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Insight on reproductive strategy in Portuguese waters of a commercial protogynous species, the black seabream *Spondyliosoma cantharus* (Sparidae)

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ABSTRACT

Information on fish reproductive strategy is essential to understand population dynamics. Samples of black seabream, *Spondyliosoma cantharus*, were collected from the western Portuguese continental coast to investigate the reproductive cycle, the timing of spawning, length at maturity and sex change, fecundity type and fecundity. This species is a protogynous hermaphrodite, showing a sharped biased sex ratio towards females for lengths smaller than 25 cm, and significantly biased towards males above this value, with no females occurring above 35 cm. Development of secondary growth follicles was asynchronous, and it was estimated that each female spawns 27 batches during the spawning season, which takes place from February to May. Half of the females' population was mature at 18.41 cm and have changed sex at 25.62 cm. Sex change takes only a brief period of time, as transitional individuals were scarce and most showed oocytes regressing into cystic structures. The species presents a clear indeterminate fecundity type with massive atresia happening at the end of the spawning season. Mean values of 203 oocytes and 5431 oocytes by gram of eviscerated female were estimated for relative batch fecundity and relative annual fecundity, respectively.

1. Introduction

Portugal has the highest seafood consumption per capita in European Union and one of the largest in the world (FAO, Food and Agriculture Organization, 2010), and although approximately 370 fish species are commercially explored in its waters (Leitão et al., 2014), only a small group is assessed for management purposes. The small-scale fisheries have a considerable socioeconomic importance for the local population and represent 80% of the national fleet (Gaspar et al., 2014) playing a decisive role in exploring a large group of coastal species. But despite its importance, the management of these fisheries is still inconsequent or inexistent due to the lack of biological information (Gaspar et al., 2014).

Sparids are one of the most targeted fish families in Portuguese coastal fisheries (Erzini et al., 1996; Cabral et al., 2003; Leitão et al., 2016). The black seabream, *Spondyliosoma cantharus*, is a protogynous Sparidae species with a vast distribution along the eastern Atlantic, occurring from Scandinavia to Namibia, around the Madeira, Cape Verde and the Canary Islands. It is also common in the Mediterranean Sea and the western Black Sea (Bauchot and Hureau, 1986) and is an important commercial fish, exploited in European waters by recreational and commercial fishers (Russell et al., 2014). In Portuguese waters it is caught by several different fishing gears, with mean annual landings of 180 ton in the last decade (DGRM, unpublish data).

Knowledge on the reproductive strategy of a fish species is essential for an effective population management. In order to understand this strategy, information on reproductive cycle, the timing of spawning and follicle development should be gathered (Alonso-Fernández et al., 2011; Lowerre-Barbieri et al., 2011). Sex changing species need a special attention to their reproductive strategy since sequentially hermaphroditic fish present different social organizations and reproductive modes according to their life-history system (Benvenuto et al., 2017).

S. cantharus exhibits life history characteristics that make it particularly vulnerable to local over-exploitation since it is a hermaphrodite slow-growing, long-lived, and exhibits habitat specificity during the spawning season, when it shows spawning aggregations and male nest guarding behaviours (Pinder et al., 2017; Russell et al., 2014). Information of spawning season, length at first maturity and sex change for the species is available for the English Channel and Bay of Biscay (Perodou and Nedelec, 1980; Soletchnik, 1982), South Coast of Portugal (Gonçalves and Erzini, 2000), Canary Islands (Pajuelo and Lorenzo, 1999), Saharan bank (Balguerías, 1995) and Mediterranean (Boughamou et al., 2015; Mouine et al., 2007; Mouine et al., 2011), fecundity data is also reported on Balguerías (1995), Gonçalves and

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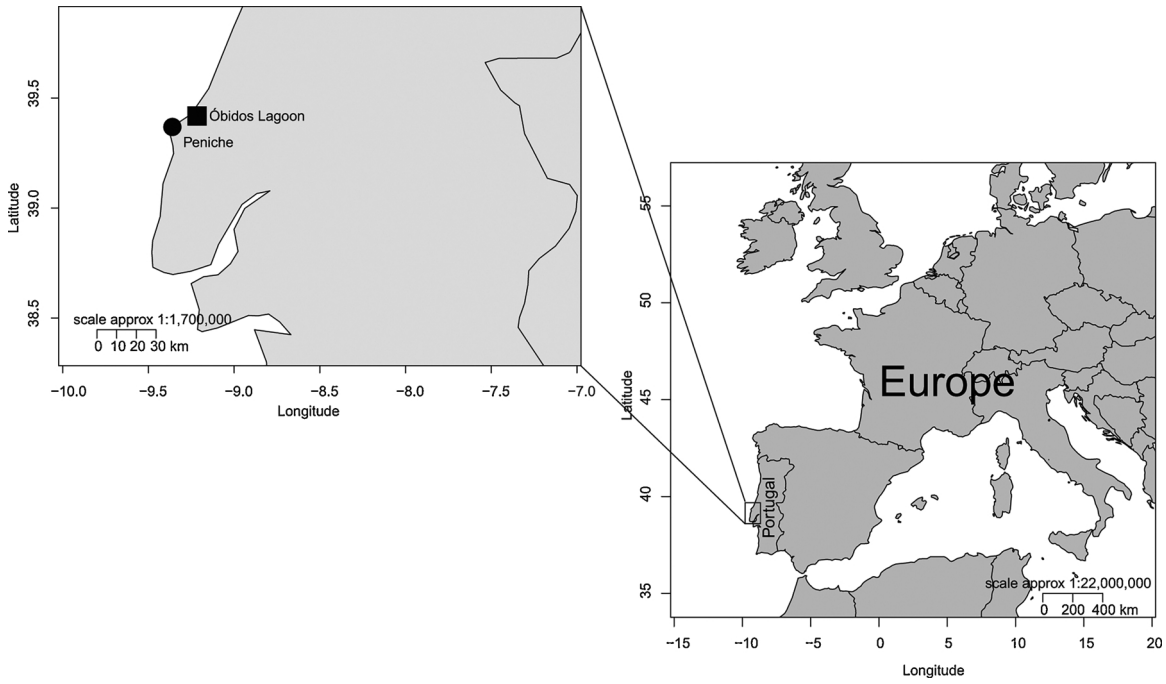

