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PALAEOENVIRONMENTAL STUDY OF HOLOCENE SEDIMENTS FROM THE COASTAL PLAIN OF PIRAEUS (ATTICA, GREECE) BASED ON OSTRACOD ASSEMBLAGES

MASTER THESIS

DIRECTION: Micropalaeontology-Biostratigraphy
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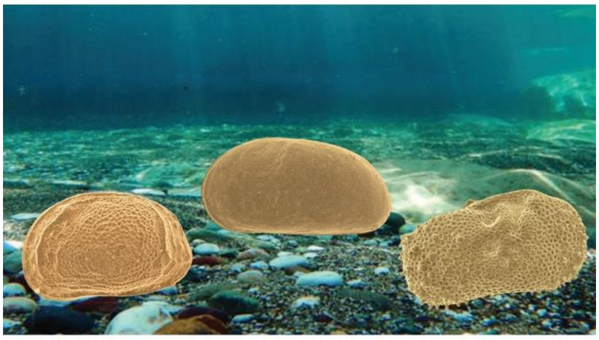

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PALAEOENVIRONMENTAL STUDY OF HOLOCENE SEDIMENTS FROM THE COASTAL PLAIN OF PIRAEUS (ATTICA, GREECE) BASED ON OSTRACOD ASSEMBLAGES

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Palaeoenvironmental study of Holocene sediments from the coastal plain of Piraeus (Attica, Greece) based on ostracod assemblages – *Master Thesis*

Παλαιοπεριβαλλοντική μελέτη των ολοκαινικών ιζημάτων της παράκτιας περιοχής του Πειραιά (Αττική, Ελλάδα) μέσω των πανίδων των οστρακωδών – *Μεταπτυχιακή Διπλωματική Εργασία*

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Περίληψη

Σκοπός αυτής της εργασίας είναι η διεξοδική ανάλυση πανίδων οστρακωδών με στόχο την αναπαράσταση της παλαιοπεριβαλλοντικής εξέλιξης της παράκτιας περιοχής του Πειραιά κατά την διάρκεια του Ολοκαίνου. Για να επιτευχθεί αυτό μελετήθηκε η σύνθεση και η κατανομή των πανίδων των οστρακωδών κατά μήκος του πυρήνα P5. Η μικροπαλαιοντολογική ανάλυση περιλάμβανε ποιοτική ανάλυση (προσδιορισμό σε επίπεδο γένους και είδους, συγκέντρωση οικολογικών στοιχείων) και ποσοτική ανάλυση (υπολογισμός δεικτών ποικιλότητας, ανάλυση Q τύπου κατά συστάδες) των συναθροίσεων των οστρακωδών σε 41 δείγματα του P5. Προσδιορίστηκαν 31 είδη οστρακωδών, τα οποία ανήκαν σε 20 γένη. Το πιο κοινό είδος που επικρατούσε στατιστικά στην συντριπτική πλειοψηφία των δειγμάτων είναι το *C. torosa*, το οποίο είναι χαρακτηριστικό είδος υφάλμυρων, συνήθως λιμνοθαλάσσιων, περιβαλλόντων. Τα είδος αυτό συνοδεύεται κυρίως από τα είδη *L. elliptica* (είδος υφάλμυρων υδάτων), *X.communis* (θαλάσσιο είδος ανθεκτικό σε μεταβολές αλατότητας) και *C. salinus*.

Με την βοήθεια της Q τύπου ανάλυσης κατά συστάδες και της οικολογίας των οστρακωδών διακρίθηκαν πέντε συναθροίσεις οι οποίες και αντιστοιχούν σε διαφορετικά περιβάλλοντα. Η κατανομή των περιβαλλόντων αυτών κατά μήκος του πυρήνα P5 κατέδειξε την παλαιογεωγραφική εξέλιξη της περιοχής:

- Από τη βάση του πυρήνα μέχρι περίπου τα 7545 cal BP η περιοχή μελέτης αντιστοιχούσε σε μια ολιγόαλη-μεσοαλη λιμνοθάλασσα, με περιορισμένη επικοινωνία με τη θάλασσα
- Από τα 7554 μέχρι περίπου τα 3987 cal BP διαμορφώθηκε σταδιακά ένα παράκτιο περιβάλλον με διακυμάνσεις στην αλατότητα. Η ερμηνεία αυτή συνάδη με τα συμπεράσματα των Goiran et al. (2011), επιβεβαιώνοντας τον Στράβωνα στο ότι η χερσόνησος του Πειραιά κάποια χρονική περίοδο ήταν νησί
- Στη συνέχεια, μετά από μια σημαντική εισροή γλυκών υδάτων λίγο πριν τα 3987 cal BP διαμορφώθηκε στην περιοχή μια ολιγόαλη λιμνοθάλασσα. Το συμβάν αυτό είναι πιθανόν να συσχετίζεται με την υγρή περίοδο που ακολούθησε μετά το συμβάν του 4200 yrs BP.
- Τέλος, μετά τα 2812 cal BP διαμορφώθηκε ένα υφάλμυρο έλος.

Η αναπαράσταση της περιβαλλοντικής εξέλιξης της παράκτιας περιοχής του Πειραιά κατά την διάρκεια του Ολοκαίνου ανέδειξε για άλλη μια φορά την αξία των οστρακωδών ως βιοδείκτες παλαιο-περιβαλλοντικών αλλαγών.

