

Spatial distribution, inter-annual variability and influence of abiotic factors on molluscan assemblages collected with otter trawl in the northern Alborán Sea.

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Molluscs constitute one of the most diverse and best represented invertebrate groups in the marine environment. In the northern sectors of the Alborán Sea and Gulf of Cádiz 1200 spp. of the 1800 spp. occurring in the Mediterranean Sea, have been found so far highlighting the importance of this area for the European molluscan fauna (Gofas et al., 2011). Molluscs are also the second group in abundance and biomass in demersal fisheries and an important component of soft-bottom benthic communities, including ecologically important and/or commercial mollusc species that are also exposed to an increasing trawling impact (Snelgrove, 1998; Kaiser & De Groot, 1999). Previous studies on molluscs of the Alborán Sea has primarily focused on those from infralittoral habitats, with few studies focussing on the composition, structure and dynamics of circalittoral and bathyal molluscan assemblages (Rueda et al., 2015). The study of soft bottom molluscan assemblages where trawling fishing fleet operates is important for improving the fisheries evaluation and management, as well as the implementation of ecosystemic and biodiversity conservation measures in the context of the new Marine Strategy Framework Directive.

In the present study, the distribution and inter-annual variability of molluscan assemblages of circalittoral and bathyal soft bottoms of the Alborán Sea have been analyzed as well as the relationships of fauna with different environmental variables. Samples were collected in 190 otter trawl hauls performed between “Punta Europa” and “Cabo de Gata”, including the Alborán Ridge, at depths from 30 to 800 m during four MEDITS-ES trawl surveys in spring between 2012 and 2015. Several environmental variables from the water column (temperature and salinity) and sediment samples were taken where each haul was performed in order to elucidate their relationships with the molluscan assemblages. Abundances of each species (individuals · h⁻¹) of each haul and trawl survey were pooled in a matrix for performing multivariate methods in order to contrast molluscan assemblages of different sites and years. The Bray-Curtis similarity index was then used to perform non-parametric multidimensional scaling ordinations (nMDS). A fourth root transformation pretreatment was applied on the quantitative data in order to minimize the contribution of the most abundant species to the analyses. Analyses of similarities (ANOSIM) were carried out for statistical comparisons of groups of samples according to different factors (e.g. year, location). Analyses of similitude percentage (SIMPER) were used to identify those species that contributed to the similarity and dissimilarity between groups of samples according to factors. These multivariate analyses were executed using the PRIMER v6 (Plymouth Routines in Multivariate Ecological Research).

Average values of abundance of molluscs (N), species richness (S), Shannon-Wiener diversity index (H' : log₂), evenness index (J') and taxonomic distinctness index (Δ^*) were calculated for each sample group. Statistical differences between these values were tested with the non-parametric Kruskal-Wallis using SPSS software.

The relationships between environmental variables and molluscs abundance in the different hauls were only studied for the 2014 trawl survey using a correspondence canonical analysis (CCA). The statistical significance of the adjusted CCA was assessed using a Monte Carlo permutation test. Prior to this, the environmental variables were screened and those which presented a correlation higher than 0.9 (after a Spearman correlation analysis) were not further considered. These analyses were executed using the R software.

Three main molluscan assemblages were detected and belonged to the: I) Continental Shelf (30-200 m); II) Upper Continental Slope (201-350 m), and III) Middle Continental Slope (351-800 m). The multivariate analyses revealed geographical differences within the Alborán Sea, being these differences more acute between the Alborán Island, mainly in the shallower assemblages (30-200 m and 201-350 m) and the remaining locations considered. These differences were due to a lower abundance in the island of species that were dominant in the continental margin, such as *Alloteuthis media*, *Sepietta oweniana* and *Turritella communis* and a higher abundance in the island of species that were less abundant in the continental margin, such as *Neopycnodonte cochlear*, *Arca tetragona*, *Loligo forbesii* and *Sepia orbignyana*.

No significant differences of the abundance, biomass, species richness and diversity index were detected in the assemblages over the four years. Nevertheless, significant abundance declines of *A. media*, *S. oweniana*, and increases of *N. cochlear* were detected in the continental shelf over the years as well as abundance declines of *Bathypolipus sponsalis* and *Galeodea rugosa* in the slope assemblages.

Regarding the environmental variables, the shallower assemblage (30-200 m) showed a significantly higher temperature, lower salinity and wider variety of sediment types than the others, with a predominance of sandy mud textures followed by muddy sand. As depth increases the sedimentary heterogeneity decreases, with dominant muddy sediments. Depth, temperature and mud percentage were the key variables that better explained the variability of the molluscan assemblage in the CCA.

In conclusions: (1) Acute geographical differences occurred between the Alborán Island and the locations of the continental margin, due to its location far from the continental influence and, therefore, with lower fisheries activity and a less muddy and more

bioclastic sediment, (2) Inter-annual trends in the abundance, biomass, species richness and diversity of assemblages were not detected, but some species displayed inter-annual changes due to biological aspects or accidental catch of gregarious species and (3) depth and some sedimentological variables displayed the most significant relationships with the molluscan assemblages, as previously observed for other invertebrate assemblages in the Alborán Sea.

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