



# The community of deep-sea decapod crustaceans between 175 and 2600 m in submarine canyons of a volcanic oceanic island (central-eastern Atlantic)



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## ABSTRACT

The community structure and faunal composition of deep-sea decapod crustaceans in submarine canyons on the slope off Gran Canaria Island (Canary Islands, central-eastern Atlantic) were investigated. Samples were collected during five research cruises (115 stations) at depths between 175 and 2554 m. A total of 26387 decapod specimens, belonging to 24 families and 38 species, were collected with traps. A cluster analysis of the stations showed four distinct assemblages: (i) in the transition area between shelf and slope (175–302 m); (ii) on the upper slope (361–789 m); (iii) on the middle slope (803–1973 m); and (iv) on the lower slope (2011–2554 m). The deep-sea decapod fauna of the Canary Islands is dominated by shrimp of the family Pandalidae, which make up more than 23% of the species. Within the Pandalidae, species of the genus *Plesionika* stand out as those of greatest abundance on the island slope. The greatest diversity of species was located on the upper slope. The standardized mean abundance and mean biomass for the transition zone between the shelf and slope and for the upper slope were nearly 5 times greater in abundance and 4 times greater in biomass than those estimated for the middle slope, and nearly 53 and 29 times greater for the lower slope, indicating a lower abundance and biomass at the shallower part of the insular slope. The mean weight per individual showed an increasing pattern with depth and an inverse pattern with the bottom temperature and salinity. The existence of depth boundaries around the Canary Islands is known to be closely linked to oceanographic conditions, determined by the water masses present in this archipelago explaining the discontinuities observed at depths of 800 and 2000 m. The boundary observed inside the bathymetric region of the Eastern North Atlantic Central Water can be related with the transition zone between the shelf and the slope of the island.

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## 1. Introduction

The communities of deep-sea decapod crustaceans on the slope of the eastern-central Atlantic region have rarely been studied by themselves or as part of other broader communities (Rosa et al., 2012), unlike such communities in other zones of the East Atlantic (Cosson et al., 1997; Fariña et al., 1997; Olabarria, 2005; Cartes et al., 2007, 2014; Frutos and Sorbe, 2014; Gunton et al., 2015) and the Mediterranean Sea (Cartes and Sardà, 1993; Cartes et al., 2003; Politou et al., 2004; Fanelli et al., 2007, 2013; Mamouridis et al.,

2011; Papiol et al., 2012).

Studies on the bathymetric distribution of faunal communities along slopes have revealed the existence of depth boundaries based on changes in fauna. Those changes seem to be a regular phenomenon in different bathyal ecosystems (Haedrich et al., 1975, 1980; Abelló et al., 1988; Cartes and Sardà, 1993; Fanelli et al., 2007; Frutos and Sorbe, 2014), with a few exceptions (Snelgrove and Haedrich, 1985). It should be noted that depth boundaries, which separate different communities, are the result of biotic or abiotic conditions (Cartes and Sardà, 1993; Maynou and Cartes, 2000; Olabarria, 2005; Cartes et al., 2007, 2008, 2009a, 2011a; Follesa et al., 2009; Fanelli et al., 2013). The faunal discontinuity separating an upper shelf-slope zone of transition is a consequence of the presence of the shelf species extending their distribution down the slope to a deeper bathyal zone (Olabarria, 2005). The deeper discontinuity, located at approximately 2000 m,

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corresponds with the upper limit of the distribution of abyssal species (Maynou and Cartes, 2000), and the presence of other boundaries between communities in the middle slope can frequently be due to hydrographic or trophic conditions (Abelló et al., 1988; Cartes and Sardà, 1993; Olabarria, 2005; Frutos and Sorbe, 2014; Cartes et al., 2015).

In deep-sea communities, many ecological aspects of decapods have been studied, and they depend on both biotic and abiotic factors (Moranta et al., 2004; Olabarria, 2005; Fanelli et al., 2007; Cartes et al., 2009a,b, 2011a). In this respect, the hydrodynamic conditions of the Canary Islands are relevant and variable in depth and may have a remarkable influence over the distribution and abundance of organisms. The Canary Islands are located in the Canary Current System, which is one of the 49 Large Marine Ecosystems of the world, characterized by their singular bathymetry, hydrography and productivity and their ability to support marine populations, which have adapted their feeding, reproductive and growth strategies (Hernández-León et al., 2007). The Canary Islands distinguish the Canary Current System from similar areas because the Canary archipelago extends more than 600 km in a direction perpendicular to the general flow of the current. Therefore, the physical setting observed in the Canary region is quite different to that recorded in other main ocean current systems due to the mesoscale variability imposed by the islands (Barton and Arístegui, 2004; Hernández-León et al., 2007). Hydrologically, these islands are characterized by the presence of four water masses: the Eastern North Atlantic Central Water (ENACW), the Antarctic Intermediate Water (AIW), the Mediterranean Water (MW), and the North Atlantic Deep Water (NADW), which are located at different depths and have characteristic thermohaline properties (Ríos et al., 1992; Hernández-Guerra et al., 2002, 2003). The end of the ENACW and the start of the lower thermocline occur at a depth of approximately 700 m and correspond with values of 11 °C temperature and 35.5 psu in salinity (Hernández-Guerra et al., 2001; Machín et al., 2006). The lower thermocline is characterized by two intermediate water masses, the AIW, detected by its temperature values (7–11 °C), and the MW, with salinity values > 35.3 psu (Hernández-Guerra et al., 2001; Machín et al., 2006). The NADW water mass is found at a depth of 2000 m and is characterized by a temperature range of 2–7 °C (Machín et al., 2006). These changes in salinity and mainly in temperature result in the presence of density and thermal barriers that affect the vertical distribution of fauna (Canals et al., 2006). Additionally, the Canary Islands occupy a key position with respect to marine biogeochemical cycles because they are located at the boundary between eutrophic NW African upwelling waters and oligotrophic oceanic North Atlantic subtropical gyre waters (Wilke et al., 2009). The annual average primary production in the oceanic area of the Canary Islands is 200 mg C m<sup>-2</sup> d<sup>-1</sup>, reaching values of 800–1000 mg C m<sup>-2</sup> d<sup>-1</sup> during the winter bloom (de León and Braun, 1973; Hernández-León et al., 2007). In the coastal areas, the average primary production is 0.81 mg C m<sup>-3</sup> h<sup>-1</sup> reaching values of 2.54 mg C m<sup>-3</sup> h<sup>-1</sup> in February (Braun et al., 1985; Hernández-León et al., 2007). The coupling of production in the coastal area off Northwest Africa and in the oceanic zone, connected through filaments and eddies topographically formed in the coast or shed by the Canary Islands, promotes a continuous transport of organic matter towards the deep ocean (Hernández León et al., 2007). In the Canary Islands, it is common to observe two layers, one at approximately 400 m and another at 600 m in which diel vertical migrations occur, which move a portion of the epipelagic biomass from 400 to 600 m (Hernández-León et al., 2007). Additionally, a higher amount of dissolved organic carbon and higher ETS activity of bacteria at the 400–600 m depth were observed in the Canaries (Arístegui et al., 2003), suggesting that the excretion and defecation by the deep scattering layers and diel vertical migrations