Abstract

Purpose of this study was the detailed analysis of ostracod assemblages in order to contribute to the presentation of the environmental evolution of the Piraeus coastal plain during Holocene. In particular, the composition and distribution of ostracod faunas along sediment core P5 was studied. The micropalaeontological analysis included the qualitative analyses (identification to species level, collection of ecological data for each species) and quantitative analyses (calculation of diversity indices, Q mode cluster analysis) of the ostracod assemblages from 41 samples of P5. A total of 31 species were identified, belonging to 20 genera. The most abundant species in the vast majority of the samples was *C. torosa*, a species characteristic of brackish lagoonal environments. It was accompanied mainly by the species *L. elliptica* (brackish water species), *X.communis* (marine species tolerating salinity fluctuations) and *C. salinus*.

The combined use of Q mode cluster analysis and the ecology of the ostracod species distinguished five assemblages which represent different paleoenvironments. The distribution of these environments along P5 indicated the palaeoenvironmental evolution of the studied area:

- From the bottom of P5 up to about 7545 cal BP, the study area represented a brackish oligohaline to mesohaline lagoon with limited communication with the sea.
- After 7554 to about 3987 cal BP, a coastal environment was formed with salinity fluctuations. This is in accordance with Goiran et al. (2011), verifying Strabos hypothesis for the Island of Piraeus.
- Upwards, a closed oligohaline palaeoenvironment is indicated, as a strong freshwater influence is recoded, beginning at about 3987 cal BP. This could be associated with the wet period that started after the 4200 yrs BP dry event.
- Finally, after 2812 cal BP a brackish marsh was formed.

The reconstruction of the landscape evolution of the Piraeus coastal plain during Holocene, highlighted once again the role of ostracods as excellent palaeoenvironmental proxies.

Foreword

The present thesis which goes by the title of “Palaeoenvironmental study of Holocene sediments from the coastal plain of Piraeus (Attica, Greece) based on ostracod assemblages” was completed within the Interinstitutional Program of Postgraduate Studies in Palaeontology-Geobiology in the Direction of Micropalaeontology. This study focuses on the palaeoenvironmental reconstruction of the Piraeus area based on the fossil ostracod assemblages of core P5 which was retrieved from the coastal plain of Piraeus. At this point I would like to express my gratitude to my supervisor Dr. Theodora Tsourou for her guidance and moral support throughout the whole process of this study. I would also like to thank the other members of my three member examining board Professor M. Triantaphyllou and Associate Professor K. Kouli for their guidance and help. I would like also to thank deeply Professors D. Kostopoulos and M. Triantaphyllou, both leading the postgraduate studies program, for being supportive throughout my studies. I would also like to thank Associate Professor K.Kouli for teaching us about pollen and being inspiring. At last I would like to thank my parents Alexander and Aggeliki for their encouragement and immense support and I dedicate my thesis to them.

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1. Introduction

1.1 Aim of the study

It is well known that ostracods are considered as one of the most useful groups of microfossils for interpreting palaeoenvironmental conditions. The composition of the ostracod fauna captures in great detail any environmental change, especially in the transitional environments of coastal ecosystems. This study focuses on the thorough qualitative and quantitative study of the ostracod assemblages from a sediment core in the coastal area of Piraeus. In particular, the composition of the assemblages was studied and a detailed recording and analysis of their distribution along the sediment core was carried out. Aim of this effort is to contribute to the presentation of the environmental evolution of the study area during Holocene.

1.2 Ostracods - An introduction

Ostracoda are small-sized crustaceans which secrete a bivalved shell and a length generally ranging between 0.5 and 2 mm. They are extensively used in geosciences due to their rich fossil record (they are small in size and present in high numbers in the sediments) and their ability to have representative species to all aquatic environments worldwide, ranging from fresh to deep marine waters (Cohen, Peterson and Maddocks 1982; Holmes & Chivas, 2002).

Ostracods were initially (1802) named Ostrachoda and later, in 1806, Ostracoda by Latreille (Oertli 1982). Carl Linné in 1758 and O.F. Müller in 1776 were the first who described ostracods and in particular recent ones.

The earliest ostracods were observed in Ordovician strata and their first forms were probably inhabiting marine environments (Pokorny, 1978). More than 65.000 fossil ostracod species have been described so far, while it is estimated that there are more than 20.000 living ostracod species of which only 8000 have been described (Morin & Cohen 1991, Cohen et al. 1998).

Ostracods have 5-8 pairs of limbs which are mainly used for feeding, movement and reproduction (Horne et al., 2002). The soft body of the ostracods is enclosed in two valves which are connected at the upper part with a hinge, forming the carapace (Athersuch et al. 1989). The bivalved calcareous carapace is composed of low-Mg calcite ($CaCO3$) (Holmes & Chivas, 2002). Valves open and close with the help of the adductor muscles which leave a scar pattern on both valves of the carapace and these scars are very useful for the taxinomical classification of ostracods (Athersuch et al. 1989; Horne et al., 2002). As the soft body grows up, ostracods discard their carapace and secrete a new one with a procedure called ecdysis.

