Underwater imagery-study of sediment and fauna for habitat characterization in mud volcanoes of the Spanish margin (Gulf of Cádiz)

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ABSTRACT

Habitat characterization using underwater images has been carried out in 4 mud volcanoes (Gazul, Almazán, St. Petersburg and Aveiro) and one mud volcano/diapir complex (Hespérides) located at the middle slope of the Spanish margin of the Gulf of Cádiz (360-1200m depth). A total of 126 species, mostly cnidarians, sponges, brachiopods, crustaceans and echinoderms and 19 habitats have been observed in the underwater images, including anoxic bottoms with cold seep fauna or remains (*Siboglinum* sp., *Lucinoma asapheus*, *Solemya elarraichensis*), bottoms with authigenic carbonates colonized by gorgonians and anthipatharians, extensive muddy bottoms with sea pens (*Kophobelemnon* sp., *Protoptilum* sp.) and bamboo corals (*Isidella elongata*) and cold-water coral banks (*Madrepora oculata*). Habitat type and distribution seem influenced by sedimentary features, presence of hard substrates with authigenic carbonates, seepage activity, depth and hydrodynamic conditions. Cold seep related species and heterotrophic species not directly linked to fluid venting represent seepage activity indicators and induce habitat and biodiversity differentiation among the fluid venting edifices.

INTRODUCTION

Underwater image analysis has gained importance nowadays, representing a well known established quantitative and qualitative method for seabed exploration [1]. Unlike traditional sampling, underwater imagery-studies are less invasive and can cover large areas, acquiring information on the distribution and diversity of habitats and species (mainly sessile mega-epifauna) in their natural environment. In deep-sea areas, imagery-studies can provide important and novel ecosystemic information of seafloor structures such as seamounts, submarine canyons and mud volcanoes (MVs) that could not be previously obtained with traditional sampling.

The Gulf of Cádiz (GoC) represents an important seepage area with ca. 80 MVs, some of them with modern fluid venting processes and others with a high availability of authigenic carbonates [2]. These structures are under protection in European waters (Habitat 1180, Submarine structures made by leaking gases, Habitat Directive 92/43/EEC). Unlike for geological features, there is scarce information on habitats and associated biota of MVs [3] and very few studies using underwater images [4].

MATERIAL & METHODS

Sediment and fauna characterization was performed on 14 underwater HD image (pictures and videos) transects from 4 MVs (Gazul, Almazán, St. Petersburg and Aveiro) and one MV/diapir complex (Hespérides) obtained with the VOR APHIA 2012 (*Vehículo de Observación Remolcado*) during the INDEMARES-CHICA0412 expedition on board R/V Ramón Margalef. Sediment type was annotated and all organisms were identified to the lowest possible taxon and quantified in each picture as colonies (e.g. cnidarians) or individuals (e.g. echinoderms). Species richness, abundance of individuals/colonies, dominance and frequency of each species were calculated for each transect or 20m-standard section. Multivariate analyses (MDS, CLUSTER, ANOSIM, SIMPER) explored the similarity of the sediment and faunistic features of the different standard sections of transects at different MVs using PRIMER 6.

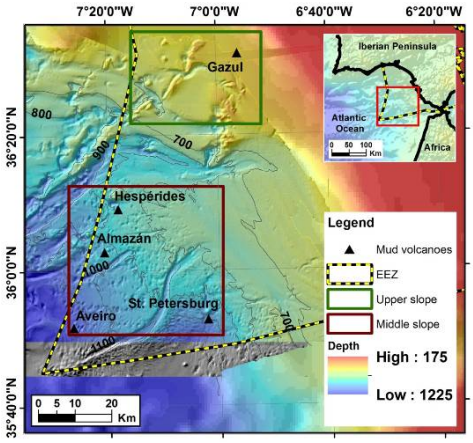

Fig. 3 Location of the explored fluid venting edifices.

RESULTS & DISCUSSION

A total of 10,292 valid pictures (93.8% of all pictures) were analyzed, containing 5,769 individuals/colonies belonging to 126 species. Cnidarians (54.9%), sponges (24.8%), brachiopods (5.7%), crustaceans (4.9%) and echinoderms (4.8%) dominated in number of species and abundance. Species richness and abundance per standard sections was maximal in Hespérides, followed by Almazán and Gazul. Aveiro and St. Petersburg displayed lower and similar species richness, but higher abundances were detected in St. Petersburg.

