



Red algal beds increase the condition of nekto-benthic fish



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ABSTRACT

The present study analysed the effect of three different benthic habitats, the maërl, *Peyssonnelia* red algal beds and sandy bottoms, on the condition of two nekto-benthic fish species: *Serranus cabrilla* and *Trigloporus lastoviza*. Sampling was conducted during the MEDITS 2010 and 2011 surveys around the Balearic Islands. The condition of the spawning females of both species was determined by using i) biochemical measurements of proteins and lipids in the muscle, liver and gonads, and ii) weight at length relationships based on eviscerated, liver, and gonad weights. Moreover, based on the total weight at length relationship, the mean somatic condition (SC) of the sexually inactive individuals of *S. cabrilla* and males of *T. lastoviza* was calculated. Lipid reserves were higher in the livers of *S. cabrilla* and *T. lastoviza* from the maërl beds. Additionally, *S. cabrilla* showed higher lipid reserves in the gonads both in the maërl and *Peyssonnelia* beds. The mean weights of the liver and gonads at a given individual length revealed the same pattern as the lipids, whereas the mean eviscerated weight was higher in the maërl beds but only for *S. cabrilla*. A positive correlation was detected between the SC and the biomass of the algal species characterizing the maërl beds for both *S. cabrilla* and *T. lastoviza*.

The high habitat quality of the red algal beds off the Balearic Islands increased the condition of nekto-benthic fish. In oligotrophic areas, such as the archipelago, these “oases” could help fish to maintain healthy populations.

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1. Introduction

Ecosystem-based fishery management (EBFM) essentially reverses the order of management priorities in the traditional approach which focused on the target species and, instead, starts with the ecosystem (Pikitch et al., 2004). One crucial goal that should be achieved for the application of the EBFM is the identification of high quality habitats that are critical for vital population processes, the so-called essential fish habitats (Benaka, 1999). However, habitat quality cannot be measured directly and can only be studied on a comparative basis (Gilliers et al., 2004). Most efforts made to detect high quality habitats have compared the abundance and biomass of target species among different habitats, mainly focusing on recruits, juveniles and spawners (Benaka, 1999), whereas fewer studies have focused on individual biological traits.

‘Fish condition’ is a widely used term for referring to the overall physiological status or health of an individual (McPherson et al., 2011). Among the most important effects of poor fish condition are increased natural mortality, suppression of reproduction, late maturity and low fecundity, as well as low larval and juvenile survival (Lambert and Dutil, 2000; Marshall et al., 1999; Morgan, 2004; Rideout and Rose, 2006; Skjæraasen et al., 2012). Moreover, a decrease in the productivity of fish stocks, as well as a higher vulnerability to human perturbations, has also been revealed (Dutil and Lambert, 2000).

Among the various methods used to determine fish condition, biochemical analyses are considered the most accurate ones because they

supply direct information on key indicators, such as the lipid and protein reserves (Shulman and Love, 1999). However, this methodology is time-consuming, expensive, and therefore, not suitable for large numbers of individuals (Crossin and Hinch, 2005). Bioenergetic and morphometric condition indexes are based on the relative weights of the liver and gonads compared to the individual size and individual weight at length relationships, respectively, and are increasingly considered as surrogate measurements of the reserves (McPherson et al., 2011). These measurements have the advantages of being easy to collect and ready to use almost immediately. However, and more specifically, in the case of condition weight at length measurements, they must be supported by more accurate techniques, such as biochemical analyses, in order to validate that the condition is effectively measured (Davidson and Marshall, 2010; McPherson et al., 2011).

In the Mediterranean Sea circa-littoral soft bottoms, two widespread benthic facies meet certain characteristic requirements that qualify them as candidates for high quality habitats, the maërl and *Peyssonnelia* beds, which are characterized by the predominance of the red algal species of the Corallinaceae and *Peyssonneliaceae* families, respectively (Pérès, 1985). The maërl beds are considered sensitive habitats, due to the high biodiversity they support, the low resilience of the rhodolith-forming Corallinaceae species (Donnan and Moore, 2003) and the role they play as ‘ecological engineers’ (Jones et al., 2000; Steller et al., 2003) by increasing the structural complexity of the soft bottoms and providing microhabitats for other species (Barberá et al., 2012; Foster,

2001; Kamenos et al., 2004). On the other hand, the *Peyssonnelia* beds support the high benthic biomass, biodiversity, production and structural complexity provided by the *Peyssonnelia* spp. and other associated red algal species with important erect development, such as *Phyllophora crispera* and *Osmundaria volubilis* (Ballesteros, 1994; Joher et al., 2012). Both facies are widely distributed on the soft bottoms of the continental shelf off the Balearic Islands, in the western Mediterranean (Ballesteros, 1994; Ordines and Massutí, 2009). However, their different environmental requirements separate them geographically. Maërl beds are usually found in areas of moderate to strong currents that frequently overturn the rhodoliths, preventing them from being buried and thus maintaining living algal surfaces all around (Basso, 1998; Wilson et al., 2004). On the other hand, the *Peyssonnelia* beds have been connected with open bays characterized by fine sediments, even mud, where calm periods alternate with periods of eddy forming currents (Bordehore et al., 2003; Ordines et al., 2011; Pérès, 1985). A third habitat, non-vegetated sandy bottoms, is commonly found around the Balearic Islands and exhibits the lowest benthic biomass and structural complexity (Ordines and Massutí, 2009).

