Distribution of Benthic Foraminiferal Assemblages on the Southern Campanian Continental Shelf

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Abstract

Benthic foraminifera in 250 samples collected on the Southern Campanian continental shelf were analysed. Q-mode cluster analysis resulted in the identification of six distinct foraminiferal assemblages, reflecting different environmental settings. The distribution of the assemblages shows a distinct zonation, that is manly attributed to grainsize and composition of sediment, bathymetry and to geographical distribution of the impact of the river supply. Cluster I (4-20 m), is related to the areas influenced by the rivers outflow on sandy-silt and very sandy silt substrates, dominated by the species *Ammonia beccarii* and *Eggerella scabra*; cluster II (10-30 m), associated with vegetated environments and/or sandy and gravelly sandy substrates, presents a characteristic epiphytic fauna composed by *Cibicides lobatulus*, *Rosalina bradyi* and *Rosalina obtusa*; cluster III (10-50 m) shows a typical infralittoral assemblage mainly related to sandy silty and very sandy silty substrates, not directly affected by the rivers outflow, with the dominance of *Ammonia tepida* and *Elphidium granosum*; cluster IV related to silty sandy substrates of the Sorrento Peninsula shelf, is chracterised by *Elphidium crispum* and *Cibicides lobatulus*; cluster V (30-100 m) is composed by silty substrates with the dominance of the opportunistic species *Valvulineria bradyana* while cluster VI is characterized by an outer-shelf assemblage on silty bottoms, with prevalent *Cassidulina carinata*

1 Introduction

Foraminifera are perfectly suitable for environmental studies, being recorders of environmental changes because of their wide distribution over all marine environments. A large number of physical and chemical parameters such as temperature, salinity, depth, sediment, oxygen, food and as well as biological interactions, influence the distribution of benthic foraminifera [1, 2, 3], making them useful tools for ecological and environmental interpretations [4].

At present, only a few studies dealing with the distribution of benthic foraminifera assemblages on the southern campanian continental shelf, most of which analysed only confined areas of the shelf [5, 6, 7, 8, 9, 10]. In the present paper we tried to defined the spatial distribution of benthic foraminifera along southern campanian continental shelf from the Sorrento Peninsula to the Gulf of Policastro and their relationship with some environmental parame-

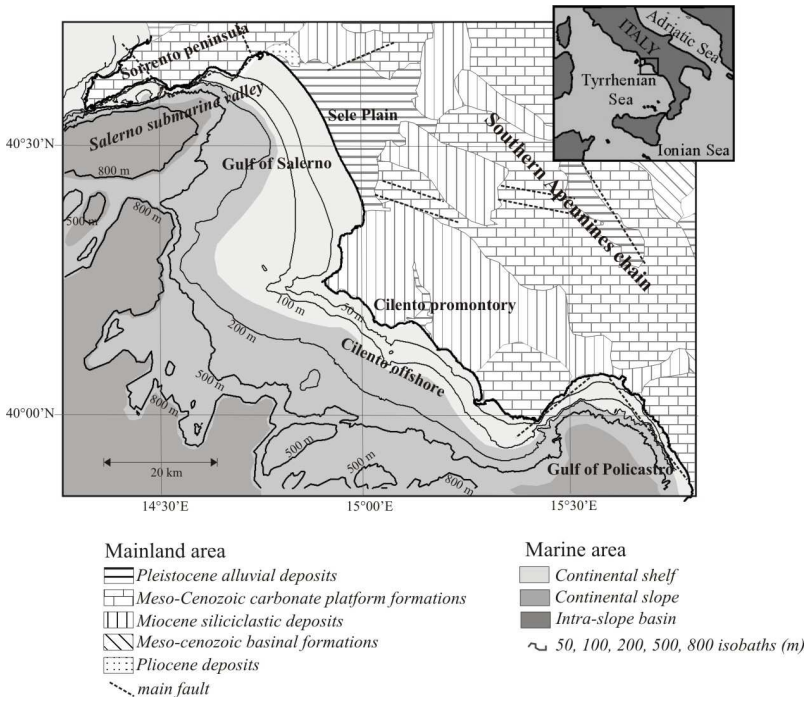

Figure 1: Geological map of the investigated area showing the mainland outcrops with deposits and generalized bathymetry with morphology of marine area.

ters.

2 General setting of the study area

The study area extends over different physiographic settings: the Sorrento Peninsula offshore, the Gulf of Salerno, the Cilento offshore and the Gulf of Policastro (Figure 1).

