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Ecological understanding for fishery management: Condition and growth of anchovy late larvae during different seasons in the Northwestern Mediterranean

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ABSTRACT

The fishery of the European anchovy *Engraulis encrasicolus* in the Mediterranean needs several ecological approaches to be properly managed. As such, several surveys were carried out to study the ecology of larvae and juveniles of this species, which reproduces during the warmest period of the year (May through September) in the Gulf of Lions. In particular, we studied the late larvae (15 mm total length until metamorphosis), especially as other authors have focused on larvae below that size. Unexpectedly, we also collected anchovy late larvae during the December 2007 survey, whose range in size corresponded to a later spawning period than previously reported. Differences in the nutritional condition of these larvae were assessed by comparing indices of lipid composition and estimating growth rates from otolith measurements to provide information on the probability of survival between the two groups. The analysis of fatty acids, used as tracers of trophic relationships, indicates that these larvae fed mainly on zooplankton. Nutritional conditions of summer and late autumn larvae were very similar. In contrast, growth rates were higher for August larvae, probably due to the different temperatures in the two seasons. Our results are especially relevant in an ecological context where the increasing mean water temperatures in the Western Mediterranean could favor the extension of the anchovy spawning period up to late-Autumn months.

1. Introduction

The European anchovy *Engraulis encrasicolus* is a highly valued fishery resource in the Western Mediterranean Sea (García and Palomera, 1996; Pertierra and Lleonart, 1996; Barange et al., 2009). Several studies have been carried out regarding diverse aspects of the biology and the ecology of the species in this area to improve the available tools for its fishery management (Palomera et al., 2007). The Northwestern Mediterranean is one of the most productive areas in this sea due to the cyclonic current that flows southwards over the slope of the Gulf of Lions, carrying a significant nutrient load from the Rhône River (Salat, 1996). The Gulf of Lions also displays notable environmental differences between seasons, which directly influence low trophic level species (Calbet et al., 2001). The anchovy population could then be easily compromised by any sort of alteration that additionally impinges on these organisms, especially during the early development stages (i.e. eggs, larvae and juveniles) when they are particularly sensitive to any change (Palomera et al., 2007). The anchovy spawning period in the Gulf of Lions extends from April to late September, with a peak in late June (Palomera, 1992). Therefore late larvae are expected to be found mainly during the summer, while juveniles should emerge in the autumn and winter.

During the SARDONE project, devoted to improve the management strategies of the European anchovy, two cruises were undertaken in August and December of 2007 in the Gulf of Lions in order to collect anchovy late larvae and juveniles, respectively. Unexpectedly, and in spite of the allegedly unfavorable conditions, a notable amount of anchovy late larvae were caught in December (a mean of 26.75 larvae/tow, against 34.20 larvae/tow in summer), well after the reported end of the spawning period.

An understanding of the growth and feeding ecology of the species is important given that this knowledge is essential to understand how the population temporally and spatially develops in the environment. The relationship between this population and the plankton community is not straightforward but some approaches have been attempted (Isari et al., 2008; Morais et al., 2010), especially those concerning how the zooplankton affects the population strength. Indeed, the growth rates and the nutritional condition of a population of several species, including European anchovy, have been key subjects for the study of the recruitment strength (Butler, 1991; Ward et al., 2006; Palomera et al., 2007; Hidalgo et al., 2008; Islam and Tanaka, 2009; La Mesa et al., 2009).

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In the present case we analyze for the first time in the Mediterranean the nutritional condition of anchovy late larvae (19–35 mm) in the field during both summer and late-Autumn seasons via lipid composition studies, and we also study their diet through the fatty acids found both in larvae and in zooplankton, which is the basic prey of anchovy at all the development stages (Plounevez and Champalbert, 1999; Pasquaud et al., 2008; Bacha and Amara, 2009; Borme et al., 2009; Catalán et al., 2010; Morote et al., 2010). Growth rates were also studied for both larvae populations to determine whether the different environmental conditions affect the early stage development of the anchovy. This work will thus help to determine to what extent the general conditions of an unexpected December late larvae population differs from the August late larvae and whether these two populations have similar viability.

2. Materials and methods

2.1. Sample collection

Samples were collected during two cruises carried out in the Gulf of Lions (Northwestern Mediterranean sea; Fig. 1) in 2007 on board the *R/V L'Europe* (IFREMER, France). The first cruise (PELMED07) was conducted in the summer from the 28th of July to the 9th of August 2007 and the second cruise (JUVALION07) was carried out in late autumn, from the 8th to the 21st of December 2007. Temperature and salinity of the water column from sea surface to 50 m depth were measured via a Seabird 19 CTD at each station. Also data of sea surface temperature in September to December since 1982 to early 2011 of Gulf of Lions area from NOAA were acquired to study possible trends.

