Nursery and spawning grounds of the squid *Loligo vulgaris* on the Portuguese shelf

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Summary

The recent sharp decrease in common squid (*Loligo vulgaris*) Portuguese landings, demands for advice based on novel and sustainable management measures. The identification of essential fish habitats (EFH) that play an important role in critical life stages of exploited species can be used as a management tool to support stocks conservation and sustainable exploitation. Therefore, data from demersal surveys between 1990 and 2013 were analysed to describe the distribution of juveniles and females in mature condition and two main nurseries grounds and four spawning grounds were identified along the Portuguese shelf. Important differences were observed between the west and south regions. The relationships between several environmental variables and the abundance of juveniles and mature females are explored to characterize *L. vulgaris* EFH.

Introduction

The common squid *Loligo vulgaris* is an important commercial species across its distribution range. In Portuguese waters, it is mainly exploited as a by-catch of the finfish demersal trawl fishery, however the depletion derived by the recreational jig fishery is unknown. Landings of common squid from the ICES sub-area IXa generally present the cephalopod typical between-year variability. However, similarly to finfish, *Loligo* sp. landings have been decreasing severely during the last two decades and without clear evidences of recovery, which demands for advice based on novel and sustainable management measures. An earlier analysis has identified areas of aggregations of *L. vulgaris* juvenile and mature females over the Portuguese shelf based on demersal research surveys (Cunha et al. 1995). Additionally, the location of important spawning areas was inferred based on the paralarvae density (Moreno et al., 2009) and egg mass recoveries. Nevertheless, dense spawning aggregations as is characteristic for some other squid species have never been described for *L. vulgaris*. This species is reported to lay eggs in clusters attached to hard substrates; using not only natural substrates but also fishing devices and various types of marine debris. In July 2009, a research team from IPMA and IEO on board a commercial vessel off the northwest coast of Portugal found out that countless egg masses of *L. vulgaris* were hauled from the sea attached to fishing gear (mainly gill nets, but also traps), only to be immediately detached and destroyed on deck (Figure1, *). Fishermen were not even aware of the organism to which they belonged. It became therefore then evident that the intense deployment of static fishing gear in coastal areas may be a serious threat to squid spawning success. The location and subsequent protection of essential fish habitats (EFH), which play an important role in critical life stages of exploited species, can be used as a management tool to support stock conservation and sustainable exploitation. In the present study we analyse the density of juveniles and mature females in demersal surveys and its relationship with several environmental variables, as proxies of potential nurseries and spawning areas of *L. vulgaris* where studies are needed to implement ways of protection from fishery impacts.

Materials and Methods

Data from demersal surveys carried out between 1990 and 2013 in winter (N=6), summer (N=9), and autumn (N=23) are analysed to identify aggregations of juveniles and females in mature condition. Each survey follow a similar depth stratified sampling design, with ca. 70-80 hauls distributed along the Portuguese continental shelf and slope, latitudes 36.7◦ to 41.8◦N and longitudes 7.47◦ to 10.0◦W in the NE Atlantic. Sea surface temperature (SST), sea bottom temperature (SBT), sea surface salinity (SSS), and sea bottom salinity (SBS) were extracted from CTD temperature profiles undertaken during

the survey cruises at the end of the fishing stations. Bottom sediment type (BS) in each sampling station was classified based on fishery charts. Squid with mantle length (ML) below 75 mm (all immature specimens) were classified as juveniles and their distribution used to identify nursery grounds; and the distribution of mature females (maturity stages 4 and 5) was used to identify spawning grounds. The spatial distribution of juveniles and mature females was mapped and discrete areas abundance seasonal identified. The persistence of each nursery and spawning ground in the seasonal time series was accessed. The relationships between environmental variables and the abundance of juveniles and mature females were tested.

Results and Discussion

Small juveniles may be found along the west Portuguese shelf throughout the year which is consistent with the extended recruitment season of *L. vulgaris* in this region. The main nursery ground was located on the northern part of the northwest shelf, and juveniles were found here in the majority of years and all seasons analysed. Another nursery ground was located on the southern part of the southwest shelf with higher juvenile abundance in summer and autumn. On the Algarve coast a summer/autumn nursery ground was identified in some years, west of Ria Formosa; in the same location where common octopus pre-recruits generally appear in significant numbers. The main nurseries of *L. vulgaris* are characterized by sand, coarse sand or rocky mud bottoms. Sea surface temperature (SST) evidenced a non-linear relationship with juvenile abundance with an optimum value around 17°C in each region. Temperature effects may account for the high inter-annual variation in juvenile abundance on the southern shelf. Four main spawning grounds were identified by the abundance of mature females in survey data: two discrete grounds on the northwest shelf (22-86m depth), one on the southwest (31-116m) and another on the southern shelf (43-83 m). Mature females were concentrated throughout the year on the most northern spawning ground, however only in winter on the southwest and south spawning grounds. The higher abundance of mature females was found over sand and coarse sand bottoms on the west shelf and also over mud with rock outcrops on the south shelf. In general, spawning grounds were located more offshore (40-60m) than nurseries (20-40m). Either spawning or winter nursery grounds were located more inshore (20-40 m) in winter than during summer or autumn. Partial effects of both SST and SBT on abundance of mature females were significant and non-linear. The overlay of occasional egg mass recoveries over the years corresponds well with the spawning grounds identified by the abundance of mature females. There was one big mismatch on the eastern south coast and the reason for this can be the poor survey sampling of the inner shelf in that area, but possible spawning migrations need to be explored. The mortality on egg masses caused by fishing gears needs to be access in the identified spawning areas.

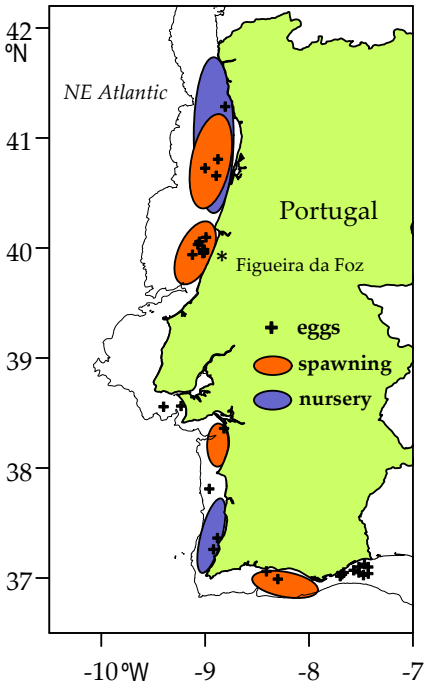

Figure 1 – Main nursery and spawning grounds, and occasional egg mass recoveries.

References

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