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Precision of Age Estimation in Goldlined Seabream *Rhabdosargus sarba* (Sparidae) from the Arabian Sea, Oman

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Abstract

Accurate age determination of commercial fish is vital to successful fisheries management. Reliable age determination is essential for almost all aspects of fishery research, especially for study of growth, production, population structure and dynamics. The validation of aging methods is an important step in estimating growth and longevity. This study presents the validation of otolith-reading method for age estimation of goldlined seabream *Rhabdosargus sarba*. A total of 1185 goldlined seabream otoliths collected from the Arabian Sea of which 350 specimens were read by two different readers for whole and sectioned otoliths. Age comparisons between whole and thin-sectioned otoliths showed agreement in age readings for age groups 2-5 years and the whole otoliths tended to give lower ages than those estimated by thin sections. APE ranged from 3 to 7% for the three readings. Common differences between readers were related to interpretation of the otolith edge type and to interpretation of the first annulus.

Keywords: Sparidae, *Rhabdosargus sarba*, Otolith; age; average percent error; management.

1. Introduction

Management of fish populations for restoration or conservation requires an assessment of the present status, and reliable knowledge of the spatial and temporal dynamics of the population. Errors in age estimation may invalidate population models based on age distributions (Beamish and McFarlane, 1983; Francis, 1990; Raitaniemi *et al.*, 1998), and may in turn lead to large errors in the management of stocks and fisheries (Pikitch & Demory, 1988). However, despite its importance, such a validation step is not carried out systematically (Beamish & McFarlane, 1983). Using otoliths for age estimation requires a validation of the otolith reading method to avoid errors in age estimation. There is various age validation methods used worldwide to prove that the zones counted are annual such as bomb radiocarbon assays (Campana & Jones, 1998; Baker & Wilson, 2001; Andrews *et al.*, 2002), tag-recaptures method (Sire, 1981; Robitaille *et al.*, 1984; Hesthagen, 1985; Hall, 1991; Heifetz *et al.*, 1999; Hining *et al.*, 2000; Powell *et al.*, 2000; Gries & Letcher, 2002) and by comparing the otolith readings of different readers. Precision of routine age determinations (e.g. from reference samples aged by different readers) ultimately reflects an ability to distinguish strong from weak year classes and is therefore an important concern for assessing stock condition (Beamish & McFarlane, 1995; Crone & Sampson, 1998; Campana, 2001). The repeatability of age estimates (i.e. precision) is an important measure to compare the proficiency of different otolith readers and to measure individual drift over time (Campana, 2001).

Sparid fishes are an important component of both small-scale fisheries (gill net, trammel net and hand line) and industrial fisheries (trawlers) in the Omani waters of the Arabian Sea. *Rhabdosargus sarba* is one of the most dominant sparid species in Oman waters.

The aim of the present study is to test the reliability of the otolith reading method in goldlined seabream, *R. sarba* age determination using comparisons of ages estimated by two readers using whole and thin-sectioned otoliths from the same fish.

2. Material and methods

A random stratified sampling design of the Oman sector of Arabian Sea was done during five bottom trawl surveys from October 2007 to August 2008. The survey area extended to cover the entire Omani coast of the Arabian Sea from Ras Al-Had in the north to the Omani-Yemeni boarders in the south (Fig. 1). A total of 1185 specimens of *R. sarba* ranging from 14 to 43.2 cm total length were collected from the area during that period. The total length to the nearest mm and total weight to the nearest 0.1 g were recorded for each specimen. The whole *R. sarba* samples were grouped in order to give a representative number and lengths, then a subsample of 350 specimens covered all length and age groups (this size range did not include individuals from all life history stages especially juveniles) was used for age determination.

Paired sagittal otoliths were removed, immersed in water to remove any attached tissues, cleaned and stored dry. Age readings were taken by examining the whole otolith immersed in water under a Zeiss research microscope at 4× and 10× magnifications connected to AxioCam HRC and Ziess KL 1500 LCD using transmitted light. Otolith dimensions (otolith weight in g, length and width in mm) were taken and related to the total length and age of the individual fish using linear regression techniques.

