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Biodiversity of suprabenthic peracarid assemblages from the Blanes Canyon region (NW Mediterranean Sea) in relation to natural disturbance and trawling pressure

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ABSTRACT

Blanes Canyon and its adjacent margin are important fishery areas (mainly by bottom trawling) located in a highly energetic oceanographic setting in the NW Mediterranean Sea. Here we assess the spatial and temporal variability in abundance, diversity and community structure of the suprabenthic peracarid assemblages in this region and examine this variability in relation to the natural and anthropogenic (trawling fisheries) disturbance regimes. The sampling was conducted between March 2003 and May 2004 in three main fishing grounds, the canyon head (average depth: 490 m), the canyon wall (average depth: 550 m) and the eastern adjacent slope (average depth: 820 m), as well as in two non-exploited areas in the western (at 900 m depth) and eastern (at 1500 m depth) slope near the canyon mouth. A total of 138 species were identified, with amphipods being the most speciose and abundant group, followed by mysids in terms of abundance. Our results show high spatial and temporal variability in suprabenthic assemblages. Densities were higher in the canyon head and western slope, which appear to be the preferential routes for water masses and particle fluxes in months of flood events, and other energetic processes. In the canyon head, where periodic erosion processes are more active, low diversity, high dominance and higher turnover (β-diversity) were observed, apparently coupled with significant temporal fluctuations in the densities of the highly motile component of suprabenthos (mysids, predatory and scavenging amphipods). In the sedimentary more stable eastern slope, high diversity values were observed, accompanied by a higher relative contribution of the less motile groups (i.e. amphipods, most isopods, cumaceans). These groups have a closer interaction with the sediment where they exploit different food sources and are more susceptible to physical disturbance. Temporal variability in their diversity may be related to changes in food quality rather than quantity. In the canyon wall, temporal fluctuations in diversity indices were only revealed in relation to the overall higher and more continued fishing pressure observed in the canyon wall fishing ground (Cara Norte/Sot site). Here, species richness and abundance declined with increasing fishing pressure but the lowest trophic and taxonomic diversities were observed under intermediate levels of disturbance. These findings underline (i) the differences between relatively low and highly motile taxa in terms of response to disturbance events; (ii) the differences between assemblages subjected to different levels of natural disturbance and trawling pressure, which modify the common bathymetric patterns of abundance and diversity often described from continental margins.

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1. Introduction

Submarine canyons are steep-walled valleys that incise continental margins, where they create unusual high variation in abundance and diversity of biological communities by increasing

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heterogeneity as well as affecting disturbance and productivity regimes (Cunha et al., 2011; Harris and Whiteway, 2011; Levin et al., 2001). Submarine canyons are the primary conduits of particulate material to the deep basin. Their topography affects local oceanography at different temporal scales (e.g. diverse current regimes, turbidity flows, cascading, re-suspension of particle flow) (Canals et al., 2006, 2013; López-Fernandez et al., 2013; Sànchez-Vidal et al., 2008; Zúñiga et al., 2009), favours the occurrence of localized areas of organic enrichment (López-Fernandez et al., 2013; Vetter and Dayton, 1999) and provides varied physical habitats (e.g. steep slopes, sedimentary terraces, rock outcrops and diverse substrate types) (Hargrave et al., 2004; Schlacher et al., 2007), thus creating different levels of heterogeneity and disturbance (Harris, 2014). Canyons are also subjected to anthropogenic influences, such as litter accumulation (Ramírez-Llodrà et al., 2013), chemical pollution (Sànchez-Vidal et al., 2015) and fisheries (Company et al., 2012; Pusceddu et al., 2014), which cause additional disturbance and play an important role in the dynamics of the canyon systems.

The complexity of canyon systems may benefit the benthic fauna in several ways, allowing the occurrence of a high functional diversity from sessile to highly motile species, suspension feeders, detritivores and deposit feeders, planktivores and scavengers (Macquart-Moulin and Patriti, 1996, Shepard et al., 1974; Vetter and Dayton, 1999, Vetter et al., 2010). Because they concentrate sediments rich in phytodetritus and other sources of organic matter, canyons show frequently enhanced abundances and/or biomasses of benthic and pelagic fauna (e.g. Albaina and Irigoien, 2007; Cunha et al., 2011; McClain and Barry, 2010), but opposite trends may also be found in relation to frequent disturbance events (García et al., 2007; Romano et al., 2013). Diversity patterns in canyons are by no means universal (Cunha et al. 2011; Ingels et al., 2013; Schlacher et al., 2007). Some canyons show high mega-epibenthic diversity (Ramírez-Llodrà et al., 2009; Vetter et al., 2010), but macro- and meiofauna often show high dominance of a few species and therefore diversity indices are frequently reduced in relation to the adjacent open slope at equivalent depths (Bianchelli et al., 2010; Gage et al., 1995). Canyon size, depth, complexity of configuration, local oceanography and anthropogenic impact, among other factors, influence these patterns (e.g. Cunha et al. 2011; Ramírez-Llodrà et al., 2009; Schlacher et al., 2007) and therefore, canyon systems contribute significantly to regional diversity (Cunha et al., 2011) and fisheries productivity (Company et al., 2008).