The continental shelf surrounding the Sorrento Peninsula widens to the north and narrows in the southern sector, is bordered by a smooth shelf-break at about 140/170 m of water depth to the north and by a sharp shelf-break at about 100/120 m of water depth to the south (Figure 1). According to [11], sediments in the northwestern sector are mainly composed by sands, in the depth range of 9/50 m and by silty-sands and sands in the outer part of the shelf, while in the southern sector the seafloor is mainly characterised by sands with *Posidonia oceanica* prairies and subordinately by silty-sands.

The Gulf of Salerno is characterizes by a northern sector with a narrow shelf (about 1-2 km wide) bordered by a shelf-break at about 100/120 m of water depth and a steep slope, and by a southern sector which displays a shelf wide up to 35 km with a shelf-break at about 180-200 m of water depth and a deep border (Figure 1). In this area

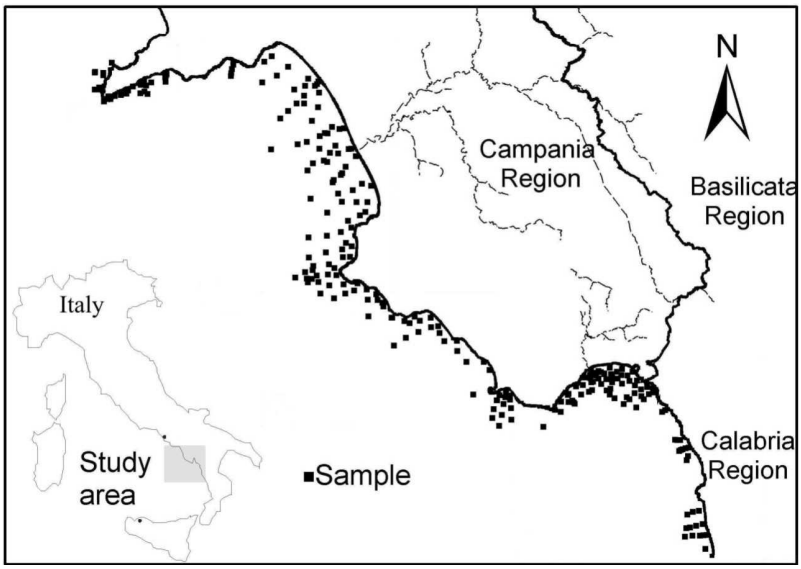

Figure 2: Location map of the studied area with sampling stations.

the continental shelf is strongly influenced by the Sele River input which represents the most important source of fresh water, nutrient and terrestrial continental organic matter.

The Cilento offshore is rather irregular with a deep shelf-break (140 to over 200 m deep; Figure 1). The inner shelf around Licosa Cape and Palinuro Cape displays wide extensions of *Posidonia oceanica* meadows down to 30 m of water depth.

The northern part of the continental shelf of the Gulf of Policastro is rather broad (up to 10 km), whereas the eastern and south-eastern sectors are narrower in some places (only 2 km) and have slopes with up to 10% inclination (Figure 1). The rivers Lambro, Mingardo and Bussento, which flow into the northern part of the Gulf of Policastro, represent the main source of organic matter to the shelf.

3 Material and methods

A total of 250 bottom samples were collected by IAMC, CNR - Naples, during two oceanographic cruises (1998 and 2003), on the southern Campanian continental shelf (Figure 2). Sediments were collected using a Van Veen grab.

For sedimentological and micropaleontological analyses two aliquots of undisturbed sediment were taken from the top 3-5 cm of seabed from each sample. In the laboratory the collected sediments for benthic foraminiferal analysis were sieved over sieves with 125 μm, dried at 60°C and then weight. If necessary, the samples were split with a microsplitter, and a minimum of 200 to 300 specimens were counted using a binocular microscope. Benthic foraminifera were classified according to [12] and [13].