The left otolith from each pair was embedded in clear epoxy resin and sectioned using a Buehler Isomet low-speed saw containing a diamond wafering blade which cuts a thin section (300 µm) through the nucleus. A grinding wheel fitted with silicon carbide paper with different grit sizes (400 to 1200 grit) flushed with water was used to remove excess resin on the face of the sections and to provide a polished face for viewing. The section is then mounted on a glass slide and read under a Zeiss compound microscope equipped with zoom lens (magnification up to 60×) using transmitted light, without knowledge of the length data.

Ages were assigned based on counts of alternating opaque and translucent bands (annual growth increments) from the whole and sectioned otoliths by two readers. The whole and sectioned otoliths were read twice by each reader with in-between periods of a month and for those fish whose counts differed, a third reading was done. The counts were compared and the precision of age estimates (agreement among counts) was calculated using the Average Percent Error (APE) of Beamish and Fournier (1981), coefficient of variation (CV) and index of precision (D: Chang, 1982). The bias and precision of annulus counts were compared among readers, and methods, using paired t-tests.

3. Results and Discussion

Reliable age determinations are essential for almost all aspects of fishery research but especially for studies of growth, production, population structure and dynamics. One of the most serious mistakes made by fisheries biologists is the failure to validate the age determination procedure that provides accurate age confirmation of the ageing technique. Without exception, age determination techniques must be validated for all age classes in the population and each time they are applied to a new species. To validate age determination of *R. sarba* from Omani coast of Arabian Sea, two different readers comparing the growth increment readings on the whole sagittal otoliths and their sections.

3.1 Otolith measurements

For 350 paired sagittal otoliths, there is no significant difference between the left and right measurements ($p > 0.05$ for Length OL, Weight OWt and Width OW), allowing the use of any of them. Different regressions were fitted and the best determined coefficients are presented in Table 1 and Figs. 2 & 3. The TL - OL and TL - OW relationships were best described by logarithmic and linear models respectively, while TL – OWt relationship was best described by power regression. Otolith weight was a good predictor of fish length in *R. sarba* ($r^2 = 0.82$). In contrast, otolith length and width were poor predictors of fish length (Table 1, Fig. 2).

On the other hand, the age – OL, age - OWt and age - OW relationships were best described by linear regression. Otolith weight was the best predictor of fish age for *R. sarba*, accounting for 99% of the variability in age followed by otolith width then otolith length (Table 1, Fig. 3).

3.2 Marginal increment analysis

The monthly marginal increment calculated for the fish with two rings, which were the most frequent in the samples, showed that rings are formed annually (Fig. 4). The mean monthly marginal increment decreased in to a low value of 0.21 in the autumn and increased in the summer months. However, the time of the ring formation of this age group was in autumn. As the distance between the last annulus and the otolith margin increased and decreased once a year, a single annulus was laid down on the *R. sarba* otolith annually. Thus, the otoliths of *R. sarba* can be used for aging studies. The same finding was found by Hesp (2003) for the same species on the west coast of Australia.

3.3 Comparison of methods

Comparison of whole and sectioned otoliths showed that the maximum estimated age was 6 and 11 years for whole and sectioned otoliths, respectively (Fig. 5). There is no significant different between ages determined using whole and sectioned otoliths at age groups 2–5 ($P > 0.1$), but the difference became highly significant ($P < 0.01$) for age groups 1 and 6.

For the whole orolith, the precision of the age estimates provided independently by the two readers was quite low (52%) in the first reading, this poor precision was due to the differences in detection of first and marginal rings. The discrepancies between estimates was between 1 and 2 years (Figs. 6&7) except in few cases (4% of examined otoliths) the difference reached 4 and 5 years. After the second and third readings, the precision between the two readers increased to 70 and 95% respectively. For the sectioned otoliths, 46% of agreement was found in the first reading raised to 75% in the second reading increased to 89% in the third one between the two readers.

