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Habitat selection and population spreading of the horned octopus *Eledone cirrhosa* (Lamarck, 1798) in Galician waters (NW Atlantic)

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ABSTRACT

Distribution and abundance of *Eledone cirrhosa*, a benthic octopus inhabiting the NE Atlantic and Mediterranean Sea, were studied in north-western Iberian waters. Capture data collected during two series of surveys, carried out during summer–autumn in Galician waters (NE Atlantic Ocean), were analyzed. "Galicia" series (*G1*, *G2* and *G3*) extended along the Galician continental shelf from Ribadeo Ría to Miño Estuary in 1974, 1975 and 1976, and "Cigala" series (*C 06*, *C 07* and *C 08*) were recorded from Finisterre Cape to Miño Estuary in 2006, 2007 and 2008. Data from a total of 276 trawls, ranging from 50 to 500 m, and corresponding environmental parameters were transferred to a Geographic Information System (GIS), providing a platform for a spatial–temporal analysis. Bathymetric distribution, variations in abundance, biomass and average body size of the octopus *Eledone cirrhosa* were analyzed through depth strata and seasons. Higher abundances were obtained in the intermediate strata and in autumn, most likely due to new recruits. Largest sizes of *E. cirrhosa* were collected in summer and average weight increased with depth throughout the sampling period. These variations of biomass and abundance suggest the existence of segregation by size and agree with the landings pattern of the trawlers fishery, in which *E. cirrhosa* is not a target species. No significant differences were found between *G1* and *G2* surveys or between *C* ones, performed at the same dates, suggesting that the polled data of surveys are useful tools for representing phenological stages of the species. Collected data and developed models illustrate a migratory behaviour during the reproductive period. Among the eight environmental variables considered, only the latitude remained significant in all developed models, suggesting an effect of photoperiod over the species distribution.

1. Introduction

The horned octopus, *Eledone cirrhosa* (Lamarck, 1798) is a benthic cephalopod inhabiting rocky and muddy bottoms over the continental shelf and slope of north-western Atlantic and Mediterranean Sea (Boyle, 1983). Its latitudinal distribution ranges from 66 to 67° N to an undefined limit in Moroccan coasts (Guerra, 1992).

The commercial importance of *E. cirrhosa* has increased during the last years in the Galician trawling fishery (NW Spain), which targets hake, mackerel, monkfish or Norway lobster. Its landings ranged from 545 to 2100 metric tons in Galicia during the last 15 years (www.pescadegalicia.com). Despite its increasing economic importance, its biology in north-western Iberian waters (Spain and Portugal) still remains poorly known, in contrast with the rest of its distribution range. Factors affecting the distribution of *E. cirrhosa* in the Mediterranean have been previously studied, particularly from a fishery perspective, and mainly in central and western Mediterranean basins (Belcari et al., 2002; Giordano et al., 2010; Lefkaditou et al., 2000; Pertierra and Sánchez, 2005; Salman et al., 2000; Wurtz et al., 1992). On the other hand, previous studies on this species, comparing north Atlantic and Mediterranean populations, revealed significant biological (mean size, spawning season, fecundity, etc.) and ecological (bathymetric distribution, habitat selection, etc.) differences (Boyle et al., 1988). Western Mediterranean specimens are smaller, with a maximum weight lower than 1 kg, and inhabits muddy bottom in circalitoral and bathyal levels (Mangold-Wirz, 1963). Spawning season peaks from end of May to August (Mangold-Wirz, 1963), although some individuals spawn in April (Mangold et al., 1971). On the other hand, north Atlantic specimens reach larger sizes (up to 2 kg) and dwell in a wider range of depth, from coastline to continental slope (Boyle, 1983). Early life stages of this species in this area have been found throughout the year, which confirm an extended spawning season (Boyle, 1983 quoting Russel, 1921 and Stephen, 1944). In Scottish waters, *E. cirrhosa* is caught in rocky, sandy or muddy bottoms. Since this

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species have no commercial interest in northern Europe, most of the catches are sold in local markets and exported to Mediterranean countries (Boyle, 1986).

Landings of this species in the north-western Iberian harbours show a cyclical annual pattern (Fig. 1), closely linked to their reproductive cycle (Regueira et al., 2013). During spring (March–May), and coinciding with the maturation peak, captures reach its maximum and then decreases until late summer (July–September), when most of adult individuals disappear due to the post-reproductive mortality. Because the continental shelf areas off Spain and Portugal are relatively narrow *E. cirrhosa* is distributed along a thin fringe parallel to the coast connecting north Atlantic and Mediterranean waters. This Iberian population shows intermediate characteristics between north Atlantic and Mediterranean populations (Regueira et al., 2013), illustrating the gradient in the ecosystem conditions.

Ecological niche can be thought to conform an *n*-dimensional space where each dimension represents one environmental variable or resource in which species are distributed according to their particular requirements (Hutchinson, 1957). Marine species-specific habitats, where they can feed, grow, mature and spawn to sustain their populations, are commonly known as Essential Fish Habitat (EFH) as defined by the EC Habitats Directive (Council Directive 92/43/EEC of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora). Characterization of EFH is crucial to improve our knowledge on the relationship among biotic and abiotic factors with life cycle of the species, and a fisheries sustainable management. Generalized Additive Models (GAMs), a form of General Linear Models (GLM), constitute the most common and well developed method for modelling fish habitats (Valavanis et al., 2008), and provides the possibility to model different environmental scenarios, including non-linear responses of biological variables to environmental forcing variables. On the other hand, they allow to define the optimal areas of potential distribution for the particular stages of the species life cycle, e.g. areas of larval development and recruits and adults grounds (Sánchez et al., 2008) and seem to represent a good trade-off between model complexity and performance for a diverse set of species (Meynard and Quinn, 2007).