The grain size analysis of samples was car-

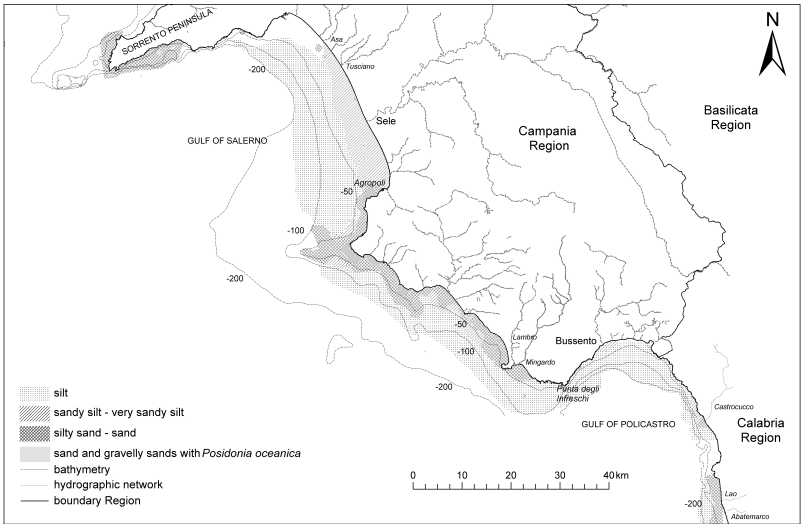

Figure 3: Distribution of sediment grain-size at the sea floor.

ried out on sediment processed with peroxide solution, then washed and dried at 40°C. The $>$1000 μm granulometric fraction was analyzed using a microsieve (2000 μm, 1400 μm and 1000 μm), while the fraction smaller than 1000 μm has been analyzed by a Laser Particle-Size Analyzer. The percentages of sand, silt and clay fractions were calculated for each sample.
Q-mode cluster analysis was performed on 34 selected species to assess the main composition of benthic foraminiferal assemblage. The cluster analysis has been applied to the selected foraminiferal data set and samples using the nearest neighbor method and Euclidian distance measure.

4 Results

The continental shelf of the study area is generally characterised by coarse sediments along the coast, while pelagic facies with fine sediments (silt) is present to open sea (Figure 3). The texture and composition of sediments show that their main source is the Sele River (northern sector) and the Bussento River (southern sector), with other contributions come from some small rivers (Asa, Tusciano Alento, Lambro, Mingardo, Castocucco and Abatemarco).
Particularly the shelf of the Sorrento Peninsula, also according to [11], is mainly characterized by silty sandy and sandy sediments.
In the Gulf of Salerno the shelf is characterized by sandy silt and very sandy silt sediments in the infralittoral zone (0-50 m), with a decreasing in grain-size from 50 to 200 m, where the seabottom is dominated by silty sediments (Figure 3). From Agropoli to Punta degli Infreschi the seafloor is generally characterized by silty-sands and sands (0-50 m) with some patches of sands and gravelly sands with *Posidonia oceanica* off the Solofrone, Alento, Lambro and Mingardo

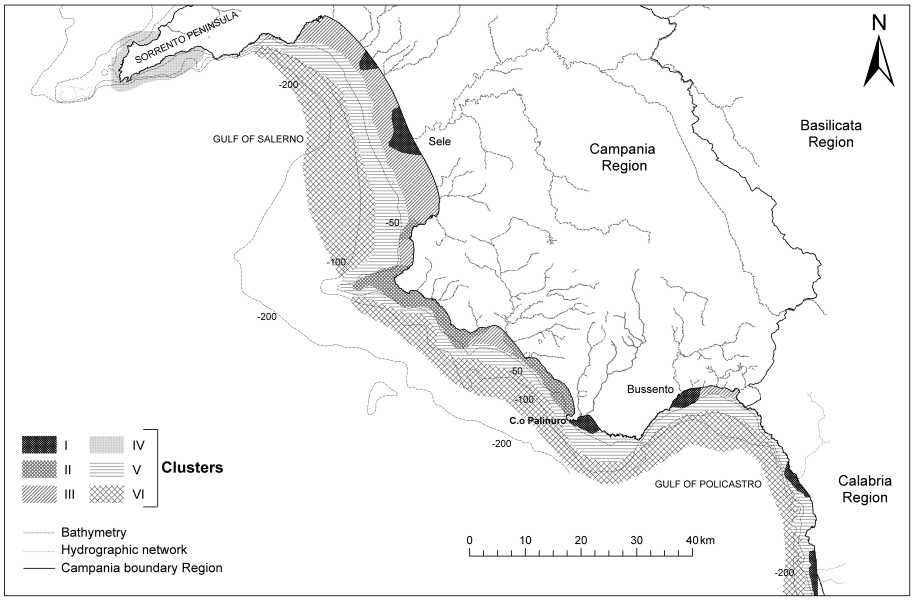

Figure 4: Spatial distribution of the six defined clusters in the study area.

river mouths (Figure 3). From 50 m seaward the seafloor is mainly composed by silty sediments (Figure 3).