Fig. 1. Map of sampling sites location on the Portuguese coast. Black circle indicates Peniche and black square indicates Óbidos Lagoon.

Erzini (2000), Soletchnik (1982) and Dulčić et al. (1998) for the eastern middle Adriatic. However, none of these studies present a thorough histological analysis and fecundity type study for the species.

Despite the particular life history strategy and commercial importance of *S. cantharus*, no data is available for the reproductive strategy of the species for the western Portuguese coast. The present study intends to enlighten diverse aspects of the reproduction of *S. cantharus* for this area. Sex transition aspects are investigated, and reproductive cycle is examined. Ovary organisation and oocyte development are studied over the reproductive cycle. Fecundity type is defined and according to the results, batch and annual fecundity are estimated.

2. Material and methods

2.1. Sampling

Monthly samples were acquired between April 2014 and June 2015 from commercial vessels operating off mainland Portugal (Peniche, Fig. 1). During the spawning season sampling had a fortnightly basis. Additional samples using a beach seine were carried on Óbidos lagoon, near Peniche, from April to December 2014, to obtain juvenile individuals since in commercial landings only mature individuals are caught.

Samples were processed in fresh, and total length (TL, to the nearest 0.1 cm), eviscerated weight (EW, to the nearest 0.01 g), gonad and liver weights (GW and LW, respectively, to the nearest 0.01 g), and sex were recorded. Gonads were fixed in 4% buffered formalin for posterior histological analysis.

Sex ratio was established for classes of 5 cm interval and significant differences from 1/1 ratio were evaluated with Pearson's Chi-squared test in R studio version 1.0.143 (RStudio Team 2016).

2.2. Ovary and test organisation

A total of 1530 individuals were sampled, from these, 773 gonads were analysed histologically. All female from December to July were histologically processed, while for the other months a subsample of 5 females with macroscopically equal gonads were histologically analysed in order to assure that maturation stage was the same. The same criteria of 5 samples per macroscopically equal gonads was defined for clear male gonads, while gonads that showed any possible presence of different tissues were processed histologically. For the juvenile individuals caught in Óbidos lagoon, 30 gonads were analysed histologically to verify if the female tissue has already started to develop. Each gonad portion was dehydrated with ethanol, embedded in methacrylate, sectioned at 3 µm and stained with toluidine blue. The spawning

Table 1
Summary of oocyte growth stages defined for *Spondyliosoma cantharus* females caught in western Portuguese continental coast during 2014 and 2015. Values of minimum and maximum diameter for each stage is given, with mean and standard deviation between brackets. N – number of oocytes measured.

Oocyte development stage	Description	Diameter (µm)	N
Primary growth (PG)	These oocytes possess intensely basophilic ooplasm, with high intensity staining. Several nucleoli are normally seen with spherical or flattened shape	13.2–133.8 (64.4 ± 24.9)	354
Cortical alveolar (CA)	Cortical alveoli start to develop in the peripheral ooplasm and oil droplets can also be seen	111.2–204.3 (158.7 ± 17.6)	192
Early vitellogenesis (EVtg)	The cortical ooplasm contains both cortical alveoli and yolk globules	162.8–385.7 (220.6 ± 33.0)	192
Advanced vitellogenesis (AVtg)	Large yolk globules and oil droplets fill the cytoplasm.	253.5–547.6 (375.6 ± 64.0)	142
Oocyte maturation (OM)	The first indicator of maturation is the coalescence of numerous oil droplets to form fewer, larger oil globules. As maturation progresses hydrating yolk globules coalesce. When the germinal vesicle is at the animal pole of the oocyte, its membrane breaks down and the germinal vesicle is no longer visible.	433.0–898.1 (689.2 ± 110.4)	158
Hydrated oocytes (H)	Germinal vesicle breaks down with completely cleared fluid yolk and a single oil globule.	712.6–1039.9 (842.4 ± 104.8)	18