The precision of otolith readings was relatively high, with the Average Percent Error (APE) at 5.16%. Hence, otoliths of *R. sarba* are readily interpretable, with a high level of agreement among replicate counts of annual growth increments. The percentage of error is rather low, except for the youngest and oldest fish for which there is a very high risk of an error of one or five years. This demonstrates the reliability of otolith reading. These results are in agreement with the only previous study on the age validation of this species (Radebe *et al.*, 2002). They mentioned that although the otoliths had to be sectioned, the growth zones were exceptionally clear and easily read, even in the oldest specimens and they gave an APE value of 4.7%.

Of the 350 otoliths and their sections examined, consensus reached 310 (88.6%). The average percent error (APE) of counts for each reading did not differ greatly. Precision of repeated age estimation was high, sectioned otolith readings were 91% and 95% in agreement with whole otolith readings for the first and second reader respectively. The values of the APE and the CV suggested that the precision levels obtained are according to the reference point values indicated by Campana (2001).

4. Conclusion

In conclusion, the comparison between readers and methods confirms the reliability of otolith-reading for estimating the age of goldlined seabream. Furthermore, the examination of otoliths provides information about life history (marine or river form, time spent in sea or river, maturity age, number of spawnings) that is not available from an examination of recaptured tagged fishes. However, the risk of error in ageing fish from otolith reading is reduced when the biologist is experienced in the principles of otolith reading and has a good knowledge of the biology of the local goldlined seabream. Besides being a contribution to knowledge of goldlined seabream, our results have a more generic interest, because they strengthen the argument for age validation. This point needs to be stressed, because uncertainty in age estimation for *R. sarba*.

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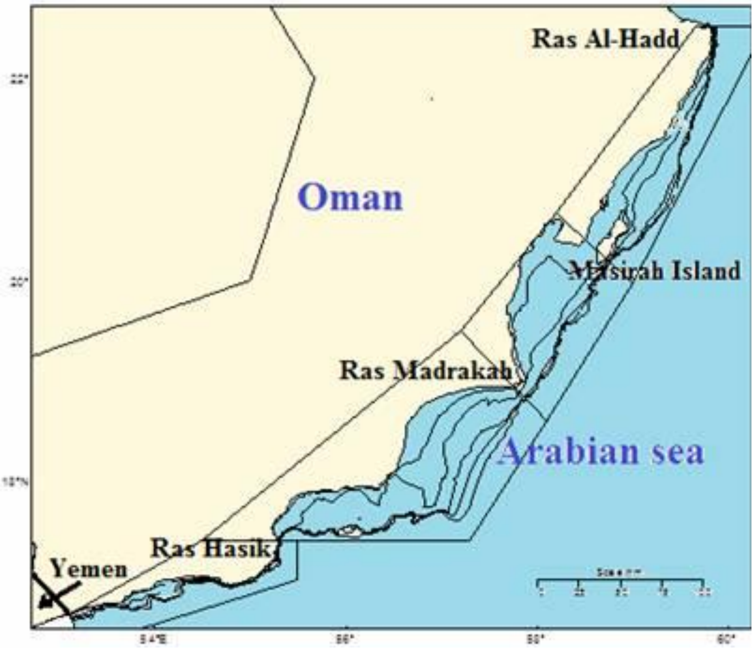

