

## Molluscan assemblages from circalittoral and bathyal soft bottoms of the northern Alboran Sea

### *Asociaciones de moluscos de fondos sedimentarios circalitorales y batiales del norte del mar de Alborán*

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**Abstract:** Molluscan assemblages from shelf and slope soft bottoms of the Alboran Sea have been sampled with a beam trawl during 2014 and 2015 MEDITS expeditions. A total of 134 spp. of molluscs (shell size > 3 mm) were identified, being gastropods the most diverse and dominant group. Four main depth related assemblages were detected in multivariate analyses and characterized by (1) *Turritella communis*, *Chamelea striatula* and *Nucula sulcata* for the inner shelf, (2) *Timoclea ovata*, *Clelandella miliaris* and *Neopycnodonte cochlear* for the outer shelf, (3) *Nassarius ovoideus*, *Calumbonella suturale* and *N. sulcata* for the upper slope and (4) *Abra longicallus*, *Euspira fusca* and *Aporrhais serresianus* for the middle slope. Species richness and abundance decreased with depth, unlike evenness and Shannon-Wiener diversity which displayed an opposite pattern. A higher spatial variability was detected for the shelf, indicating that more assemblages may occur at this level and further sampling is needed for covering all sedimentary habitat types of the Alboran Sea.

**Key words:** Molluscs, beam-trawl, deep-sea, sedimentary habitats, southern Spain

### 1. INTRODUCTION

The Alboran Sea represents an area where oceanographic, geological, ecological and biological processes occurring in the Atlantic and Mediterranean basins interact (IEO-MAGRAMA 2012). The interchange of water masses from those basins, the heterogeneous seafloor, the high productive coastal waters and the confluence of fauna from different biogeographic areas promote a high biodiversity and ecological complexity when compared to the other areas of Europe (for molluscs Gofas *et al.*, 2011). Benthic communities of the Alboran Sea provide an important contribution to the local and European biodiversity, nevertheless some of them have been poorly studied so far, especially those from circalittoral and bathyal soft bottoms (Salas, 1996; Gofas *et al.*, 2011; Gofas *et al.*, 2014; Marina *et al.*, 2015; Díaz *et al.*, 2015).

Molluscs are important components of benthic communities, with a wide diversity of species and

ecological functions, including the provision of food to higher trophic levels, habitat construction and improvements of the water and sediment quality due to their feeding activity (filtration, deposit feeding) (Gosling, 2003).

Soft bottoms are one of the most common habitats in marine systems and sometimes can support high biodiversity (Snelgrove & Butman, 1994). This is also the case for the Alboran Sea, where the diversification in different sedimentary micro-habitats enhances an enrichment of the molluscan fauna (Salas, 1996; Rueda *et al.*, 2000; Urrea *et al.*, 2011; Gofas *et al.*, 2014). Despite the importance, heterogeneity and extension of soft bottoms of the Alboran Sea, there are relatively few studies on the spatial distribution and structure of circalittoral and bathyal molluscan assemblages, with most studies only dealing with certain mollusc groups (Salas, 1996; Pedrouzo *et al.*, 2014) or areas within the Alboran Sea (Gofas *et al.*, 2014; Marina *et al.*, 2015). The characterization of soft bottom assemblages is

important not only for improving knowledge on the distribution and characteristics of species and benthic communities but also for obtaining basal values for further monitoring programs under the European directives (e.g. Habitat Directive, Marine Strategy Framework Directive). This is of particular importance in the Alboran Sea, where an important commercial fishing fleet mainly composed of artisanal fishing and trawling boats occurs, among other anthropogenic activities, and this may result in important impacts on sedimentary habitats that need to be monitored (Camiñas *et al.*, 2004).

The present study aims to increase the scarce knowledge on the composition and structure of molluscan assemblages of circalittoral and bathyal soft bottoms of the Alboran Sea.

## 2. MATERIAL AND METHODS

Faunistic samples have been collected with a beam-trawl (horizontal and vertical openings of 1.3 and 1.2 m, respectively, and mesh size of 10mm) on board the R/V Miguel Oliver during the MEDITS expeditions of April-May 2014 and 2015. Sampling was performed by trawling at a boat speed of ca. 1.8-2 knots during 5-10 (depending of being an inner or outer shelf sampling station) and 15 minutes (slope sampling stations). A total of 35 samples were collected at depths from 40 to 774 m from Estepona to Almeria and including the Alboran Island (Fig. 1). In each sample (only down to 3 mm fraction), species were separated, identified to the lowest possible taxonomic level and specimens counted and weighed to the nearest 0.5 g. Abundance and biomass data of every species were standardized to 1000 m<sup>2</sup> according to the sampling area of each haul.