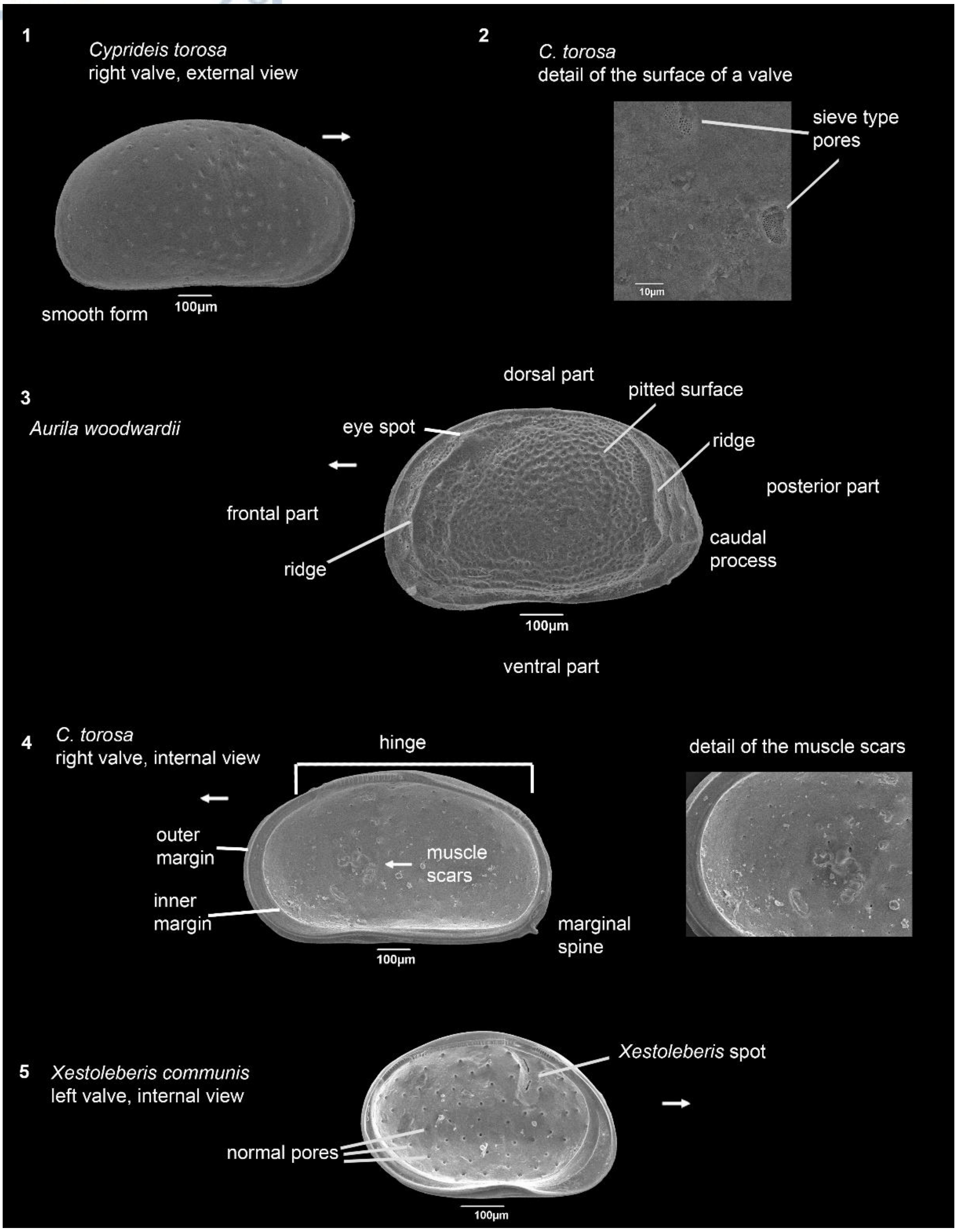

Figure 1. Main external and internal morphological characteristics of the ostracod valves. Pictures were taken by SEM and represent some of the main ostracod species in this study. Arrows indicate the frontal part.

Ostracod assemblages are indicative of the environmental conditions of their habitat, especially of salinity in marginal marine environments (Frenzel & Boomer, 2005). They also provide useful information concerning water temperature, type of the substrate, water depth, grain size, as well as anthropogenic impact (Ruiz et al., 2006). Knowledge on recent ostracods indicates that certain taxa have very particular ecological tolerances. Consequently, changes in the population structure of the assemblages over time reflect changes in environmental conditions.

In contemporary marginal marine environments salinity fluctuations are intense and constitute the main factor that determines the composition and diversity of the ostracod assemblages, which are dominated by 1-3 ostracod species (Boomer & Eisenhauer, 2002). The number of marine species decreases linearly when salinity drops up to about 10 ppt, but presents a sharp decline in lower salinities, while the number of freshwater species decreases abruptly when salinity exceeds 3 ppt (Elofson, 1941; Wagner, 1957). In brackish waters with salinity range from 3 to 10 ppt ostracod assemblages are characterized by low species diversity but high number of individuals. For example, *Cyprideis torosa* is a typical brackish water species which thrives in a salinity range between 2 and 17 ppt (Morkhoven, 1962).