Canyon topography generally provides nursery and spawning areas for megafaunal species including those of commercial value (Sardà and Cartes, 1997; Sardà et al., 2009, 1994; Stefanescu et al., 1994). By their proximity to the mainland, shelf-incising canyons are especially targeted for fisheries and their benthic assemblages are often exposed to bottom trawling (Harris and Whiteway, 2011). Recent evidence of trawling impacts on slopes and submarine canyons includes changes in sediment properties (e.g. reduction in organic carbon, erosion and mixing sediments), seafloor morphology (smother topography), increased water turbidity (Martín et al., 2014; Puig et al., 2012) as well as changes in the structure of benthic assemblages (e.g. by removal of large predators and sessile epifauna) (Miller et al., 2012, Pusceddu et al., 2014; Ramírez-Llodrà et al., 2009). These impacts can affect larger areas than the ones directly affected (e.g. by extended sediment plumes) (Martín et al., 2014; Puig et al., 2012). Some alterations in the biodiversity and community structure of benthic assemblages are the elimination of rare and/or sensitive species, the increased dominance of scavengers and a few tolerant/opportunistic species, as well as the reduction of the mean body size of dominant species (Gage et al., 2005).

The knowledge on the dynamics of biological assemblages subjected to disturbance is fundamental to understand the relationships between the structure and functioning of the ecosystems and the natural and anthropogenic environmental factors that affect them. Here, we address suprabenthic assemblages, a key compartment of deep-sea food webs composed by small-sized fauna (mainly peracarid crustaceans), with varied feeding modes and life styles (Fanelli et al., 2009; Madurell et al., 2008), that establish a strong relationship with the seafloor but are also characterized by their diel vertical migrations (Brunel et al., 1978). Together with other fauna in the deep scattering layer, suprabenthos has an important role in recycling organic matter towards the pelagic ecosystem (Dilling and Alldredge, 2000; Trueman et al., 2014).

Suprabenthic assemblages are a major food resource for benthic and bentho-pelagic fish, epibenthic crustaceans and cephalopods, many of which with commercial value (Carrassón and Cartes, 2002, Fanelli et al., 2009). In this region, suprabenthos is part of the diet of the deep-sea rose shrimp *Aristeus antennatus* (Risso, 1816), which has been regularly targeted by crustacean trawlers for the past seven decades at depths from 300 to 900 m (Gorelli et al., 2014; Sardà and Cartes, 1997; Sardà et al., 2009). Under the scope of the RECS II project (Integral Study of a Submarine Canyon in the Western Mediterranean Sea (Blanes Canyon): Application to the exploitation of the deep-water rose shrimp)), a multidisciplinary study was undertaken to characterise the hydrodynamic conditions and benthic assemblages in the Blanes Canyon region and their relationships to the rose shrimp fisheries (Ramírez-Llodrà et al., 2009, Romano et al., 2013; Sardà et al., 2009; Zúñiga et al., 2009). Here we aim at (1) describing the spatial and temporal variability of the suprabenthic assemblages in the Blanes Canyon region (2) examining this variability in relation to natural and anthropogenic disturbance regimes (e.g. current flow, particle fluxes and shrimp trawling fisheries).

2. Methodology

2.1. Study area

Blanes Canyon is the largest canyon in the Catalan margin, NW Mediterranean (Fig. 1). Here, the circulation is dominated by the North Current (NC) which is mainly forced by the Atlantic Water (AW) incoming through the Gibraltar Strait and extending from the surface down to 100–200 m depth. The more saline Levantine Intermediate Water (LIW), originating in the eastern Mediterranean basin, extends down to approximately 600 m depth and the Western Mediterranean Deep Water (WMDW), which forms during the winter in the Gulf of Lion, extends down to the seafloor (Millot, 1999). Wind-induced cooling and evaporation of surface waters during winter in the NW Mediterranean leads to a massive open ocean dense water formation. Coastal surface waters also become denser and these cold and turbid water masses cascade downslope, mainly through submarine canyons. Exceptionally intense cascading events, reaching current speeds $>85\ cm\ s^{-1}$ inside submarine canyons and with high potential dragging capacity, occur at a decadal timescale under very dry, windy and cold winters (Canals et al., 2006).

The Blanes Canyon head incises the continental shelf at 60 m depth, less than 4 km offshore, in a NW-SE direction (Lastras et al., 2011). The width increases with depth and reaches a maximum of 20 km wide when the canyon meets the Valencia Channel at 2400 m deep. The upper course of the canyon is characterised by a V-shaped cross-section, indicative of intense erosion processes, and is flanked by several gullies; the lower course has a U-shaped cross-section, indicative of high sediment deposition (Lastras et al., 2011).

The regime of particle fluxes in Blanes Canyon is subjected to a very high spatial and temporal variability determined by its physiography, as well as by the proximity to the Tordera River mouth

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