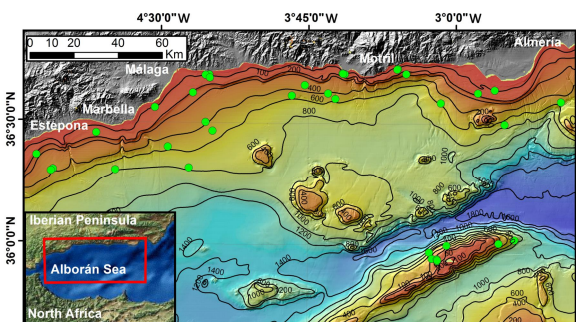


Fig. 1. Location of beam-trawl samples (green dots) collected during 2014 and 2015 MEDITS expeditions in the Alboran Sea

A data matrix containing the standardized abundance of all species per sample was subjected to cluster analysis and non-metric multidimensional scaling (MDS), in order to detect the main molluscan assemblages. Data were fourth-root transformed and the Bray–Curtis index was used as a between-sample similarity measure. Unweighted Pair-Group Method with Arithmetic Mean (UPGMA) was applied to link samples into clusters. Similarity Percentage analysis

(SIMPER) was used to characterize the detected assemblages by assessing the species contribution to each of them. Different groups of samples (assemblages) were *a priori* compared using an analysis of similarities (ANOSIM) in relation to different sampled zones (Alboran Island, western, central and eastern Spanish margin of the Alboran Sea) or different depth strata including the shallow-medium circalittoral (0-100m), deep circalittoral (100-200m), upper bathyal (200-500m) and medium bathyal (>500m). All these multivariate analyses were executed using the PRIMER 6 (Plymouth Routines In Multivariate Ecological Research) software from Plymouth Marine Laboratory, UK.

The characterization of molluscan species was done according to the dominance of species in relation to their abundance (%Da), biomass (%Db) and frequency of occurrence in the samples. The following ecological indexes were also used to describe the assemblages detected in multivariate analyses and those in relation to zones and depth strata that were *a priori* established: species richness (S, spp . sample<sup>-1</sup>), total abundance (N, individuals . 1000 m<sup>-2</sup>), total biomass (B, g . 1000 m<sup>-2</sup>), Shannon-Wiener diversity index (H') and evenness (J). Non-parametric analyses were used for testing differences in the mean values of the ecological indexes between the assemblages detected.

## 3. RESULTS

A total of 134 species and 12,628 individuals of molluscs have been collected in the present study, represented by 66 species of gastropods, 50 bivalves, 14 cephalopods, 2 scaphopods, 1 polyplacoforan and 1 solenogastre. Gastropods represented the top dominant group with 64.07% of the total abundance collected, followed by bivalves (34.97%), cephalopods (0.82%), scaphopods (0.09%), solenogastres (0.02%) and polyplacophorans (<0.01%).

The top ten dominant species in terms of total abundance were mainly those occurring in the shelf and upper slope such as the gastropods *Turritella communis* (29.05%, %Da), *Nassarius ovoideus* (20.71%), *Euspira fusca* (2.07%) and *Clelandella miliaris* (1.83%) as well as the bivalves *Timoclea ovata* (8.64%), *Nucula sulcata* (4.86%), *Abra longicallus* (4.46%), *Chamelea striatula* (4.36%), *Venus nux* (4.12%) and *Neopycnodonte cochlear* (2.49%), among others (Fig. 2). The top ten dominant species in terms of biomass were the gastropods *T. communis* (17.55%, %Db), *N. ovoideus* (8.25%), *Xenophora crispa* (6.68%), *Galeodea rugosa* (2.96%) and *E. fusca* (2.27%), the bivalves *V. nux* (17.19%), *C. striatula* (8.20%), *N. cochlear* (7.17%) and *N. sulcata* (2.83%) as well as the cephalopod *Eledone moschata* (2.20%). Top frequent species included the bivalves *N. sulcata*

(present in 62.85% of samples), *A. longicallus* (45.71%), *T. ovata* (34.28%) and *Cuspidaria cuspidata* (31.43%) as well as the gastropods *E. fusca* (57.14%), *N. ovoideus* (57.14%), *Aporrhais serresianus* (37.14%), *T. communis* (34.28%) and *Callumbonella suturale* (31.43%).