transport carbon downward (Hernández-León et al., 2007). The diel vertical migrations transfer an important fraction of the biological production in the euphotic zone to the deeper layers of the ocean, generating a new cloud of organic material that reaches the lower section of the slope (Hernández-León et al., 2007). Geologically, these islands are characterized by numerous small submarine canyons formed by lateral collapse landslides (Masson et al., 2002; Acosta et al., 2003).

Submarine canyons are complex environments that are rich in nutrients due to both their geomorphology and their material and hydrographic flows (Guerreiro et al., 2009; Pusceddu et al., 2010), which differ from typical slopes because they offer mosaics of habitats and faunal assemblages (Stora et al., 1999; Sabatini et al., 2007; Cartes et al., 2009b; De Leo et al., 2010, 2014). Submarine canyons play an important role in the transfer of organic matter inputs from the shelf to the lower slope, as well as focusing zooplankton and nekton scattering layers and benthic macro- and megafauna (Puig et al., 2001; Canals et al., 2006; De Leo et al., 2010, 2012; Gunton et al., 2015). The broad range of substrate types and complex topography inside submarine canyons can enhance biomass and productivity by providing a higher number of niches, a wider range of resources and an enhanced benthic diversity compared to more homogenous open slope areas (Schlacher et al., 2007; Vetter et al., 2010; Paterson et al., 2011; De Leo et al., 2012, 2014; Leduc et al., 2014). These higher values in the canyons may be restricted in some cases to a depth strata (e.g. De Leo et al., 2012), but in other cases, they are similar to the slopes or higher values can even be found on the slopes compared to adjacent canyons (e.g. Houston and Haedrich, 1984; Soltwedel et al., 2005; Bianchelli et al., 2010; Vetter et al., 2010; Leduc et al., 2014). In canyon systems fueled largely by coast-derived organic detritus, the enhancement of benthic fauna decreases with depth as a consequence of the consumption of organic material down-slope (Vetter and Dayton, 1998; De Leo et al., 2012). In large canyons that extend far onto the continental slope, primary production may be enhanced by canyon-hosted eddies, yielding peaks in the abundance of the benthic community at depth in submarine canyons (Duineveld et al., 2001; Escobar-Briones et al., 2008; De Leo et al., 2010, 2012). Other environmental factors, such as the frequency and intensity of disturbance, sediment slumps, water mass properties and the vertical flux of particulate organic carbon, can also have an influence on the differences in benthic invertebrate communities between canyons and slopes (Vetter and Dayton, 1998; Company et al., 2008; Levin and Dayton, 2009; Levin et al., 2010; De Leo et al., 2012; Leduc et al., 2014). Species that live in submarine canyons have greater mobility and are more diverse than those of typical deep-sea assemblages in the same area due to habitat heterogeneity and the input of organic matter (Rowe, 1971; Sabatini et al., 2007; De Leo et al., 2012). Some deep-sea decapods do day-night movements along submarine canyons, possibly for trophic reasons (Sabatini et al., 2007). This movement pattern responds to the ability of deep-water shrimp to adapt their life cycles to the morphology of a canyon (Sabatini et al., 2007). Additionally, this pattern can be related to the predatory character of these animals moving at night to catch prey because decapod shrimp find the canyons to be a suitable place to obtain food and reach different depths in a short distance (Sabatini et al., 2007). This vertical daily migration ability present in the behavior of some decapod shrimp provides them with an important role in the transference of matter and energy to deeper areas (Cartes, 1993). Submarine canyons can also be recruitment areas for various species (Cartes and Sorbe, 1999; Vetter and Dayton, 1999).

Decapods are considered a secondary group in the megabenthic communities of the central Atlantic bathyal ecosystems (Haedrich et al., 1975, 1980; Lampitt et al., 1986). Deep-sea decapods play an important role in deep-sea trophic webs as vectors

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