1.3 Ostracods in geoarchaeological studies

The study of ostracod assemblages plays a crucial role in geoarchaeological studies. Due to their environmental sensitivity ostracods have been the main micropalaeontological group in geoarchaeological investigations not only in the peri-Mediterranean region (e.g. Spain: Anadón and Gabàs, 2009; Italy: Mazzini et al., 2001; Goiran et al., 2014; Greece: Pavlopoulos et al., 2004; Theodorakopoulou et al., 2009; Triantaphyllou et al., 2010; Cyprus: Morhange et al., 2000; Lebanon: Marriner et al., 2005; Israel: Rosenfeld et al., 2004; Mischke et al., 2014), but they are also very prominent in other areas of the world (e.g. Portugal: Lord et al., 2011; United Kingdom: Boomer et al., 2007; Holmes et al., 2010). As it has already been mentioned, ostracods are very sensitive to environmental changes especially when it comes to marginal marine areas. Changes of salinity in these areas are connected to sea level fluctuations and freshwater input and therefore to climate change. The ostracod assemblages record in detail these oscillations allowing to interpret the palaeoenvironment and therefore to reconstruct the landscape evolution of the studied area and to estimate of the impact of climate change.

The geoarchaeological studies are mainly based on the knowledge of the ecology of certain species and/or the ecological preferences and behavior of the ostracod assemblages in order to determine the palaeoenvironment or the palaeoclimate. Additionally, ostracod shell chemistry is considered as a significant tool. In particular, SEM-EDS analyses (Rossi et al., 2015) and d18O, d13C, and Sr/Ca and Mg/Ca ratios contribute to the paleohydrochemical reconstruction of the studied area (e.g. Rosenfeld et al., 2004; Anadón and Gabàs, 2009). Furthermore, ostracods in several cases, especially when other microfossils are absent, are used as a stratigraphic tool (e.g. Davies and Griffiths, 2005). A detailed reference to the ostracods' contribution in geoarchaeological studies is presented by Mazzini et al. (2015).

An example of geoarchaeological implementations of ostracods is the study of the middle Paleolithic Nahal Mahanayeem Outlet Site in Israel, where the depositional environment of the shallow lake or saline springs near by the alluvial occupation of the Middle Paleolithic humans, was reconstructed based on the ostracod content of the samples as well as the sediments' geochemical data (Kalbe et al., 2015). A similar study was also conducted in he Acheulian archaeological site Gesher Benot Ya'aqov (GBY), along the shoreline of a Pleistocene Lake, the GBY Lake, within the Jordan Rift valley of the Israel (Rosenfeld et al., 2004). In this study ostracod assemblages were analyzed in comcination to the ostracod shell chemistry, aiming to the palaeoenvironmental reconstruction during Pleistocene.

The landscape evolution of areas with ancient harbors has been a popular subject in geoarchaeological studies and ostracod assemblages are an integral part of them. Areas of special interest have been, for example, the coastline of Kition, Larnaca, Cyprus (Morhange et al., 2000), Tyre's ancient northern harbour, Phoenicia (Lebanon) (Marriner et al., 2005), Oiniadai's harbours (Acheloos River delta, NW Greece) (Vött, 2007), the coastal area of the Vravron Bay (Attica, Greece) which has been used as a harbor from Middle Bronze Age to Myceneae (Triantaphyllou et al., 2010), the ancient harbour basin of Ostia (Italy) (Goiran et al. (2014), Magdala, the ancient harbor of Galille (Rossi et al, 2015).

1.4 Ostracods in geoarchaeological studies in coastal areas of Greece

Greece has a very rich history, with historical strata being full of artefacts. A common type of Greek artefacts are pottery objects, which led to the application of ceramic micropalaeontology (Quinn, 2000). The mineralogy of the ceramics as well as their content of microfauna can provide a lot of information about the pottery such as its time of creation, the techniques used for its creation and the origin of its material (Quinn, 2000).

The use of ostracods as bioindicators in studies aiming to palaeoenvironmental reconstruction in Greece has also been popular, mostly in the last twenty years.

The multidisciplinary studies of Triantaphyllou et al. (2003) and Pavlopoulos et al. (2004) that concerned the coastal plain of Marathon located in NE Attika (famous for the ancient battle of 490 BC between the Athenians and the Persians) where the first to utilize ostracod assemblages as an palaeoenvironmental tool in a site of great archaeological interest.

Figure 2. Map where the peri-Mediterranean geoarchaeological sites mentioned in the text are indicated.

Vött (2007) and Vött et al. (2011) reconstructed late Holocene landscape changes in the vicinity of the ancient seaport Oiniadai (Acheloos River delta, NW Greece), incorporating micropalaeontological data and examined their geoarchaeological implications. Accordingly, Vött et al. (2007) presented evidence of multiple tsunami impact on the Bay of Palairos-Pogonia, NW Greece, based on sedimentological, micropalaeontological and geoarchaeological data.

Alvarez-Zarikian et al. (2008) dealt with submergence and uplift in the area of ancient Helike (Gulf of Corinth, Greece) based on microfaunal (including ostracods) and archaeological evidence.