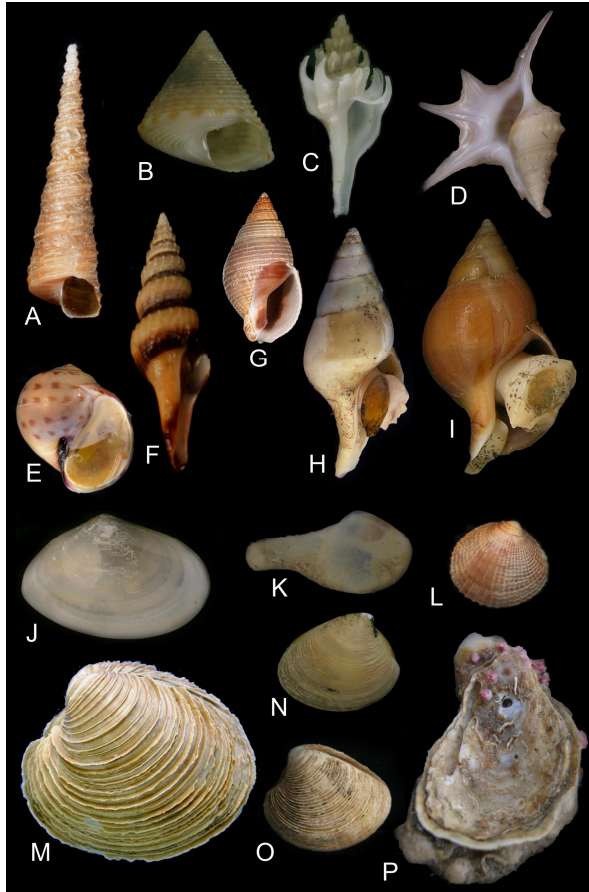


Fig. 2. Dominant and common mollusc species found in beam-trawl samples collected in the northern Alboran Sea: A: *Turritella communis*; B: *Clelandella miliaris*; C: *Pagodula echinata*; D: *Aporrhais serresianus*; E: *Euspira grossularia*; F: *Fusiturris similis*; G: *Nassarius ovoideus*; H: *Colus jeffreysianus*; I: *Buccinum humphreysianum*; J: *Abra longicallus*; K: *Cuspidaria rostrata*; L: *Timoclea ovata*; M: *Venus nux*; N: *Nucula sulcata*; O: *Chamelea striatula*; P: *Neopycnodonte cochlear*.

Four main molluscan assemblages with samples mainly from the inner shelf (<100 m), outer shelf (100-250 m), upper slope (250-500 m) and middle slope (>500m) were detected in MDS and Cluster using abundance data (Fig. 3). Similar groupings were obtained when using qualitative data. SIMPER analyses of the depth-related assemblages observed in cluster and MDS highlighted (1) low intra-group similarity (values between 15-35%) (high variability between samples belonging to the same bathymetric assemblage and also detectable in MDS), with higher similarity values for the middle slope assemblage (ca. 35 %), but (2) high between-group dissimilarities, especially between shelf assemblages and the middle slope (ca. 98 % dissimilarity). The main species contributing to each bathymetric assemblage were

(1) *T. communis*, *C. striatula*, *N. sulcata*, *N. ovoideus* and *V. nux* for the inner shelf; (2) *T. ovata*, *Clelandella miliaris*, *Neopycnodonte cochlear*, *Fusinus pulchellus* and *Xenophora crispa* for the outer shelf; (3) *N. ovoideus*, *C. suturale*, *N. sulcata* and *E. fusca* for the upper slope and (4) *A. longicallus*, *E. fusca*, *A. serresianus*, *C. suturale*, *Pagodula echinata*, *N. sulcata* and *C. cuspidata* for the middle slope.

