First approach to ageing the cuttlefish *Sepia bertheloti*. Comparison of growth in two fishing areas

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INTRODUCTION

The African cuttlefish *Sepia bertheloti* (Orbigny, 1839), is distributed throughout West Africa (Jereb and Ropper, 2005; Guerra-Marrero et al., 2019) that can reach sizes of 175 mm for males and 130 mm for females (Okutani, 1980). It is a species captured by trawling nets at depths between 70-140 m (Roper et al. 1984), with a greater presence in the fisheries from Sahara to Guinea-Bissau areas. The species is caught as by-catch in these fisheries, where the main target species of cuttlefish are *Sepia officinalis* and *Sepia hierreda* in the northern and southern waters respectively (Guerra et al., 2014).

At present, there is no information about its age and growth for the specie. In this study we compare the populations of two West African areas: Morocco in the North and Guinea-Bissau in the south. Given the difficulties in estimating de age of this species in structures such as the statolith, this study aims to analyse the age and growth of the African cuttlefish by using beaks, where preliminary results in other cuttlefishes suggest a daily deposition (Lishchenko et al., 2018)

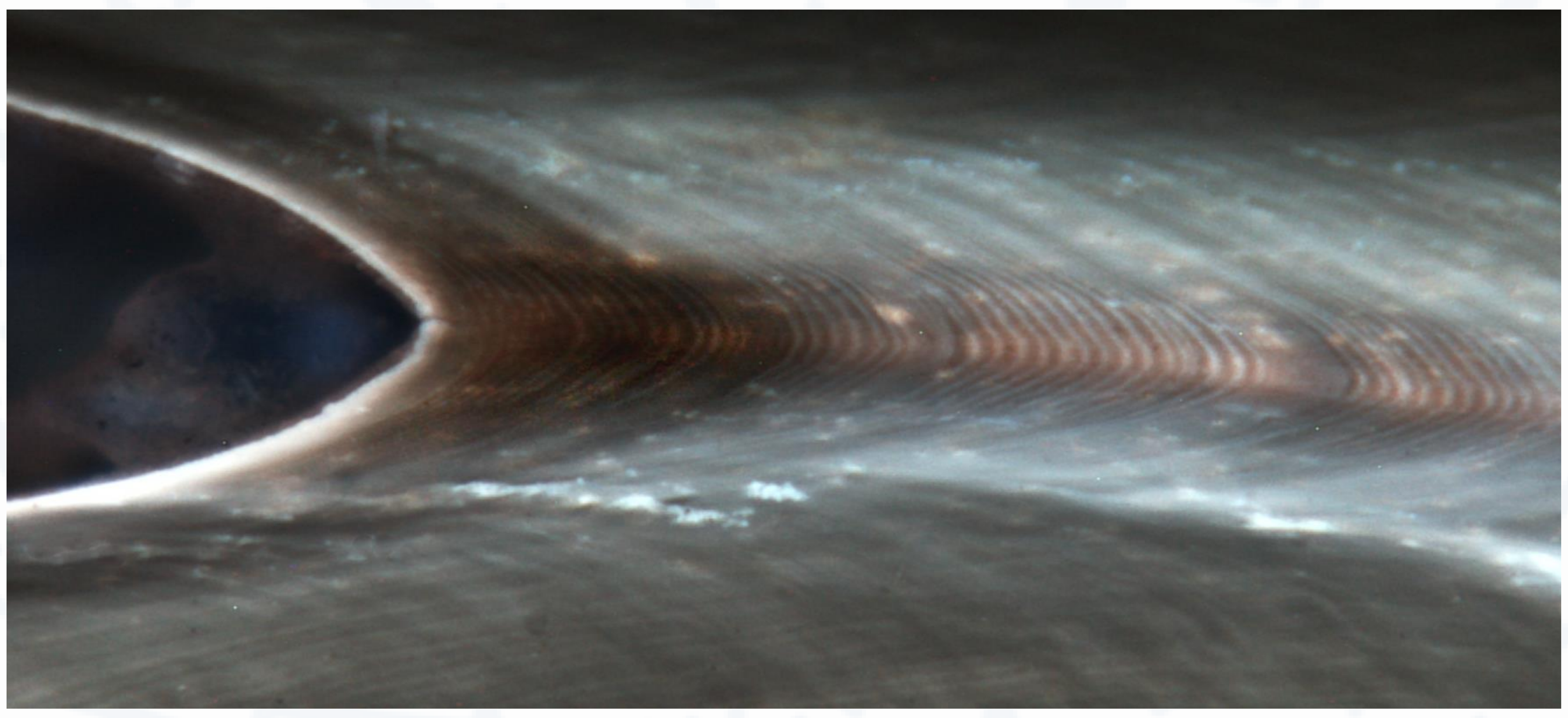

Figure 2. Appearance of growth increments in the lower beak section of *Sepia bertheloti* (300x).