Other multidisciplinary studies were conducted by Pavlopoulos et al. (2007) and Theodorakopoulou et al. (2009) in the coastal Istron area at the Gulf of Mirabello, in northeastern Crete, with indications of human installations from the Neolithic to the Roman period. Sedimentological, micropalaeontological and palynological study of sediment cores combined with radiocarbon datings and historical data, had to be merged in order to create a multidisciplinary approach of the interaction between the landscape evolution and the ancient humans.

The work of Triantaphyllou et al. (2010) is an other example where micropaleontological analysis of a sediment core in addition to palynological and sedimentological analysis in combination with accurate historical information concluded to a detailed palaeoenvironmental reconstruction of acoastal area. In particular, Triantaphyllou et al. (2010) studied the palaeoenvironmental evolution since 3000 BC of the Vravron Bay, located in the vicinity of the homonym archaeological site, a marshy plain at the eastern part of the Attica. Sufficient evidence for palaeoenvironmental changes and landscape evolution since the early Bronze Age covering all subsequent historical periods since 1540 deriving from the sedimentological, micropalaeontological and palynological data, was provided.

Pavlopoulos et al. (2010) performed a multidisciplinary (macropalaeontological, micropalaeontological, micromorphometric and sedimentological) analyses aiming to the middle to late Holocene palaeoenvironmental reconstruction of the Palamari Bay located on the northeastern coast of Skyros Island (Sporades Islands, Aegean Sea, Greece), where a fortified prehistoric settlement is found, dated between 2800 and 1700 BC.

2. Study area - Geological setting

2.1 Study area

The study area is located at the coastal plain of Piraeus (Saronikos Gulf, Attica). The Saronikos Gulf is a landlocked, semi-enclosed gulf located between the southwest coasts Attica and the northeast coast of Peloponnese (Foutrakis and Anastasakis, 2020). The Saronikos Gulf is open in the southeast, while it is closed in the northwest by the area of Corinth.

Goiran et al. (2011) were the first who conducted an interdisciplinary geoarchaeological research at Piraeus peninsula combining cartographic, topographic and historic data, radiocarbon datings, sedimentological and foraminiferal analysis. Their main target was to unlock the past landscape evolution of this area verifying Strabo (Greek geographer, historian and philosopher; 68-63 BC to 20-25 AD) who wrote in his work *Geographica* in the first century AD that Piraeus peninsula was formerly an island. Later, Apostolopoulos et al. (2014), based on the lithostratigraphy of the borehole data and geophysical investigation in the area, identified a big depression in the southeastern part of the survey area and a circular channel in its north part, confirming that part of the Piraeus peninsula was an island. Triantaphyllou et al. (2016), in a multi-proxy study (benthic foraminifera, pollen, non-pollen palynomorphs, molluscs and magnetic susceptibility), interpreted the palaeoenvironmental conditions of the lithostratigraphic units, which were distinguished by the previous researchers.

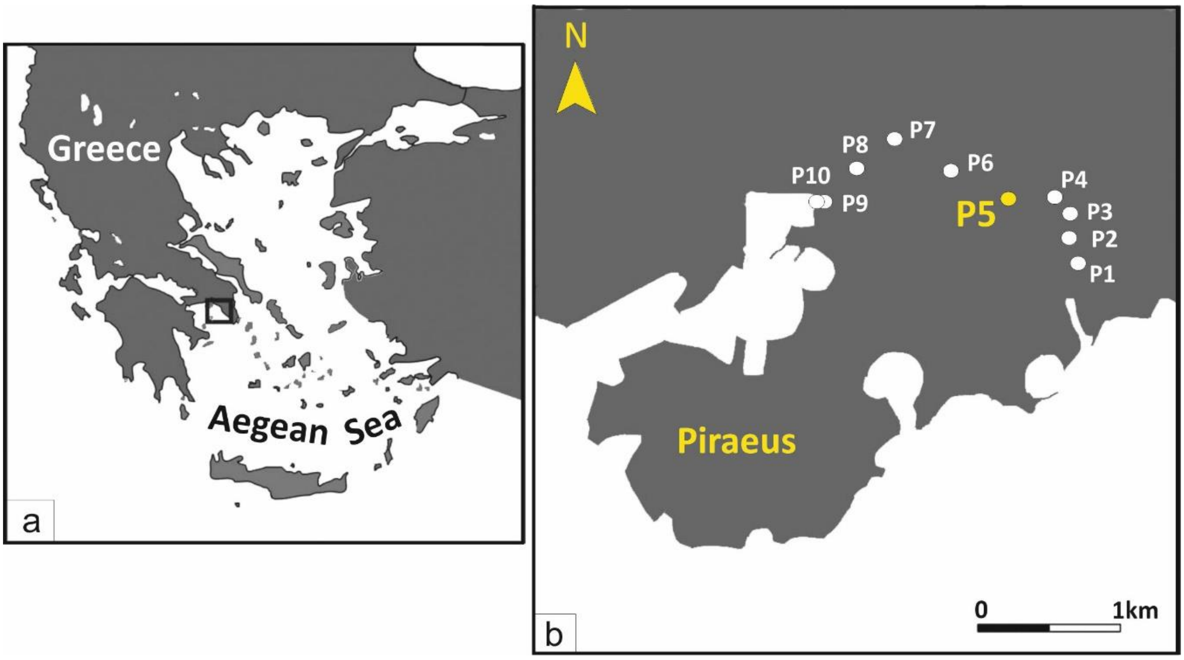

Figure 3. (a) Location map of the study area (b) Position of the studied core P5 in the Piraeus peninsula (P1-P10 are all the boreholes that were drilled in the Piraeus coastal plain by Goiran et al. (2011)).