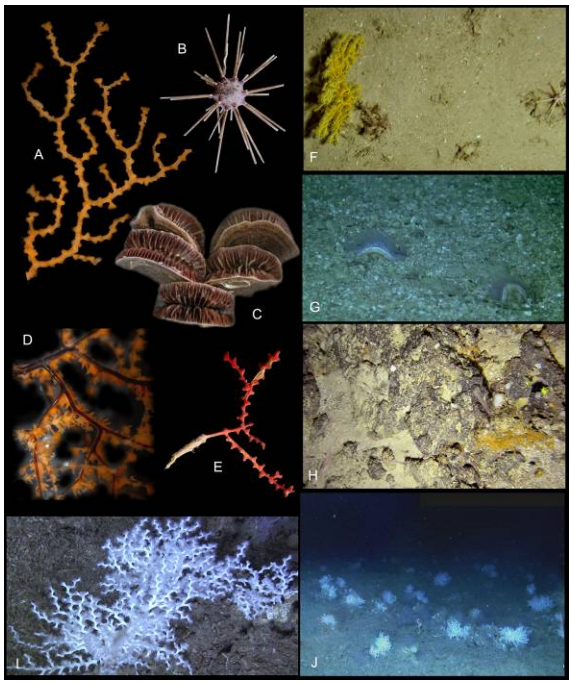

Fig. 2. Habitats and habitat-forming species observed in different fluid venting edifices of the Spanish margin of the Gulf : (A) *Chelidonisis aurantiaca*, (B) *Cidaris cidaris*, (C) *Flabellum chunii*, (D) *Leiopathes glaberrima*, (E) *Swiftia pallida*, (F) *Placogorgia* sp., and *Cidaris cidaris* (Almazán), (G) *Flabellum chunii* (Hespérides), (H) Authigenic carbonates with Desmospongiae and *Leiopathes glaberrima* (Hespérides), (I) *Madrepora oculata* (Gazul). (J) Cold-water coral bank with *Madrepora oculata* and *Lophelia pertusa* (Gazul).

Regarding multivariate analyses (CLUSTER, MDS), the standard sections of Gazul displayed a high similarity (Group 1), nearly all sections of Hespérides and Almazán formed another group (Group 2) and all sections of Aveiro and St. Petersburg as well as some of Hespérides and Almazán ormed a third group (Group 3). Gazul is characterized by the highest inter-section similarity (67.52%), followed by Aveiro (44.21%), St. Petersburg (30.48%), Hespérides (28.33%) and Almazán (26.27%). The largest differences between fluid venting edifices were observed for Aveiro and Gazul (dissimilarity=99.20%) due to the dominance of *Madrepora oculata*, *Antipathella subpinnata* and *Polyplumaria flabellata* in Gazul and *Pheronema carpenteri*, *Radicipes* cf. *fragilis* and *Protoptilum* cf. *carpenteri* in Aveiro. Aveiro and Hespérides also displayed large differences (dissimilarity=97.73%) due to the high dominance of *P. carpenteri* and *R.* cf. *fragilis* in the former and of *Gryphus vitreus*, *Telestula* sp. and *Munida* sp. in the latter. The same was observed for Hespérides and St. Petersburg (dissimilarity=95.01%) due to the higher abundance of the above mentioned species in the former and of *P.* cf. *carpenteri* and *Kophobelemnon stelliferum* in the latter. The transects located in the northeastern and southern areas of Hespérides are less different (from 73.74% to 86.26%) than those of Almazán because the dominant species are similar, including *Telestula* sp., *Neocomatella europaea*, *Swiftia pallida*, Desmospongiae 3 and *Gryphus vitreus*. Gazul always displayed large differences with other MVs (dissimilarities from 90.80% up to 99.20%) because of the presence of specific species for Gazul, which rises above the interface between the Surficial Atlantic Water and the Mediterranean Outflow Water, factor that should promote the absence of typical middle slope species. The most similar fluid venting edifices seem to be St Petersburg and Aveiro (dissimilarity=76.58%) with similar dominant species (*R.* cf. *fragilis*, *Pheronema carpenteri*). The depressions of Almazán, and all transects of Aveiro as well as those of St. Petersburg are part of the largest grouping (Group 3) due to the high dominances of *Isidella elongata*, *P.* cf *carpenteri* and *R.* cf. *fragilis*.

Environmental variables such as substrate type, seepage activity, depth and hydrodynamics of the different MVs may influence the distribution of species and therefore the occurrence of this wide variety of habitats in this MV field.

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