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Preliminary observation on sexual maturity of black anglerfish (*Lophius budegassa*) in north-eastern Atlantic waters

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ABSTRACT

The reproduction of black anglerfish (*Lophius budegassa*) was studied from samples collected during 5 years, from January 2006 to December 2010, in Celtic Sea, West and South of Ireland (ICES Div. VIIb–k) and Northern Spanish Atlantic waters (ICES Div. VIIIc–IXa). A total of 1167 specimens (4–99 cm) were sampled. The sex ratio, the spawning period and the maturity ogives by length were studied. The sex ratio in both areas studied varied with length, and it was close to 1:1 (male:female), 1:1.22 (54.90% of females) in Div. VIIb–k, and 1:1.01 (50.30% of females) in Div. VIIIc–IXa. A seasonal variation in sex ratio by length was observed at first time in Div VIIIc–IXa, with a very low proportion of intermediate sized females (40–60 cm) in the second semester. A seasonal reproductive migratory behavior is discussed. The spawning period was between December and July in Div. VIIIc–IXa. Spawning males were found throughout the year, but fewer spawning females, as in previous studies. The L50 values were estimated in Div. VIIIc–IXa: 38.2 cm for combined sexes, 36.0 cm for males and 53.0 cm for females. These values of sex ratio and L50 are similar to those obtained in closed areas studied.

1. Introduction

Black anglerfish (*Lophius budegassa* Spinola, 1807) is an important bottom living species in European fisheries, having a depth range between around 50 m and 800 m (Dardignac, 1988; Azevedo and Pereda, 1994). It is distributed in Mediterranean and Eastern North Atlantic from British Isles to Senegal, but there is considerable overlap with the other European anglerfish, white anglerfish (*Lophius piscatorius*). Black anglerfish, as its European congener, is a determinate spawner (Quincoces, 2002). The process of oocytes maturation is similar to that in other teleosts, although the morphology of ovaries differs markedly at a cellular level, from that of most other teleosts. A gelatinous matrix is produced inside the ovaries, the oocytes are arranged in clusters and, within each oocytes cluster, there is a gradation in the size of oocytes. As the ovaries develop, one group of oocytes becomes clearly demarcated from the others (Afonso-Dias and Hislop, 1996). The eggs seem to be shed in a single batch and the egg ribbons are far too long and wide to be a result of only one of several batches (Afonso-Dias and Hislop, 1996; Quincoces, 2002). Although an individual female may spawn only once a year, the spawning period of *L. piscatorius* seems to be of long duration (Afonso-Dias and Hislop, 1996).

The reproductive aspects relevant to the stock assessment of black anglerfish have been studied in several European Atlantic areas: Shetland Islands, West of Scotland and Rockall Bank (Laurenson et al., 2008b), Northern Bay of Biscay (Quincoces et al., 1998; Quincoces, 2002) and Atlantic Iberian waters (Azevedo, 1996; Duarte et al., 2001). The spawning period seems to be from October to July in North Atlantic waters (Azevedo, 1996; Duarte et al., 2001; Quincoces, 2002). Spawning males of both European anglerfish have been found in almost every month of the year (Afonso-Dias and Hislop, 1996; Duarte et al., 2001; Quincoces, 2002). The spawning grounds in the northern Bay of Biscay are located in the continental shelf and the upper continental slope, around 100 and 400 m (Azevedo, 1996; Quincoces, 2002).

Maturity stage is an important biological parameter that is used for the calculation of maturity ogives (and therefore of spawning stock biomass), for the definition of the spawning season of a species, for the monitoring of long-term changes in the spawning cycle, for the establishment of management technical measures (as the minimum landing size), and for other research needs regarding the biology of fish (ICES, 2007). The studies of black anglerfish in North Atlantic waters have estimated L50 maturities of between 37 and 49 cm for males and between 53 and 70 cm for females (Azevedo, 1996; Duarte et al., 2001; Quincoces, 2002; Laurenson et al., 2008b).

The European institutes cover sampling of maturity and sex ratio of this species through Data Collection Regulation (DCR)

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program of the UE (Reg. EC No. 1639/2001) since some years ago. The European laboratories involved in the collection of white and black anglerfish maturity data had used a similar macroscopic maturity stage key, however differences in some stages were found when the maturity stage keys were compared in the Workshop on Sexual Maturity Staging of Hake and Monkfish (ICES, 2007). One of the main goals of that workshop was to present a standard maturity key that allows the minimization of macroscopic misclassification. The proposed macroscopic maturity stage key was in agreement with the available histological information of the species and was based on knowledge of the reproductive cycle (ICES, 2007). The using of that new standardized maturity stage classification since 2008 has been fundamental when stock assessment is based on information from several institutes.

The sex ratio estimated in several studies was close to 1:1 (male:female), with values between 1:0.74 and 1:1.23, i.e. 42.55% and 54.95% of females respectively (Duarte et al., 2001; Quincoces, 2002; Laurenson et al., 2008b). The sex ratio also varied with length. The proportion of females and males is roughly equal in the smaller lengths. Males are more numerous from around 30 to 45–50 cm length interval. After about 50 cm, females outnumber males, and above about 70 cm all fish are females (Duarte et al., 2001; Quincoces, 2002; Laurenson et al., 2008b).