Zooplankton samples for an analysis of biomass and plankton composition were collected using a standard WP2 net with a mesh size of 200 μm and sieved through a 3000 μm plankton mesh to obtain the 200–3000 μm mesozooplankton fraction, and by means of a scaled-down version WP2 net, with a mesh size of 53 μm and a mouth diameter of 25 cm, and sieved through a 200 μm plankton mesh to obtain the 53–200 μm fraction of microplankton. All zooplankton samples were split with a Motoda plankton splitter (Motoda, 1959) and one-half was preserved in formalin to carry out subsequent qualitative analysis, while the other half was frozen on board for biomass measurements and lipid analysis. As the need to comparatively assess the nutritional condition of the two different temporal larvae populations only arose during the December cruise, plankton samples for lipids analysis were not collected during the first cruise.

Late larvae of anchovy were caught with a pelagic trawling net, towed at an average speed of 3.6 knots over a 30–40 min time span. This trawling time might seem too long to obtain larvae in proper conditions for biochemical analysis; however, the alteration of lipid composition in muscular tissue of fish larvae is small within a time up to 3 h after death (Lochmann et al., 1996).

Samples were immediately frozen in liquid nitrogen after sorting on board and transferred into a −80 °C freezer just after the arrival in the laboratory.

2.2. Lipid and fatty acid analysis

Wet weight and standard length of each larva were measured in the laboratory to the nearest 10 μg and 0.1 mm, respectively, before removing the head for otoliths analysis and the gut, as

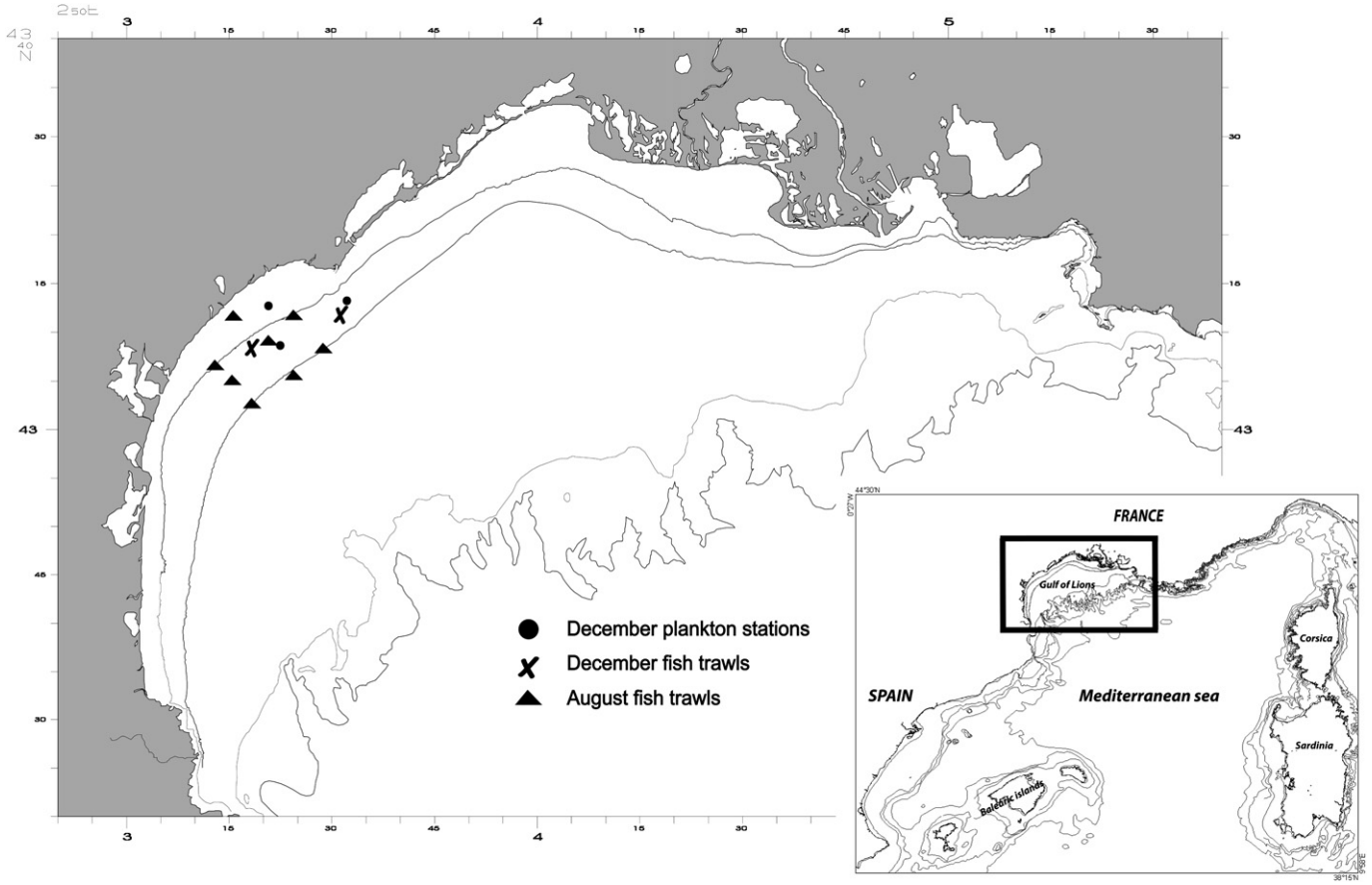

Fig. 1. Map of the study area, with the positions of plankton stations and trawls in August and December 2007.