MATERIAL AND METHODS

A total of 1123 individuals of *Sepia bertheloti* were collected from June 2018 to January 2020. They were caught by commercial trawlers operating in Morocco (552 individuals) and Guinea-Bissau (571 individuals). See Figure 1.

A subsample of 78 individuals from Morocco and 128 from Guinea-Bissau were analysed. The subsample was randomly performed by categorizing the individuals by size range for both sexes every 5 mm of Dorsal Mantle Length (DML).

The beaks were extracted, cleaned and stored in distilled water at a temperature of 4ºC, according to the procedure described by Perales-Raya et al. (2014).

The methodology used for processing the Lower beaks was that described by Perales-Raya et al. (2010). Once the beaks were processed, they were analysed using a Nikon Microscope Multizoom AZ100 with and UV-epiillumination attachment (vertical reflected light) (Fig. 2).

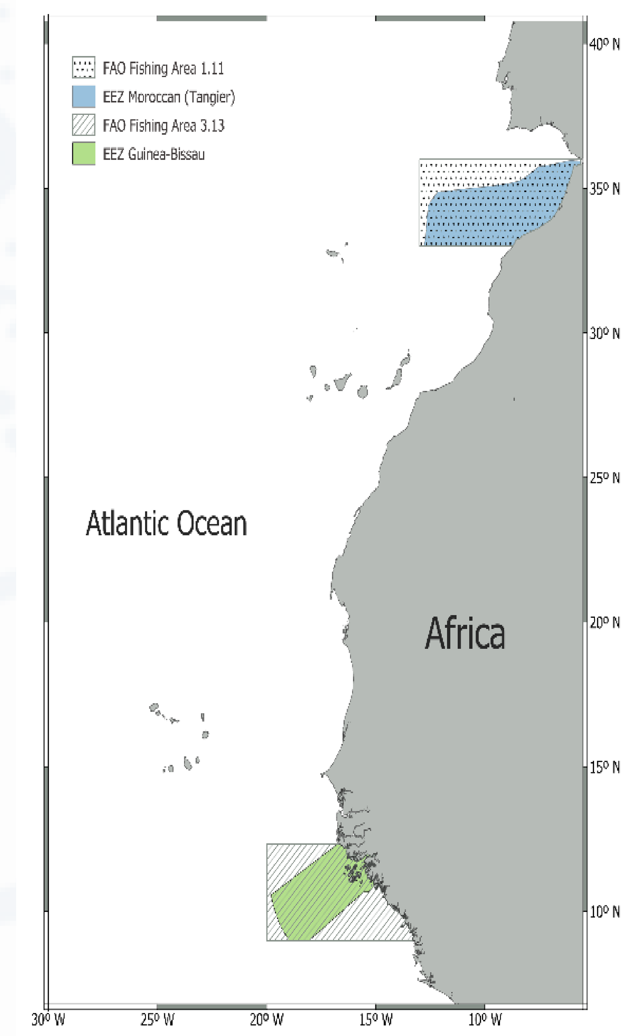

Figure 1. Sampling areas (FAO Fishing Areas) where the commercial trawlers caught *Sepia bertheloti* in Morocco (Tangier zone) (FAO 1.11) and Guinea-Bissau (FAO 3.13). Exclusive Economic Zone (EZZ) for Morocco (Tangier zone) and Guinea-Bissau in the FAO Fishing areas are shaded

The increments observed were counted twice by the same trained reader. Coefficient of variation (CV) was used to estimate the precision of the readings and the reproducibility of the method. According to Campana et *al*. (2001), to avoid any bias, the CVs were averaged by age classes and CV<7,6% were take as valid, rejecting reads with CV> 7,6%. Growth patterns and growth models were analysed according to Forsythe and Van Heukelem (1987) and Bolser et al. (2018).

RESULTS

Reliable readings were obtained for 183 of 206 beaks analysed. Twenty-three beaks (11.17%) were discarded because the structure had malformations (Fig. 3) or were severely damaged during grinding.