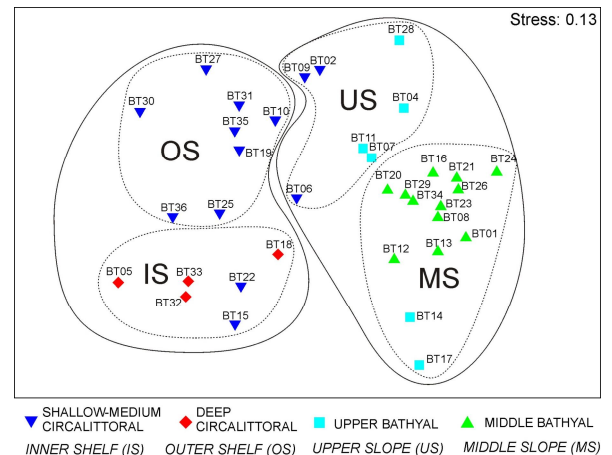


Fig. 3. MDS applied to the abundance data (individuals\*1000m<sup>-2</sup>) of molluscs obtained from beam-trawl samples collected in the Alboran Sea in spring 2014 and 2015. Circles contain main groups of samples obtained in the CLUSTER at 20 and 30% similarity.

Regarding the community descriptors, a decreasing trend of S with depth was detected, with maximum mean values at the outer shelf. At the Alboran Island, S values were always higher than at similar depths of the continental margin for the shelf but not for the slope. A decreasing trend of abundance with depth was also detected, with mean values ranging between 860 and 70.9 individuals . 1000 m<sup>-2</sup>, at the inner shelf and middle slope, respectively. Values of H' and J displayed an opposite pattern, with maxima at the slope.

Two-factor ANOSIM analyses displayed significant differences in relation to depth strata *a priori* established ( $R_{ANOSIM}=0.66$ ,  $p<0.001$ ) but not to geographical sectors within the Alboran Sea ( $R_{ANOSIM}=0.14$ ,  $p=0.08$ ). Nevertheless, the strongest differences among sectors were always found between Alboran Island and the central and eastern part of the northern Alboran Sea.

#### 4. DISCUSSION

A total of 134 spp. were found in this study, however a higher number of species is expected since several mollusc species have sizes below 3 mm, which represent the fraction (1-3 mm) that has not been analyzed for the present study. The Alboran Sea represents a basin with a high biodiversity of molluscs at infralittoral (Urrea *et al.*, 2010), circalittoral (Marina *et al.*, 2015) and bathyal soft bottoms (Gofas *et al.*, 2014). Nevertheless, species richness values per

sample recorded in this study are lower than those from previous studies because (1) micromollusc (< 3mm) and molluscs from thanatocoenosis were not included in the results, (2) the sampling method does not really target the endofauna or demersal cephalopods and (3) several samples were collected in fishing grounds where trawling activity may cause an impact on habitats and benthic communities, including mollusc species (Camiñas *et al.*, 2004). Some molluscs species occurring in the same sampled areas, mainly cephalopods, were collected with otter trawl by Ciercoles *et al.* (2015) but not with this method, highlighting the importance on combining methods in biodiversity studies and monitoring.

Top-dominant species are similar to those described in previous studies on specific locations of the Alboran Sea, such as those from muddy and fine sand bottoms at the inner and outer shelf of the bay of Málaga (Díaz *et al.*, 2015) or the ones at circalittoral bottoms from the Site of Community Importance Calahonda-Castell de Ferro (Marina *et al.*, 2015). Dominant species from the slope are not similar to those described by Gofas *et al.* (2014) for *Leptometra phalangium* aggregations of the Djibouti banks, probably because soft bottoms from those seamounts are coarser and dominated by other species (e.g. *Limopsis aurita*) as also observed in soft bottoms exposed to strong currents from the gulf of Cádiz (Díaz del Río *et al.*, 2014).

Molluscan assemblages from the shelf displayed a more scattered pattern in the MDS and a lower intragroup similarity in the SIMPER when compared to the slope ones. This may be related to sedimentary and water mass variability that is more acute at the shelf, and generally results in a wider differentiation of habitat types in both the Mediterranean Sea and Atlantic Ocean (Templado *et al.*, 2012). García *et al.* (2015) displayed a similar pattern for fish assemblages of the Alboran Sea, with higher longitudinal differentiation along the shelf than the slope of the Alboran Sea. Depth related molluscan assemblages observed in this study may represent the main and primary ones, with further variability due to environmental changes especially at the shelf. Further sampling under the framework of the Marine Strategy Framework Directive monitoring programs may contribute to disentangle the environmental factors related to the horizontal variability of molluscs within each of the main bathymetric assemblages detected.

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