IDENTIFICATION OF PREFERENTIAL SPAWNING AREAS FOR THE EUROPEAN SQUID

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Abstract
According cephalopods short life cycle, population dynamics is mainly determined by between-year variability in reproductive success. Therefore, stock management may be improved after protecting the main spawning areas. The microsites where the European squid, *Loligo vulgaris* spawns within a Marine Protected Area have been identified by deploying an array of 30 artificial structures at diffrent depths. We belive that this species selects the spawning area searching for an optimal temperature range that maximizes egg survival. Our results sugest that adults migrate from off- to in-shore at winter, i.e.,when the water temperature near the cost is appropriate. Sandy bottoms seems to be preferred, which may be related with predator avoidance.

Keywords: Cephalopods, Spawning, Marine parks, North-Western Mediterranean

Introduction
The implementation of Marine Protected Areas (MPA) is one of the keys for the protection of marine species and could be used for fisheries management[1]. However, the high mobility of certain species, such as the European squid (*Loligo vulgaris*) [2], with a home range higher than MPA limits the usefulness of MPAs. Although, this species seems to aggregate at specific areas to spawn [2]. The identification of where and when these spawning aggregations occur may be very important for protecting the future recruits and for maximizing spawning success. The aim of this study is to identify the preferential spawning microsites of *L. vulgaris* within an MPA. The European squid is exploited by the trawling fleet, the small-scale fleet and the recreational fishery[3]. The study was carried out in Cabrera National Park (CNP) a small Archipelago south of Mallorca Island (Fig. 1).

Material and Methods
30 Artificial Spawning Attractors (ASA) were deployed over three main benthic habitats (sand, seagrass and rocky bottoms), and covering different depth ranges (Figure 1). The ASA were monthly sampled from june 2012 until june 2013. Number of egg clutches per ASA was modelled using a Generalised Linear Model (GLM). The model was fitted with the glm function of the R package (http://www.r-project.org/). A Poisson distribution of the response variable (monthly number of eggs clutches per ASA) was considered. The explanatory variables considered were; i) benthic habitat, ii) depth, iii) sea temperature, and iv) the interaction between depth and sea temperature.

Results
We found spawning activity all-year-round but with seasonal changes in the preferred depth for spawning. During colder months, spawning tend to be widespread, including shallow waters. Conversely, during the rest of the year, spawning is limited to deeper sites.

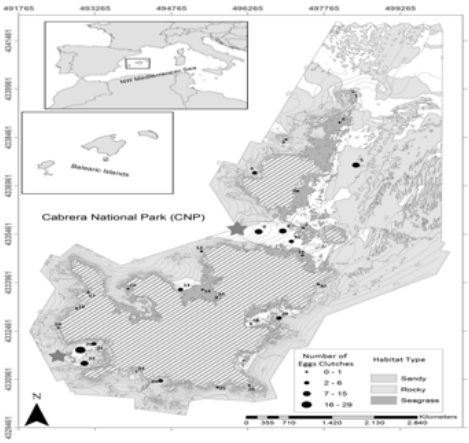

Fig. 1. Sampling area (CNP), distribution of the ASA (black circles). Size of circles indicates the number of the total eggs clutches. Stars indicate principal spawning area.

The GLM showed how the interaction between depth and sea temperature effects on squid spawning ($p<0.05$). In addition, sites with sandy bottoms were preferred as spawning habitat ($p<0.05$). Consequently, two main zones were determined as preferential spawning grounds: Canal and Ses Rates (Fig.1).

Discussion
The spawning at the park extends all-year-round. Our results agree with other studies performed for the same species, both in the Mediterranean and the Atlantic [4,5]. Despite the European squid spawned along all the depth range sampled, results suggests the existence of an optimal depth for spawning in function of the season. They spawned preferentially at shallow waters during cold months and at deeper water at warm months. This spatio-temporal spawning pattern may be linked with the optimal temperature range for maximizing the spawning success[6]. In addition, the spatio-temporal pattern described here is in accordance with the hypothesis of spawning migrations that has been suggested for the same specie and geographic area[7]. Sandy bottoms were preferred for *L. vulgaris* perhaps to avoid predators like *Epinephelus marginatus*[8]. We suggest to implement management measures that take into account the spatio-temporal pattern of spawning would maximize spawning success and would improve stock abundance.

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