In the Gulf of Policastro (from the coast to about 50 m of water depth) the sediments off the Castrocucco, Lao and Abatemarco river mouths are composed by silty sands and sands down to 50 m depth, while in front of the Bussento river mouth sandy silty and very sandy-silty bottoms are dominant (Figure 3), with a decreasing in grain-size below this depth (silt).

A total of 229 benthic foraminiferal species, belonging to 104 genera, were identified in the total assemblages. Generally, well-preserved foraminiferal tests dominate in all the samples.

The Q-mode cluster analysis grouped the samples into six homogeneous clusters (Figure 4).

Cluster I, grouped the samples between 4 and 20 m (Figure 4), mainly characterized by silty-sandy and sandy-silty sediments (Figure 7). The assemblage is composed of the species *Ammonia beccarii* and *Eggerella scabra*, and is mainly found close to the river mouth where the fauna presents a low density and biodiversity (Figure 5). In the Gulf of Salerno this cluster occurs mostly off the Asa and Sele river mouths while towards the south-eastern part of the Campanian coastal zone (from Capo Palinuro to the Gulf of Policastro) its distribution is recorded off the rivers Lambro, Mingardo, Bussento, Castrocucco, Lao and Abatemarco (Figure 4). Cluster II, is composed by the epiphytic species *Cibicides lobatulus*, *Rosalina bradyi* and *Rosalina obtusa* and is mainly located in the central sector of the study area from Agropoli to Capo Palinuro (10 - 30 m, Figure 4), where the sea floor is dominated by sands,

silty sands and gravelly sands with *Posidonia oceanica* (Figure 7). Cluster III, is located between 10 and 50 m, and seems to be characteristic of sites less influenced by the river input (Figure 4); the assemblage is characterized by high biodiversity (Figure 5). Cluster IV, is confined to the western part of the study area (Sorrento Peninsula, Figure 3) with a fauna dominated by the species *Elphidium crispum* and *Cibicides lobatulus* (Figure 5). Cluster V, is located parallel to the coast, from 30 to about 100 m (Figure 4) and groups the samples essentially composed by silty sediments (Figure 7), probably characteristic of sites influenced by the river plume; the assemblage shows the highest biodiversity (Figure 5) with the dominance of *Valvulineria bradyana*. Finally cluster VI, groups the stations farthest away from the river mouth (Figure 4), the sediments of this area are all composed by silt (Figure 7); the fauna is characterized by *Cassidulina carinata*, *Valvulineria bradyana* and *Bulimina marginata* (Figure 5).