Figure 1. Oman coast of the Arabian Sea showing the surveyed area

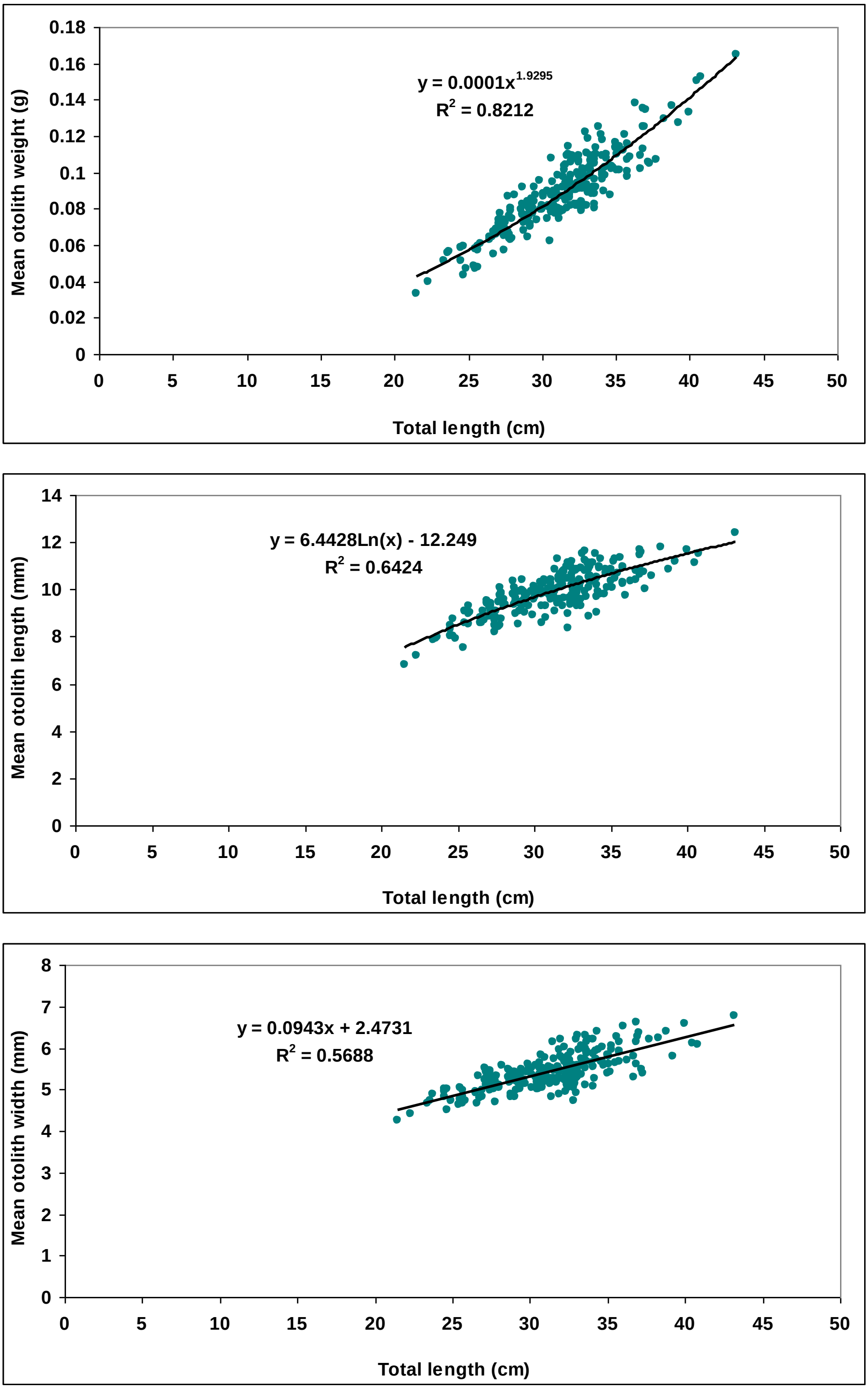

Figure 2. Total length – otolith measurements relationships

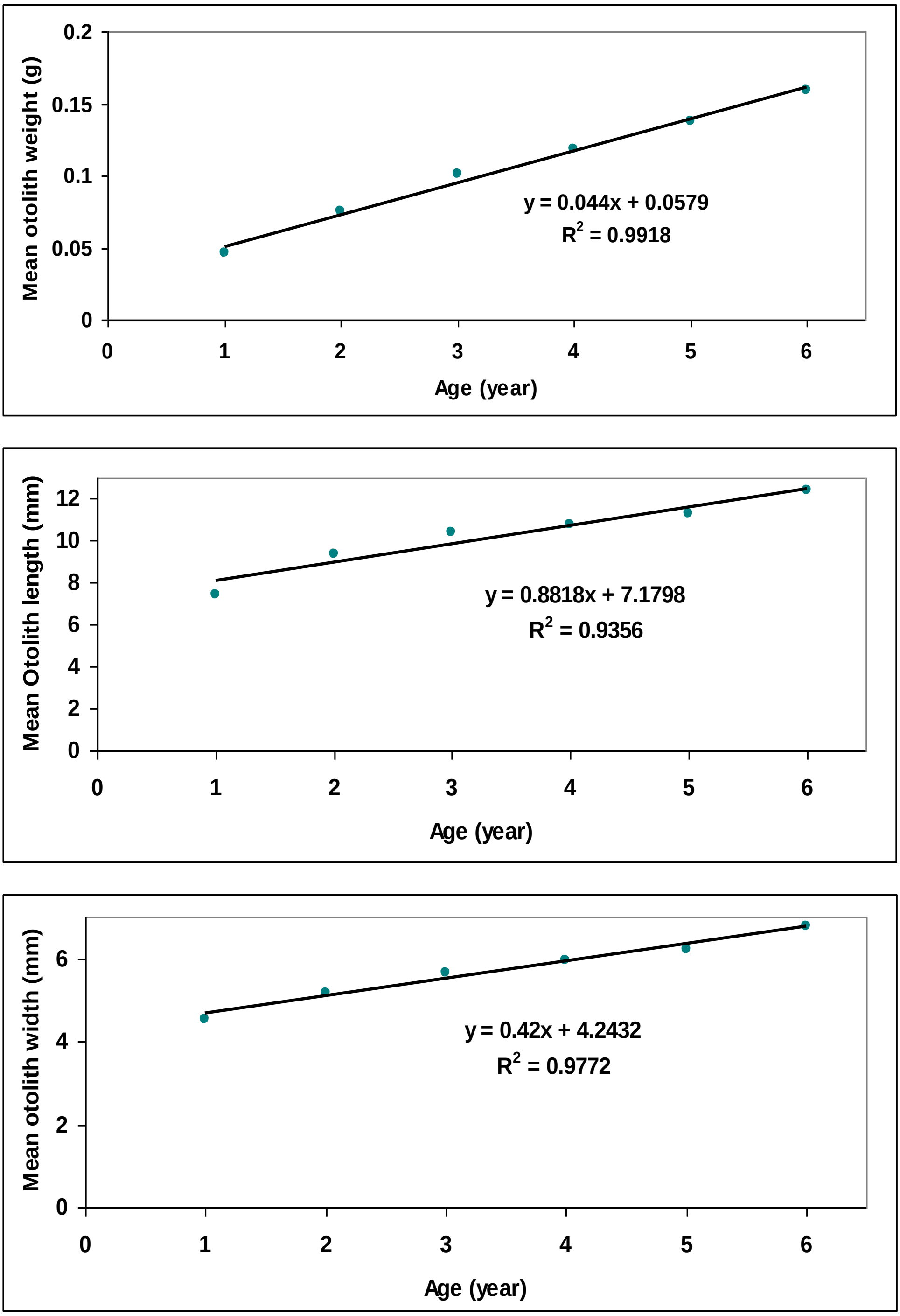

Figure 3. Age – otolith measurements relationships