2.2 Geological setting

The alpine basement belongs to the Atticocycladic geotectonic zone and it is considered as one of the most aseismic areas in Greece with limited neotectonic activity (Papazachos, 1990; Lekkas, 2001). Western Attica is mainly built on sedimentary rocks, such as limestones and clastics of the alpine basement, while recent post-alpine sediments cover the foothills of the mountains and areas of lower altitude (Lekkas, 2001; Papanikolaou et al., 2004).

The Athens Basin is an area of extensional tectonic regime with NNE-SSW direction expressed mainly by marginal faults (Papanikolaou, et al., 2004). The Piraeus peninsula is part of the Athens Basin and it is structured by Pliocene marine post alpine formations with marls, sandstones, conglomerates and limestones. The area began to form its present geography after the formation, in middle Pleistocene, with the propagation of Cephissus River (Papanikolaou et al., 2004).

Three main lithostratigraphic units were distinguished for the area of the Piraeus Harbor, which are from the bottom to the top (Apostolopoulos, et al. 2014, based on previous literature):

- The Upper Cretaceous limestones, which are located north of the Piraeus harbour.

- The “Marls of Piraeus” which are consisted mainly of marls, marly sandstones and limestones and conglomerates, combined with thin layers of fine-grained materials (containing fossils and organic material) such as siltstones, clays, silty and clayey sands. They represent a shallow marine environment of Neogene Age.

- The Holocene deposits divided from the “Marls of Piraeus” by an unconformity. The deposits’ composition differs from place to place. They are consisted of material of fluvial origin, archaeological strata , various deposits of lagoon or neritic origin etc.

The alluvial sedimentation mainly of Cephissus River led to the formation of Halipedon (salt-field) in the area of Phaliron, a marshy area that covered a great part of the region, which existed even in the first years of the 20th century (Panagos, 1968; Economidou, 1993).

3. Materials and methods

3.1 Sampling, dating and lithology of Core P5

Core P5 is one of the ten rotational boreholes (10 cm in diameter) that were drilled in the Piraeus coastal plain and presented by Goiran et al. (2011) (fig. 2). A total of 41 samples were obtained from the core for the purposes of the current study.

The core P5 is about 15m long and it is mainly consisted of clay and sandy clay but the upper part (the last 3.5m) are more coarse with fine-coarse sands, rubbles and pebbles (Goiran et al., 2011) (fig. 3). Additionally, from the bottom up to 7m depth the lithostratigraphic column is characterized by the presence of bivalves and gastropods.

Nine radiocarbon datings were carried out and demonstrated that this core covers a sedimentary record of more than 7552 cal. yr B.P. (details in Goiran et al., 2011) (fig. 3).

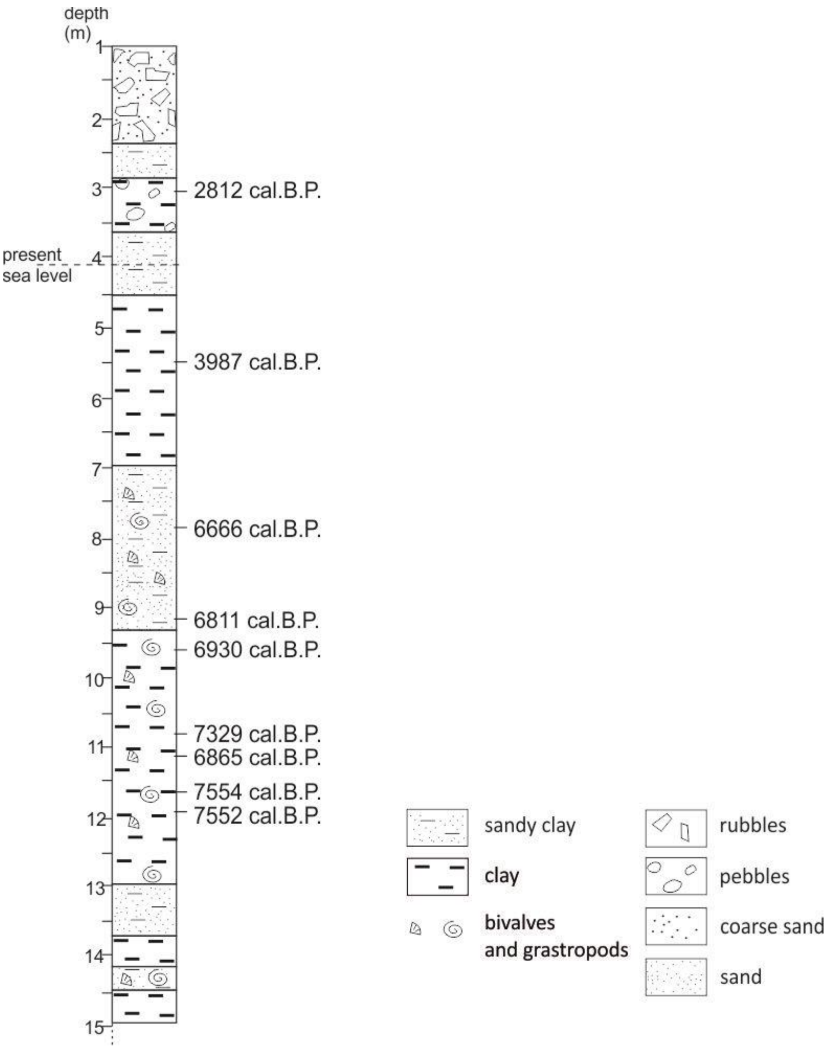

Figure 4. Lithostratigraphic column of core P5 and the AMS radiocarbon datings (modified from Goiran et al., 2011).