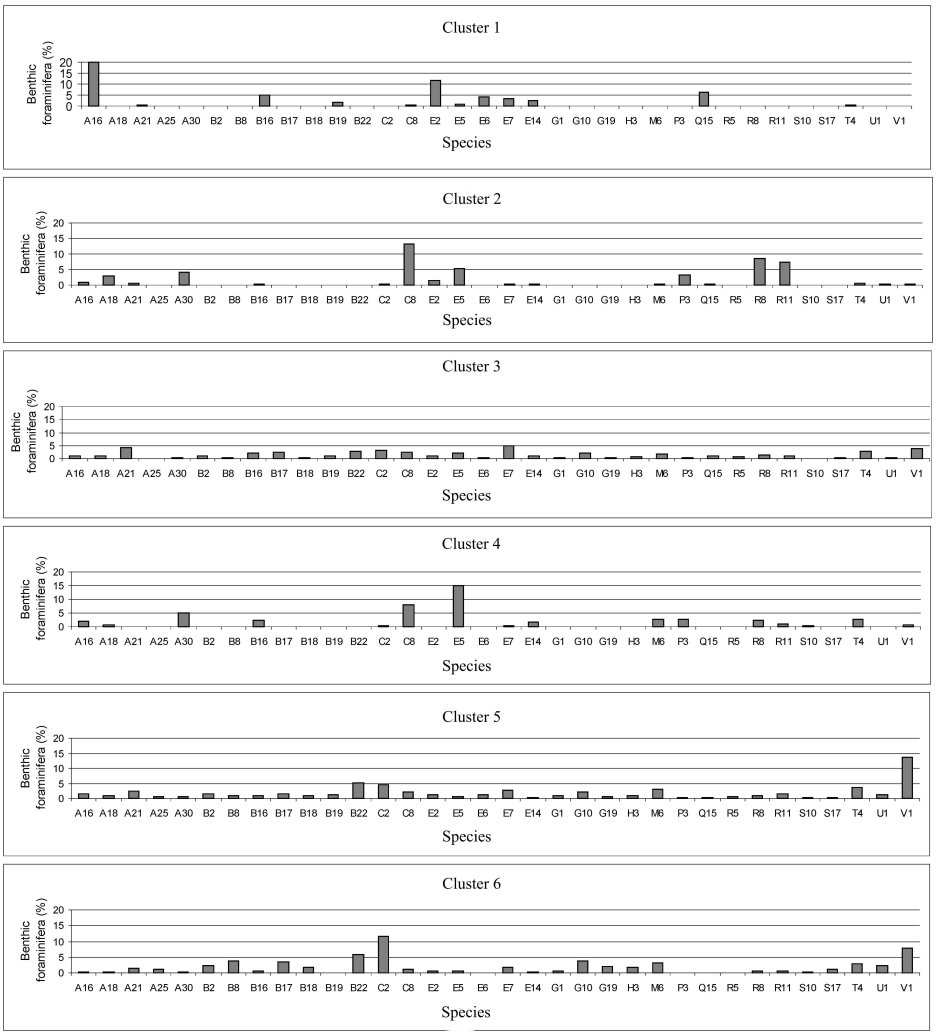

Figure 5: Average Abundance Values (AV) of the 34 selected species within the six clusters: A16: *Ammonia beccarii*, A18: *Ammonia inflata*, A21: *Ammonia tepida*, A25: *Amphycorina scalaris*, A30: *Asterigerinata mamilla*, B2: *Bigenerina nodosaria*, B8: *Bolivina alata*, B16: *Buccella granulata*, B17: *Bulimina aculeata*, B18: *Bulimina costata*, B19: *Bulimina elongata*, B22: *Bulimina marginata*, C2: *Cassidulina carinata*, C8: *Cibicides lobatulus*, E2: *Eggerella scabra*, E5: *Elphidium crispum*, E6: *Elphidium cuvilleri*, E7: *Elphidium granosum*, E14: *Elphidium punctatum*, G1: *Gavelinopsis praegeri*, G10: *Globocassidulina subglobosa*, G19: *Gyroidina umbonata*, H3: *Hyalinea baltica*, M6: *Melonis barleanum*, P3: *Planorbulina mediterranensis*, Q15: *Quinqueloculina seminulum*, R5: *Reussella spinulosa*, R8: *Rosalina bradyi*, R11: *Rosalina obtusa*, S10: *Sigmoilopsis schlumbergeri*, S17: *Sphaeroidina bulloides*, T4: *Textularia calva*, U1: *Uvigerina mediterranea*, V1: *Valvulineria bradyana*.

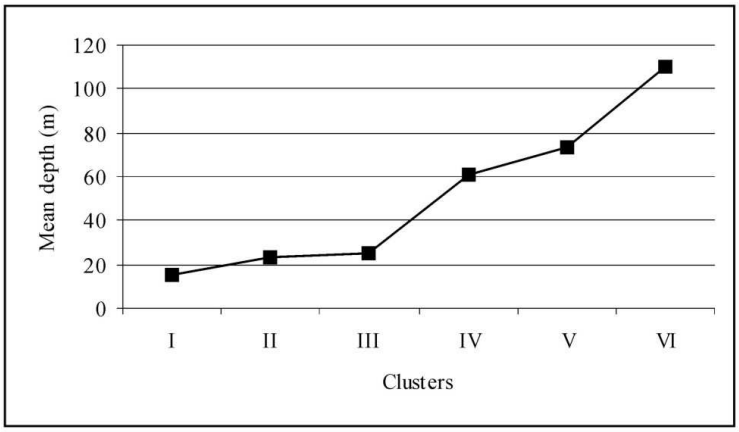

Figure 6: Comparison between the six clusters and mean depth values.

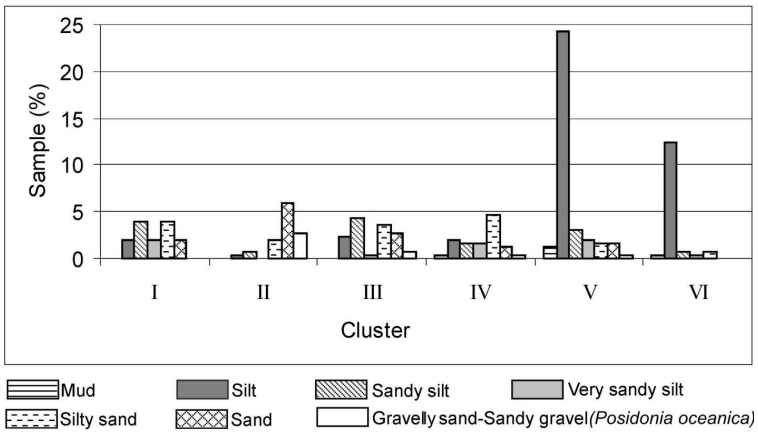

Figure 7: Composition of sediment in the six defined clusters.