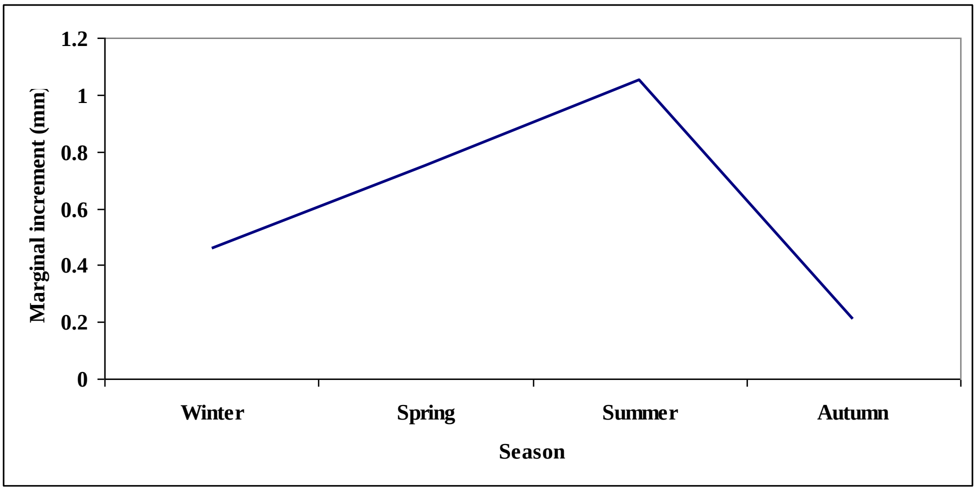

Figure 4. Time of annulus formation for *Rhabdosargus sarba* in the Arabian Sea

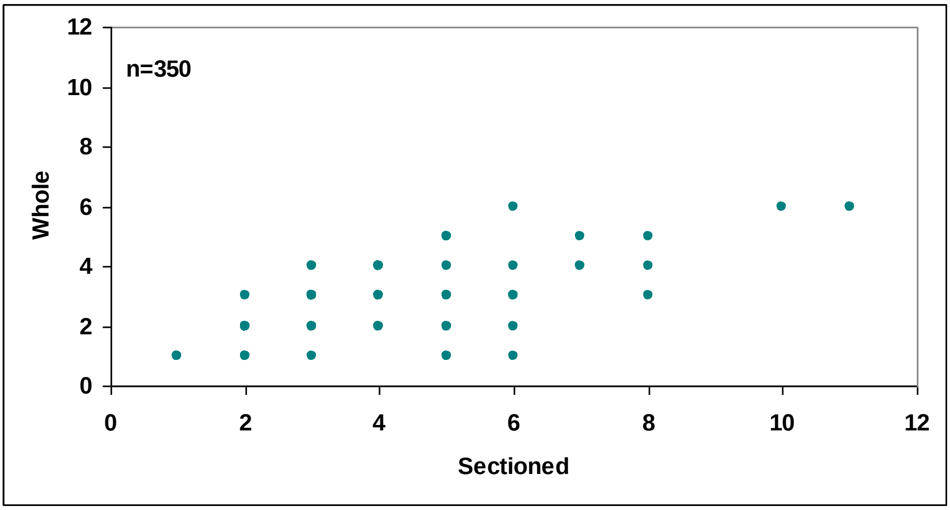

Figure 5. Whole and sectioned otoliths' readings

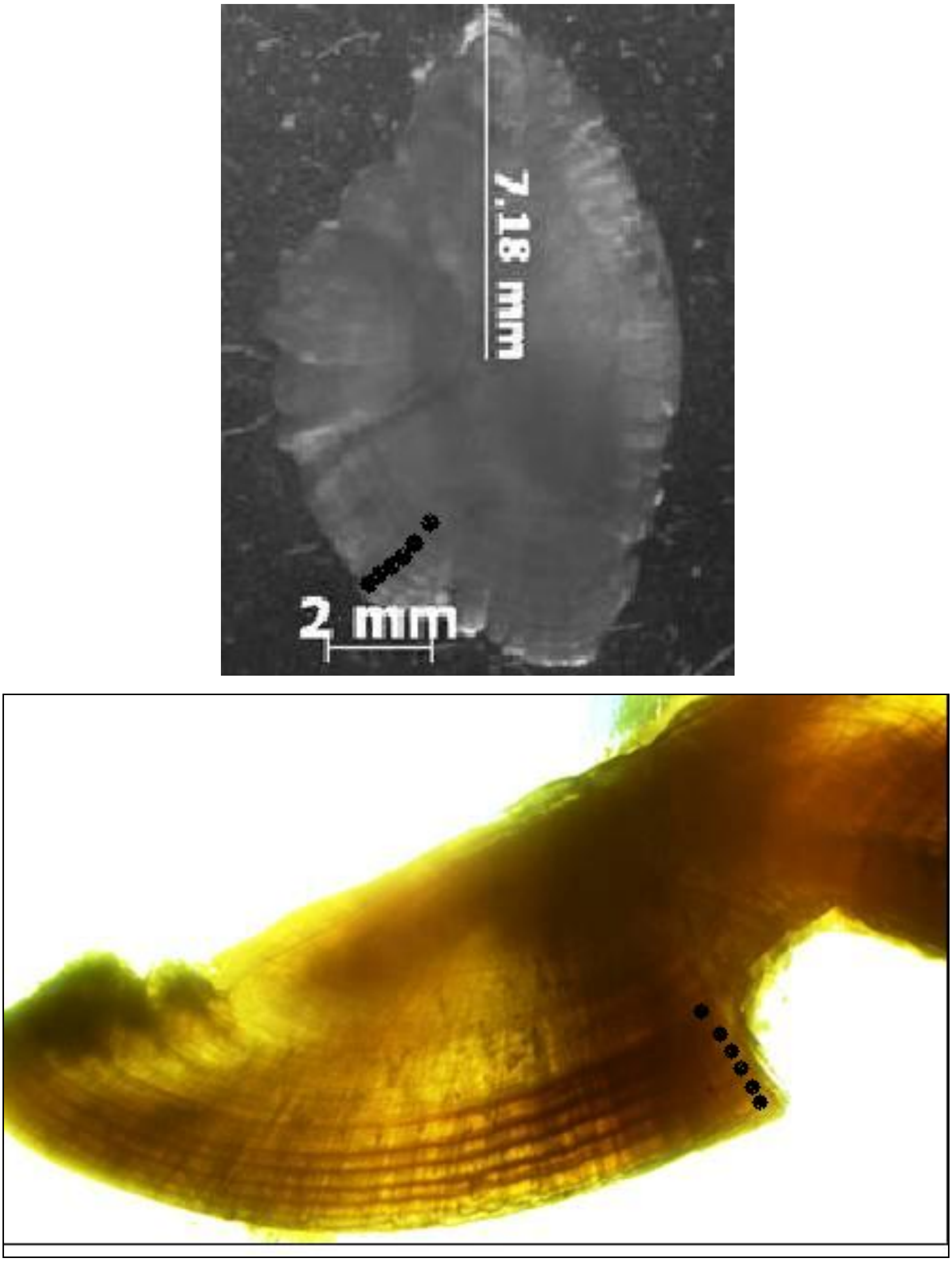

Figure 6. Otolith of *Rhabdosargus sarba*, whole and after sectioning with the same number of rings

Figure 7. Otolith of *Rhabdosargus sarba*, whole and after sectioning with different readings

Table 1. Parameters of the fits related to otolith measurements.

Model fitted	a	b	r^2
TL – OWt (Power)	0.0001	1.9295	0.82
TL –OL (exponential)	3.325	6.4428	0.64
TL –OW (linear)	2.4731	0.0943	0.57
Age – OWt (linear)	0.0579	0.044	0.99
Age – OL (linear)	7.1798	0.8818	0.93
Age – OW (linear)	4.2432	0.42	0.98

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