Cuttlefishes from Guinea-Bissau showed an estimated age between 94 (72 mm DML) and 433 days (160 mm DML), with a mean age of 231.19 days Estimated age for individuals from Morocco ranged from 111 (60 mm DML) to 419 days (140 mm DML), with a mean value of 220.53 days.

According to the AIC parameters (Table 1), the Schnute's and exponential models were those that best described the growth pattern of males and females, respectively, in the Morocco population (Fig, 4). Exponential model, in turn, was the best one to describe the growth of the entire population (all individuals, Fig.4). In the population of Guinea-Bissau, the von Bertalanffy model was the best describing the growth pattern in males while the exponential model was the best for females (Fig. 4). For all the individuals, the Exponential model was the best fitted (Fig. 4).

Statistically significant differences in growth rates (G and AGR) between sexes (t-test, p<0.0001) and areas (t-test, p<0.0001) were found. The individuals from Guinea-Bissau showed a higher instantaneous relative growth rate than the individuals from Morocco, showing faster growth at the same age (Table 2)

Model	Dorsal Mantle Length – age data								
Morocco	Males			Females			All		
	AIC	AICw	BIC	AIC	AICw	BIC	AIC	AICw	BIC
Logistic	412.32	0.02	420.27	233.80	0.17	239.27	655.50	0.10	665.18
Gompertz	411.49	0.03	419.44	234.13	0.14	239.60	654.81	0.14	664.18
von Bertalanffy	410.58	0.04	418.58	234.47	0.12	239.94	654.24	0.19	663.91
Schnute	**404.55**	**0.86**	**410.52**	234.95	0.09	239.05	660.96	0.01	668.22
Power	424.15	0.00	430.12	235.51	0.07	239.61	666.56	0.00	673.82
Linear	419.69	0.00	425.66	234.18	0.14	238.28	660.46	0.01	667.72
Exponential	410.28	0.05	416.24	**232.86**	**0.27**	**236.96**	**652.09**	**0.55**	**659.35**

Model	Dorsal Mantle Length – age data								
Guinea-Bissau	Males			Females			All		
	AIC	AICw	BIC	AIC	AICw	BIC	AIC	AICw	BIC
Logistic	564.01	0.13	572.89	229.41	0.10	235.02	833.29	0.06	843.67
Gompertz	562.61	0.27	571.49	229.25	0.10	234.85	832.25	0.10	842.63
von Bertalanffy	**561.40**	**0.48**	**570.29**	229.09	0.12	234.69	831.31	0.16	841.69
Schnute	577.82	0.00	284.48	253.98	0.00	258.19	858.34	0.00	866.13
Power	583.70	0.00	590.36	228.90	0.13	233.10	842.14	0.00	849.93
Linear	577.00	0.00	583.66	228.18	0.19	232.38	834.98	0.03	842.76
Exponential	564.21	0.12	570.88	**226.84**	**0.36**	**231.04**	**828.54**	**0.65**	**836.33**

Table 1. Statistical parameters of different growth model fitted to *Sepia bertheloti*. Dorsal Mantle Length-age data for Morocco and Guinea-Bissau. AIC: Akaike's information criterion, AICw: Akaike weight, BIC: Bayesian Information Criterion. Best model fit is given in bold underlined.

Age class (Days)	Morocco DML $\bar{X} \pm SD$	Morocco G	Morocco AGR	Guinea - Bissau DML $\bar{X} \pm SD$	Guinea - Bissau G	Guinea - Bissau AGR
Females						
<100				72.00±0.00	-	-
101-190	81.78±16.27	-	-	94.38±15.24	**0,402**	0,332
191-280	100.71±13.89	**0,147**	0,141	107.5±12.29	0,182	0,183
281-370				129.25±16.40	0,288	0,340
Males						
101-190	89.6±15.51	-	-	93.52±21.45	-	-
191-280	108.52±9.97	**0,281**	0,277	130.42±13.58	**0,455**	0,505
281-370	123.67±6.62	0,129	0,149	146.79±12.77	0,144	0,199
>371	137.00±3.61	0,137	0,179	166.50±4.76	0,131	0,205

Table 2. Dorsal mantle length growth-rates for each age-class of *Sepia bertheloti* females and males from Morocco and Guinea-Bissau. G: instantaneous relative growth rate (% DML d^{-1}); AGR: absolute growth rate (mm d^{-1}). $\bar{X}$: average; SD: standard deviation.