3.2 Laboratory treatment and micropalaeontological analysis

All samples underwent a detailed quantitative and qualitative analysis. Each sample (10 g dry weight) was treated with H_2O_2 to remove the organic matter, and subsequently washed through a 125μm sieve and dried at 60°C. All ostracods were collected from the fraction > 125 μm. There was a large difference in the abundance of the specimens among the studied samples, consequently, in cases where the specimen abundance was too high treated material underwent splitting by using an Otto micro-splitter. The final aliquot of the sample had to contain at least 200 ostracods. Complete carapaces were counted as two valves. Complete carapaces were rare. Finally, the total number of specimens was calculated for the purposes of the statistical analysis.

Ostracods were collected and identified under a Zeiss stereoscope. Furthermore, representatives from all the identified ostracod species were observed and photographed under a scanning electron microscope (SEM Jeol ISM 6390, Faculty of Geology and Geoenvironment National and Kapodistrian University of Athens).

Ostracods were classified according to Horne et al. (2002). All ostracods were identified in genus and species level. The identification was based on several publications such as Barbeito-Gonzalez (1971; Naxos Island), Bonaduce et al. (1975; Adriatic Sea), Stambolidis (1984; Evros delta), Tsourou (2008; Andros Island), Meisch (2000) and the Stereo Atlas of Ostracod Shells (e.g. Athersuch & Whittaker, 1976; Athersuch, 1980).

3.3 Data quantitative analysis

Statistical analysis was conducted in order to perform detailed quantitative interpetation of the studied samples by using the software packages Microsoft Excel 2013 for Windows, Grapher 13 and PAST 3.25 (HAMMER et al., 2001).

More specifically, the following assemblage structure indices were calculated and analyzed based on the absolute abundances of the ostracod species (Appendices 2a-c and 3):

The number of taxa (S) per sample.

The relative frequencies (percentage %) of each species in every sample.

The Dominance Index (D) which expresses the abundance of individuals of the most popular species (Simpson 1949).

The diversity expressed by two indices: Shannon-Wiener diversity index (H΄) (Shannon et al., 1963) and Simpson diversity index (D') (Simpson, 1949).

Additionally, assemblages were distinguished by the application of the Q-mode hierarchical cluster analysis and the Ward's method on the relative abundances of the ostracod species and the diversity indices. The results were presented in a dendrogram. Clustering is the procedure which divides into groups data following a certain pattern, where smaller groups called clusters concentrate the data with similar properties dividing them from the totality of samples (Parker et al., 1999).

Furthermore, distribution diagrams were constructed for the most abundant taxa and the determined ostracod assemblages, as well as the diversity and dominance indices.

4. Ostracod identification and classification

The current study revealed at least 31 ostracod species belonging to 20 genera from the sediment core P5 from Piraeus coastal area. Ostracod species identification was based on both external and internal morphology of the ostracod valves (Athersuch et al. 1989; Horne et al. 2002) such as the shape of the carapace and the valves, the ornamentation of the external part of the valves, the hinge structure, the adductor muscle scars pattern, the margin, the marginal pore canals and the vestibulum. Ostracod classification was based on the taxonomic scheme proposed by Horne et al. (2002). The main ostracod species are illustrated in 4 plates at the end of the chapter.

Class OSTRACODA
Subclass Podocopa
Order Podocopida
Suborder Cytherocopina
Superfamily Cytheroidea

Family Hemicytheridae
Genus *Aurila* POKORNY, 1955

***Aurila convexa* (BAIRD, 1850)**
Cythere convexa n. sp., W. Baird, 1850, The Natural History of the British Entomostraca, 174, pl. 21, fig. 3.
Aurila convexa (Baird), Uffenorde, 1972, p. 77, pl. 8: fig.4.
Aurila convexa (Baird), Yassini, 1979, Revista Espanola de Micropaleontologia, p. 379, pl.5: fig. 7-9.
Aurila convexa (Baird), Bonaduce et. al., 1975, Pubbl. Staz. Zool. Napoli, vol. 40, p. 43, pl. 21, fig. 17.
Aurila convexa (Baird), Stambolidis, 1984, p. 88, pl. 4: fig. 7.

