INFLUENCE OF FOOD AVAILABILITY AND COASTAL CIRCULATION IN THE SPAWNING STRATEGIES OF FISH SPECIES OF CABRERA NATIONAL PARK (NW MEDITERRANEAN).

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Abstract
Temporal variation of fish larvae during the winter-summer transition in Cabrera National Park (SE Mallorca) reveal two spawning strategies of coastal species; (1) a few species spawn early in the year coupled with the zooplankton biomass peak (e.g. *Diplodus sargus, Boops boops*), and (2) a larger proportion of species spawn in early summer when hydrographic conditions are milder but food availability is lower (e.g. *Coris julis, Serranus hepatus*). Specific abundances in spring were fairly higher than in summer (~7 fold). We interpret these strategies on the basis of food availability and change in coastal circulation.
Keywords: Ichthyoplankton, Circulation, Fishes

Introduction
Discerning the environmental factors that are relevant in each coastal area for the survival of early life stages and, particularly, the identification of critical zones and periods for the resource development is essential for the management of marine protected areas (MPAs). Among the physical and biological signals affecting ichthyoplankton assemblages, seasonality is one of the most notable forcings. Yet, there is no unique adaptative response of fish larvae to seasonal changes. Conversely, in order to optimize the reproductive success, larval timing may strongly differ among species. A combination of favorable hydrodynamic conditions, food availability and quality, and predation avoidance, among other factors, may determine the spawning period, particularly in temperate seas such as the Mediterranean Sea with a marked seasonal cycle in temperature.

Archipielago de Cabrera National Park is a marine protected area situated to the south of Mallorca (Balearic Islands). As in other oligotrophic areas, food availability is low and increases in zooplankton biomass generally restrict to a late winter bloom. A major aspect of the circulation around the Mallorcan shelf is the presence of island trapped waves (ITWs) generated by local wind forcing [1]. Transport is thus conditioned by prevailing meteorological conditions. Retention mechanisms near the adult habitat together with food availability are postulated as major constrains to fish larvae survival. This study seeks to identify the consequences of spawning timing of coastal fish species in the waters of Cabrera National Park in the context of these two factors.

Materials and methods
Sampling consisted on fortnightly measurements at three stations located between Mallorca and Cabrera that were visited between February and August 2007. These measurements where complemented with current records from a bottom mounted ADCP. Zooplankton samples were collected with vertical tows of a WP2 net and fish larvae were sampled by oblique hauls of a bongo net (0.6 m mouth opening). Wind maps were constructed by optimal interpolation from wind data recorded by two coastal stations and Quikscat satellite data for the period (2000-2009). Synoptic wind patterns were identified using the Self-Organizing Map (SOM) algorithm. To compute a range of likely larval transport outcomes, an individual based model (IBM) for larval dispersal was developed using velocity fields of a high-resolution (~200 m) ocean circulation model (POM). Simulations were run for 30 days forced by the computed wind patterns to simulate the generation and propagation of ITWs.

Results and discussion
Fish larvae belonging to a total of 57 taxa were identified. Larval mean abundances fluctuated between 25 and 162 ind m^2 which is in the range of average values in Mallorca [2]. Attending adult habitat, fish larvae were grouped into two groups: i) larvae of shorefish and shelf dwelling species and ii) larvae of mesopelagic species, dwelling in the open sea. The species included in the latest group, the majority of them belonging to Myctophidae family, were more abundant in summer, but their presencewas episodic and presumably associated to oceanic water intrusion in the continental shelf. Concerning the species included in the first group, a clear temporal variability in the ichthyoplankton composition was observed between spring and summer, with an increase in the number of taxa in summer. Some species, such as *Diplodus sargus* and *Boops boops* were particularly abundant in spring and showed the highest abundances in April, following the seasonal peak of zooplankton. Other species, such as *Serranus hepatus* or *Coris julis*, peaked in summer though, in general, their abundances were lower than that of the spring species. The onset of the spawning period for these species occurred in early June when water temperatures raised above 20ºC.

Wind patterns from SOM classification reveal a seasonal wind regime characterized by two typical wind modes. Eastern winds are prevalent on summer (Jun.-Aug.) whereas alternation between easterly and westerly episodes occurs in spring (Mar.-May). These changes in wind forcing have consequences in mean coastal transport that reveal a shift in current direction at the beginning of early summer. Numerical simulations of wind forced ITWs capture well the main features of measured current variability suggesting that coastal circulation responds energetically to this local forcing and that shelf currents are relatively uncoupled from oceanic flows. This is also evidenced by the scarce and episodic presence of oceanic fish larvae. Larval trajectories computed with the IBM model reveal the differences in the dispersion patterns attending to wind forcing. ITWs generated by the westerly winds tend to disperse larval particles toward the outer shelf, whereas the eastward winds (prevailing in summer) retain larval particles in the north-western coast of Cabrera. This suggests that while increased food availability may be advantageous for the development of spring species, larvae would be more susceptible to be advected far from the adult habitat. However, loss by dispersion could be partially compensated by a higher abundance of larvae in the plankton during that period. On the other hand, summer spawning would guarantee larval fish retention in the coastal environment. This last strategy would be advantageous for the maintenance of fish populations in the area, what is especially relevant in the context of the MPAs.

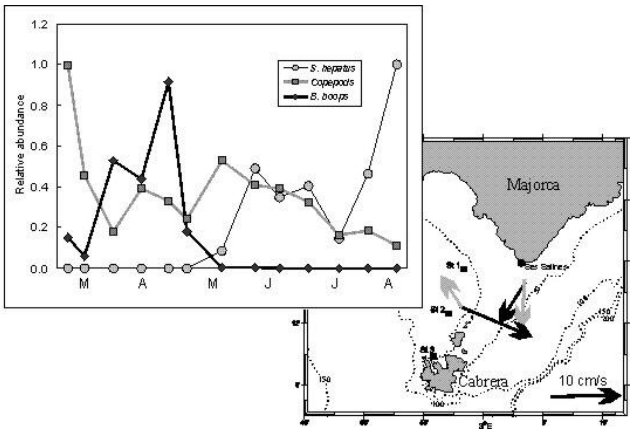

Fig. 1. Map showing the three sampled stations and mean summer (gray) and spring currents (black) currents. Inset: relative abundances of copepods and a spring (*B. boops*) and summer (*S. hepatus*) species

References
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