It is necessary that the more reliable and updated available information on sex ratio and maturity ogive of each stock of this species be available for their assessments. No previous information on reproduction of black anglerfish in Celtic Sea, West and South of Ireland (ICES Div. VIIb–k) has been found. On the other hand, the only two previous studies on the maturity of this species in the Atlantic Iberian stock, one based on individuals from Portuguese waters from 1989 to 1993 (Azevedo, 1996), and the other was based on joint information of Spanish and Portuguese waters from 1996 to 1997 (Duarte et al., 2001). Due to the verified geographical variability of the reproductive parameters and their possible temporal variability, it is important to have them updated for each geographical area, so that may be as useful as possible, especially for the annual stock assessment of this species.

Regarding to the main oceanography features in the studied area, water movement in Celtic Seas is, generally, from south to north, with oceanic water from the North Atlantic entering from the south and west of the region and moving north towards either the Arctic or North Sea. The most conspicuous upper layer mesoscale features in Spanish Atlantic waters are a poleward-flowing slope current in autumn and winter, and wind-induced coastal upwelling in spring and summer (OSPAR, 2000b). At intermediate levels the dominant mesoscale phenomenon is the northward propagation of cores of Mediterranean Water. Eddies, and in summer upwelling filaments, are the structures that most effectively transport mass and heat between coastal and offshore waters. The topographical diversity and the wide range of substrates result in different types of habitat (OSPAR, 2000b). The large range of habitats in both regions support a diverse fish fauna, including many commercially important species, as black anglerfish (OSPAR, 2000a,b). Those oceanographic factors may also influence the survival of larvae and the success or failure of the recruitments of this species, as in other bottom species in the area (Sanchez, Gil, 2000; Sánchez et al., 2003).

The present study of the reproductive biology of black anglerfish is based on the examination of specimens caught by the Spanish fleet in north-eastern Atlantic waters during 5 years (2006–2010). The aim of the study is to improve the knowledge and to present updated information on sex ratio and maturity ogive of the two main Atlantic stocks of this species: Celtic Sea, West and South of Ireland (ICES Div. VIIb–k) and Northern Spanish Atlantic waters (ICES Div. VIIIc–IXa2). These results will have implications for the stock assessment of this species.

2. Materials and methods

2.1. Sampling

Samples were collected from periodical (monthly or quarterly) samplings during 5 years, from January 2006 to December 2010. They were obtained by buying ungutted individuals from commercial landings, and on board of commercial and IEO research vessels.

The area sampled covered some of the main areas where the Spanish fleet capture anglerfish: Celtic Sea, West and South of Ireland (ICES Div. VIIb–k) (northern stock of the southern shelf) and Northern Spanish Atlantic waters (ICES Div. VIIIc–IXa2) (southern stock of the southern shelf) (Fig. 1).

A total of 1167 black anglerfish (length range 4–99 cm) were sexed. Table 1 indicates the number and length range of fish sexed by stock. The total length (cm), sex and gonad maturity of each specimen was recorded. Sex was determined by a macroscopic examination of the gonads, and these were staged macroscopically using a five-stage maturity scale that was international

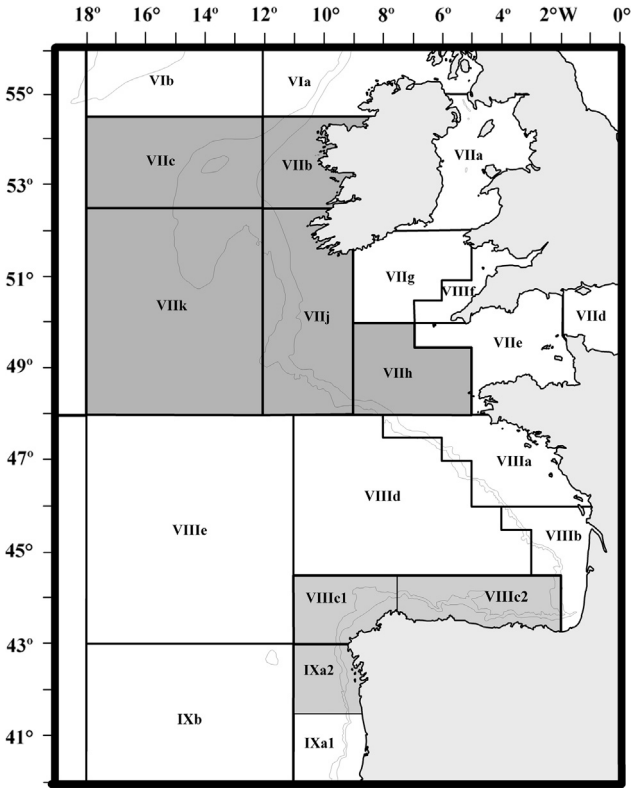

Fig. 1. Sampling ICES Divisions of North-east Atlantic: Celtic Sea, West and South of Ireland (ICES Div. VIIb–k) (dark gray); Northern Spanish Atlantic waters (ICES Div. VIIIc–IXa2) (light gray).

Table 1
Number and length range of black anglerfish sexed by area.

Area	Number				Length (cm)	
	Males	Females	Indeterminates	Total	Min	Max
ICES Div. VIIb–k	105	128	30	263	4	91
ICES Div. VIIIc–IXa	415	420	69	904	5	99