The aim of this paper is to describe migratory behaviour of *E. cirrhosa*, by defining habitat use during three particular stages of its reproductive period, according to catch data registered in two survey series performed in summer–autumn in NW Iberian waters.

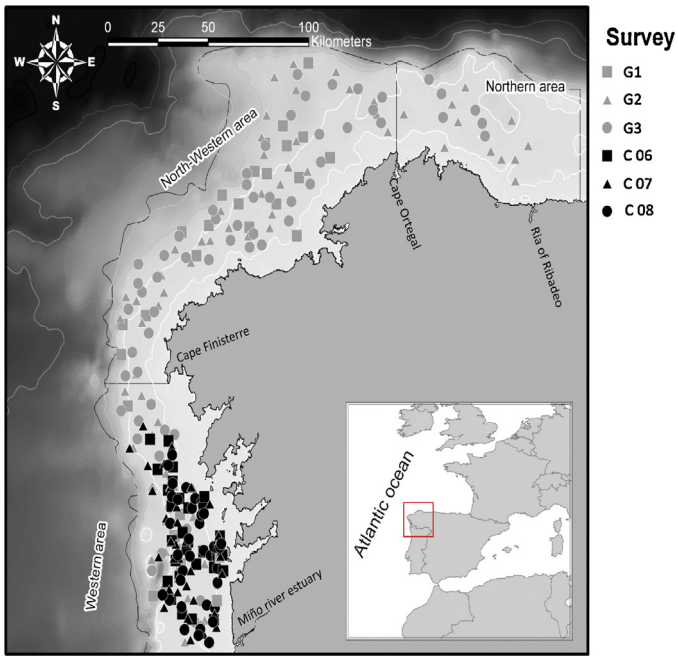

Fig. 2. Data from three series of surveys have been considered to infer spatial–temporal patterns of *Eledone cirrhosa* in North-western Iberian. The map shows hauls distribution by survey through sampling areas. *G* series surveys (1974–1976) are drawn in grey and *C* series surveys (2006–2008) are drawn in black.

2. Materials and methods

2.1. Study area

The study area comprised the northwest coast of the Iberian Peninsula, from the Ría of Ribadeo to the Miño river estuary, on the border between Spain and Portugal. For descriptive purposes, and according to main coast orientation, the studied area was divided in three regions: northern area (N) from Ría of Ribadeo to cape Ortegal, north-western area (NW) from cape Ortegal to cape Finisterre and western area (W) from cape Finisterre to Miño river estuary (Fig. 2).

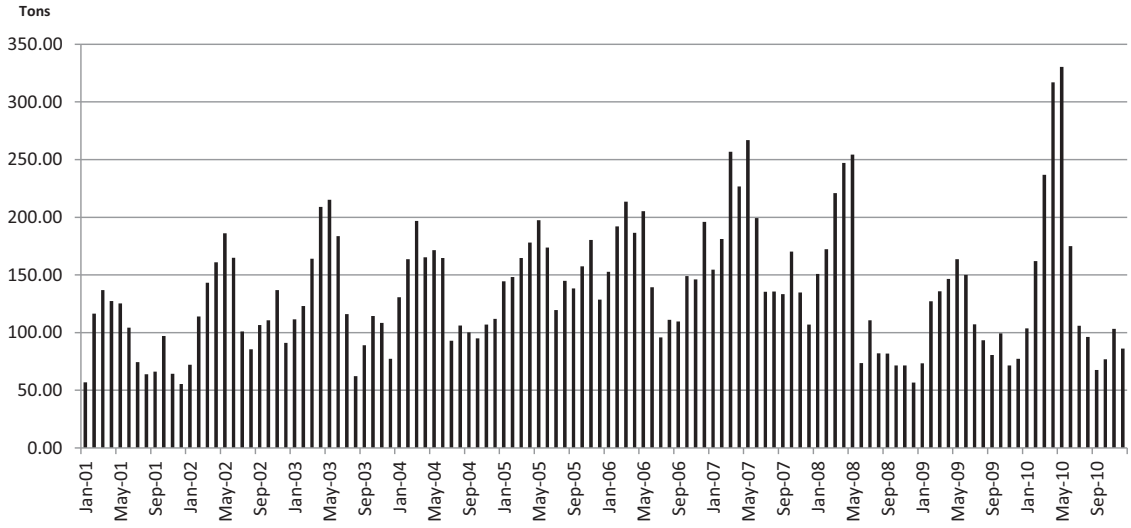

Fig. 1. The graphic shows monthly landings of *Eledone cirrhosa* registered in Galician harbours during the period 2001–2010 (data source: www.pescadegalicia.com). The evolution of annual landings shows an increasing trend of catches year by year and a clear annual cyclical pattern, closely linked to the reproductive cycle of the species.