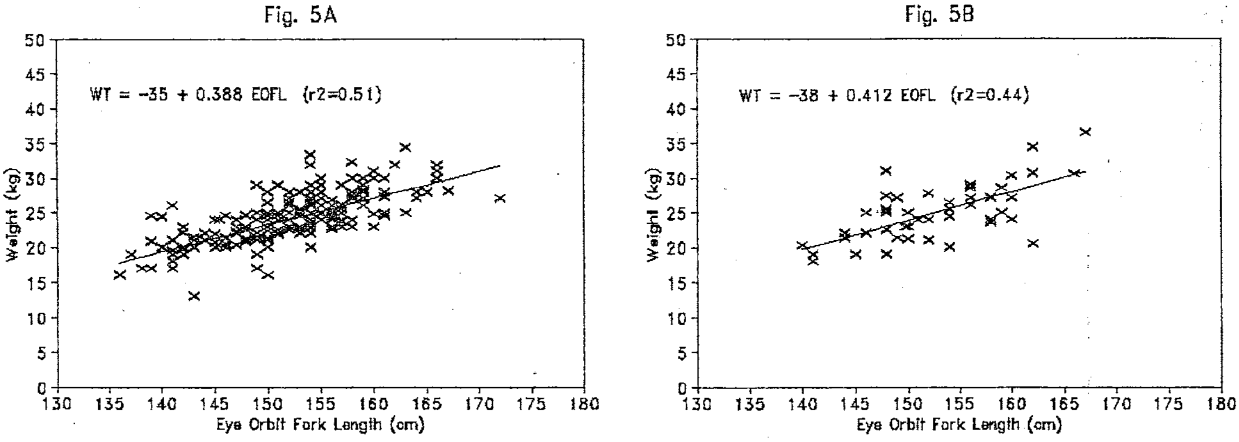

Fig. 5. Plot of linear regression of weight on eye orbit fork length for male sailfish from Dakar, Senegal in 1980 (A) and 1982 (B).

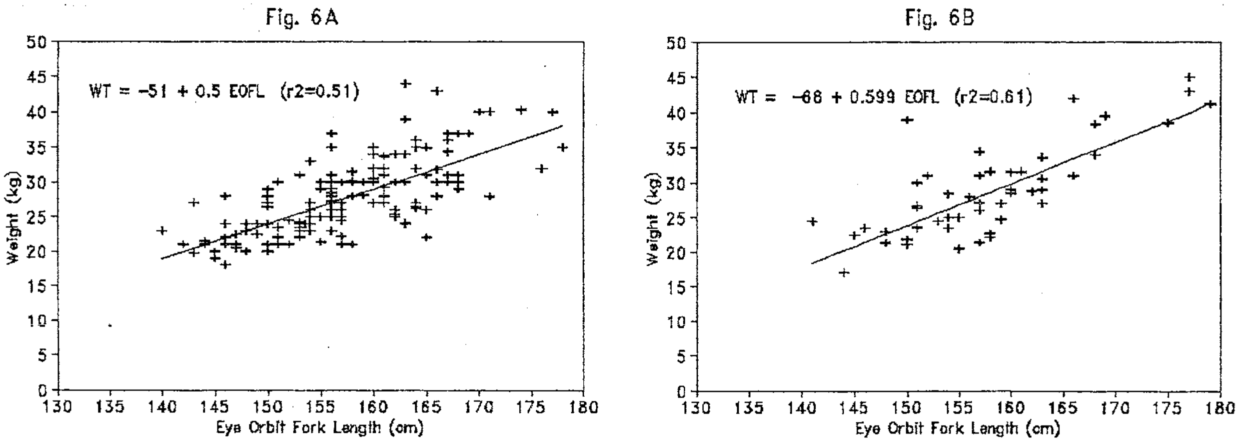

Fig. 6. Plot of linear regression of weight on eye orbit fork length for female sailfish from Dakar, Senegal in 1980 (A) and 1982 (B).

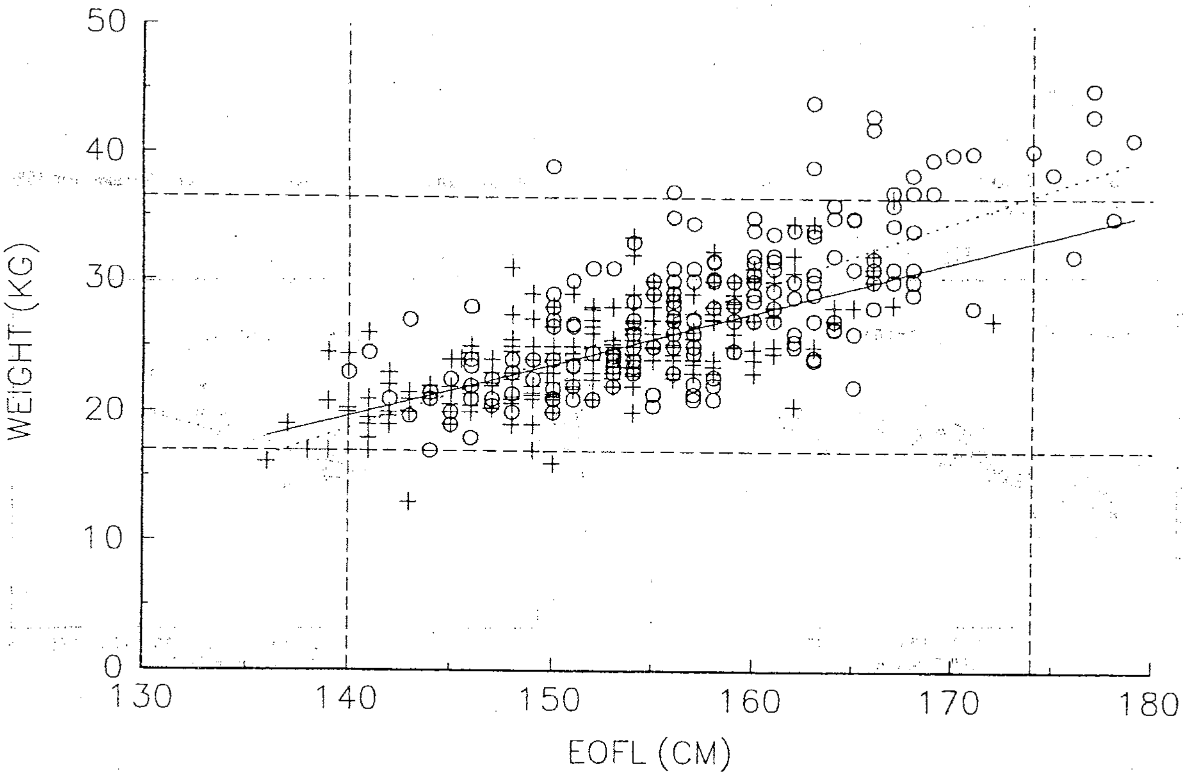

Fig. 7. Plot of linear regressions of weight on eye orbit fork length for male and for female sailfish from Dakar, Senegal, in 1980 and 1982 combined. The equation for males (+) is WT = -35.36 + 0.383 EOFL, r^2 = 0.494. The equation for females (o) is WT = -55.47 + 0.53 EOFL, r^2 = 0.536. Vertical dashed lines indicate shortest female and longest male (Table 1). Horizontal dashed lines indicate lightest female and heaviest male.