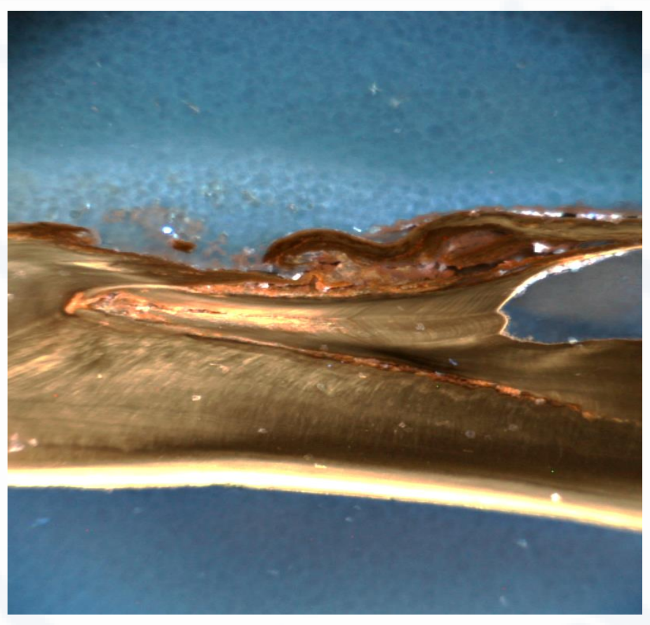

Figure 3. Beak discarded from the analysis due to malformations

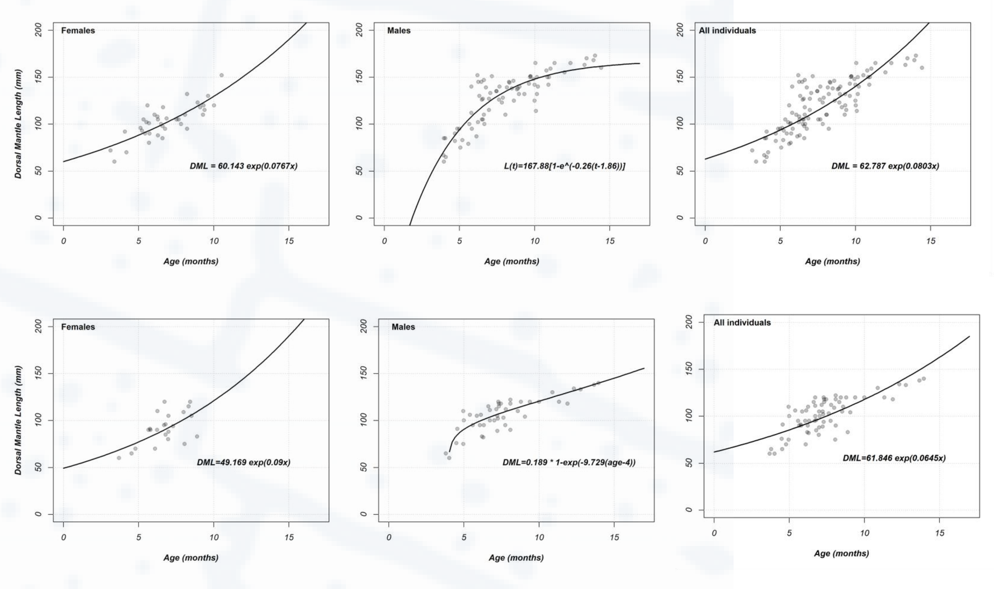

Figure 4. Best growth models fitted to Dorsal Mantle Length at age data for females, males and all individuals of *Sepia bertheloti* caught in Guinea Bissau (Top) and Morocco (down).

CONCLUSIONS

- Assuming the initial hypothesis of 1 increment – 1 day of life, a maximum life expectancy of 433 days was obtained for Guinea-Bissau and 419 days for Morocco.
- Specimens from Guinea-Bissau showed larger sizes than individuals from Morocco for the same age classes.
- For both areas, the best model that describes the growth of all individuals is the exponential. It was also shown that males have a higher growth rate than females, and in turn, the population of Guinea Bissau was the one that presented the highest growth rate.
- The differences in growth patterns seem a priori to be related to the different oceanographic conditions of both areas (individuals from Guinea Bissau grow faster due to its warmer waters).

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ACKNOWLEDGEMENTS

AGM was supported by a grant of the University of las Palmas de Gran Canaria (ULPGC) with a research staff training contract (PIFULPGC-2017-CIENCIAS-2).