5 Discussion and conclusion

The southern campanian continental shelf shows a very diversified benthic foraminiferal fauna. The Q-mode cluster analysis allowed recognising of six assemblages (Figure 4), probably strong controlled by an interaction between organic matter, water depth and grainsize of seabottom.

The distribution of benthic foraminiferal assemblages in the studied area has been already defined, by different authors, for selected sectors characterize by rivers outflows [5, 7, 6]. However, the present study underlines that the river contributions seem to have a relevant importance in the composition, structure and distribution of benthic foraminiferal assemblage along the southern campanian continental shelf.

Generally, the distribution patterns of the clusters show a distinct tendency with the change in bathymetry. Indeed, as shown in Figure 6, the mean depth in each cluster increases moving from cluster I to cluster VI, with a significant shift from cluster III to cluster IV.

Between 4 and 50 m water depth three different biofacies are present: an assemblage (with *Ammonia beccarii* and *Eggerella scabra*; Cluster I) on silty-sandy and sandy bottom, related to river contributions and located off of the main rivers mouths (Figure 4). This assemblage dominated by *Ammonia beccarii* and *Eggerella scabra* (Figure 5), is characterised by a low diversity attributed to the opportunistic behaviour of these species in the organic matter rich environment influenced by freshwater [14, 15, 16, 5, 6]. An assemblage (with *Cibicides lobatulus*, *Rosalina bradyi* and *R. obtusa* Cluster II; Figure 5) on silty-sandy, sandy and gravelly-sandy bottoms with vegetation cover mostly *Posidonia oceanica* (Figure 3) [16, 17, 18]. This assemblage well fits with that found by [5] in the northern sector of the Salerno Gulf, by [6] in the Policastro Gulf and by [7] in different sectors of the continental shelf between Agropoli and Capo Palinuro (Southern Tyrrhenian Sea). A typical infralittoral assemblage on silty bottom with *Elphidium granosum* and *Ammonia tepida* (Cluster III; Figure 4), that suggests an environment with more stable salinity conditions, probably with lower fresh water input and not directly affects by the rivers outflows (Figure 4). The presence of *Elphidium granosum* reveal a distinct changes in percentage of organic matter as reported by [15] and [16] in the Adriatic Sea. Also *A. tepida*, which shows increasing values from cluster I to cluster III (Figure 5), prefers shallow, saline and brackish environments [19, 4, 16, 20, 21, 22].

Cluster IV is located on the shelf around the Sorrento Peninsula and groups stations from 9 to102 m water depth (Figure 3). The dominance of *Elphidium crispum* and *Cibicides lobatulus* (Figure 4) in the whole area can be attributed to the silty-sandy and sandy bottoms with *Posidonia oceanica* prairies [13].

The increasing biodiversity in the deepest biofacies, sheltered from the river influence (Cluster V and VI, Figure 5), suggests that the environmental conditions are not stressfull for the benthic foraminiferal fauna, which is dominated by *Valvulineria bradyana* and *Cassidulina carinata*; the distribution of these biofacies seem to mainly follow the bathymetry and sediment grain-size. However the relevant percentages of *Valvulineria bradyana*, within cluster V and of *Cassidulina carinata* within cluster VI (Figure 5), can be still

related to the presence of percentage of organic matter at the seafloor probably dispersed to the outer shelf. In the Adriatic Sea, [16] decribes a minimum water depth of 40 m for *V. bradyana*, in the outer part of the organic carbon enriched clay belt.
[23] shows that this species is a relevant marker of high productivity, while [24] and [25] observed that it is an opportunistic species, living in sediments containing high amounts of organic matter. Cluster VI, shows a very similar distribution to cluster V but with a more significant positive correlation with depth (Figure 6). Here the fauna is dominated by *Cassidulina carinata* which can be found in areas with sustained organic input as reported for the continental shelf and open slope of East New Zealand [26] and for the French upper middle bathyal station in the Bay of Biscay, where it appears to respond quickly to labile organic matter input by a reproductive event [27].

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