Two ubiquitous and frequent nekto-benthic fish species of the continental shelf off the Balearic Islands are commonly distributed in all these three habitats: the comber (*Serranus cabrilla* Linnaeus) and the streaked gurnard (*Trigloporus lastoviza* Bonaterre). *S. cabrilla* is a serranid distributed in the Mediterranean Sea and eastern Atlantic, occupying most types of habitats such as rocks, *Posidonia oceanica* seagrass meadows and sandy and muddy bottoms, from the shoreline down to a depth of 200 m (Fischer et al., 1987). *S. cabrilla* shows an accentuated territorial behaviour and site fidelity (Schunter et al., 2011), feeding mainly on nekto-benthic crustaceans and fish (Fasola et al., 1997; Kalogirou et al., 2012). *T. lastoviza* is a triglid found in the Mediterranean and eastern Atlantic from the shoreline down to approximately 160 m. It lives on sandy and muddy bottoms, algal beds, and *Posidonia* meadows (Kalogirou et al., 2010; Labropoulou and Machias, 1998). This benthophagous species is intimately related to the bottom and uses the first three free rays of its pectoral fins as tactile organs and for locomotory assistance when moving over the sea bed in search of food, which is mainly comprised of decapod crustaceans and mysids (e.g. Boudaya et al., 2007; Labropoulou and Machias, 1998; Renus et al., 2000; Terrats et al., 2000).

In the current study, it was hypothesized that the maërl and *Peyssonnelia* beds may represent high quality habitats for the nekto-benthic fish species. To investigate this hypothesis, the present work compared the biochemical and weight at length measurements of the condition of *S. cabrilla* and *T. lastoviza* between maërl, *Peyssonnelia* beds, and sandy bottoms.

2. Material and methods

2.1. Sampling

A total of 40 bottom trawl hauls were undertaken between depths of 50 and 150 m during the 2010 and 2011 MEDITS surveys (both during the second and third weeks of June) off the Balearic Islands (Fig. 1). The sampling scheme and methodology applied during these surveys are described in detail in Bertrand et al. (2002). The hauls had a duration of 20–30 min with a towing speed of 2.8 knots. The set and haul of the net from the bottom, as well as its horizontal and vertical opening (on average, 16.4 and 2.8 m, respectively) were measured using the SCANMAR system.

Samples were sorted by species, weighed and counted. The abundance and biomass of *S. cabrilla* and *T. lastoviza* were determined and standardized to one square km, by using the distance covered and the horizontal opening of the net in each haul. Furthermore, total length (TL, to the nearest mm), total weight (TW, to the nearest 0.01 g), sex, and maturity stage (i.e. immature, developing, spawning, regressing and resting), estimated by visual macroscopic observation according to the scale described in Brown-Peterson et al. (2011) were recorded for a representative number of individuals of the two species in each haul.

Based on previous information of the location of extensive areas of the three habitats to be compared in the present study, maërl (Barberá et al., 2012), *Peyssonnelia* beds (Ballesteros, 1994), and sandy bottoms (Ordines and Massutí, 2009), two representative sampling stations per habitat were a priori selected within these areas (Fig. 1). At these stations, the biological sampling of both species included recording the eviscerated, liver and gonad weights (EW, LW and GW, respectively), measured to the nearest 0.01 g, and the collection of muscle, liver and gonad tissue samples that were stored frozen at $-20\text{ }^{\circ}\text{C}$.

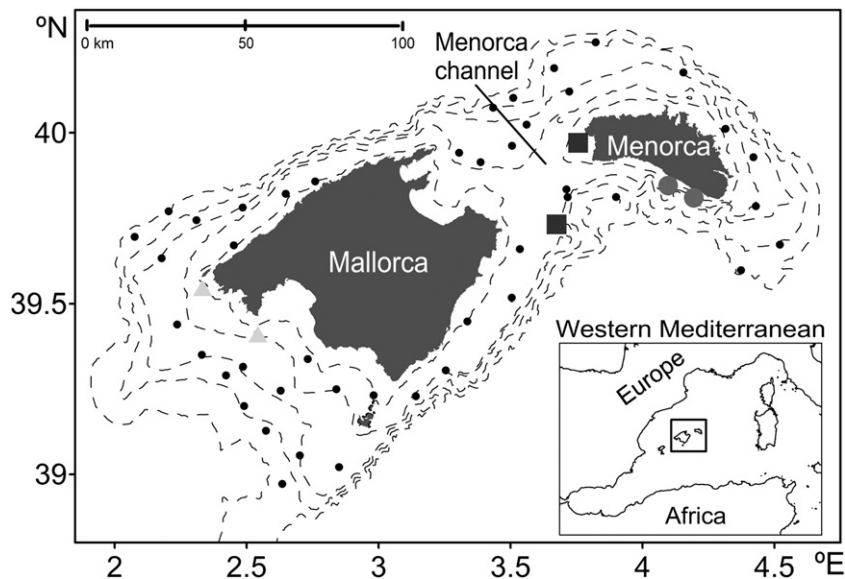


Fig. 1. Map of the study area, Mallorca and Menorca (Balearic Islands, western Mediterranean), showing the initial geographical position of the stations covered during the MEDITS survey in 2010 (fully dotted). Stations selected a priori for each habitat are highlighted as follows: maërl (dark grey squares); *Peyssonnelia* beds (grey larger circles); and sandy bottoms (light grey triangles).

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