***Aurila woodwardii* (BRADY, 1868) (Pl. 4, fig. 1-2)**
Cythere woodwardii n. sp. Brady 1868, Cote de Sicile; in: Les Fonds de la Mer, L. De Folin and L. Perier, Paris, 1,93, pi. 10, figs. 19-21.
Aurila woodwardi (Brady), Stambolidis, 1984, pl. 5: fig. 2.
Aurila woodwardi (Brady), Yassini, 1979, Revista Espanola de Micropaleontologia, pl.5: fig. 3-4.
Aurila woodwardii (Brady), Athersuch 1980, On *Aurila woodwardii*. Stereo-Atlas Ostracod Shells, 7(9): 45-52.

Genus ***Urocythereis* RUGGIERI, 1950**

***Urocythereis neapolitana* ATHERSUCH, 1977**
Urocythereis neapolitana. Athersuch, 1977, Bull. Br. Mus. Nat. Hist. (Zool). 32 (7), p.262, pl.15-17.
Urocythereis neapolitana Athersuch, Tsourou 2008, p.148, pl.4, fig 4.

Genus *Caudites* CORYELL & FIELDS, 1937

***Caudites calceolatus* (COSTA, 1853)**
Citherina calceolata n. sp., Costa, 1853, Ostracodi. Paleontologia del Regno di Napoli, 3, p.185, pl.16, fig. 14.
Caudites calceolatus (Costa), Barbeito-Gonzalez 1971, Mitt. Hamburg. Zool. Mus. Inst., B. 67, pl.XIII: fig. 1c-3c.
Caudites calceolatus (Costa), Bonaduce et. al., 1975, Pubbl. Staz. Zool. Napoli, vol. 40, pl. 26: fig. 10-13.

Family Loxoconchidae

Genus ***Loxoconcha* SARS, 1866**

***Loxoconcha* sp.**

***Loxoconcha affinis* (BRADY, 1866)**
(Pl. 3, fig. 1-2)
Normania affinis n. sp. Brady, 1866, The Transactions of the Zoological Society of London, 5(5), p.382, pl.61, figs 12a-d.
Loxoconcha affinis (Brady), Athersuch 1976, Stereo-Atlas of Ostracod Shells, 3(2): 91-98;
Loxoconcha affinis (Brady), Athersuch, 1979, Journal of Natural History, 13, p. 140: fig. 7.
Loxoconcha affinis (Brady), Stambolidis, E.-A., 1984, taf. VI: fig. 1-2.
Loxoconcha affinis (Brady), Danatsas, 1989, pl. 9: fig. 10-12.

***Loxoconcha elliptica* BRADY, 1868**
(Pl. 2, fig. 1-9)
Loxoconcha elliptica n. sp. Brady 1868, p. 435, pl. 27: fig. 38, 39, 45, 48.
Loxoconcha elliptica Brady, Stambolidis 1984, pl.6: fig. 11-12.
Loxoconcha elliptica Brady, Athersuch & Whittaker, 1976, Stereo-Atlas of Ostracod Shells, 3(2): 99-106.
Loxoconcha elliptica Brady, Mischke, et al. 2012, Quaternary International, 261. p.19, pl.1: fig. 8-9.

***Loxoconcha rubritrincta* RUGGIERI, 1964**
(Pl. 3, fig. 3-6)
Loxoconcha rubritrincta n. sp. Ruggieri 1964, p. 521, pl. 63: fig. 8-11.
Loxoconcha rubritrincta Ruggieri, Barbeito-Gonzalez 1971, Mitt. Hamburg. Zool. Mus. Inst., B. 67, p. 308, pl. 32: fig. 1c-4c.
Loxoconcha rubritrincta Ruggieri, Stambolidis 1984, pl.7: fig. 3-6.

Genus *Sagmatocythere* ATHERSUCH, 1976

***Sagmatocythere napoliana* (PURI, 1963)**
(Pl.4, fig.7)
Loxoconcha napoliana n.sp. Puri, 1963, Experientia, 29, 373.
Sagmatocythere napoliana (Puri), J. Athersuch, 1976, Stereo Atlas of Ostracod Shells, vol. 3(2): 117-124;

Loxoconcha napoliana (Puri), Stambolidis 1984, 1984, pl.8: fig. 13.

Family Xestoleberididae
Genus ***Xestoleberis*** **SARS, 1966**

Xestoleberis **sp.**

Xestoleberis communis **MUELLER, 1894**
(Pl. 2, fig. 10-12)
Xestoleberis communis n. sp. Mueller 1894, Fauna Flora Golf. Neapel, p. 338, pl. 25: fig. 32, 33, 39; pl. 26: *fig. 1, 6.*
Xestoleberis communis Mueller, Barbeito-Gonzalez, 1971, Mitt. Hamburg. Zool. Mus. Inst., B. 67,
pl.XXXIX: fig. 1d- 3b.
Xestoleberis communis Mueller, Bonaduce et. al., 1975, Pubbl. Staz. Zool. Napoli, vol. 40, pl. 72:, Fig. 1-5.
Xestoleberis communis Mueller, Athersuch 1976, Pubbl. Staz. Zool. Napoli, 40, p293, pl.11: fig.4, pl.12: figs.1-4, text-figs.5a, c, e-h, and 6c.
Xestoleberis communis Mueller, Danatsas (1989), pl.12: fig. 14-16.
Xestoleberis communis Mueller, Barra (1997), pl. VI: fig. 1.

Family Cytheruridae

Genus *Hemicytherura* ELOFSON, 1941

Hemicytherura videns **(MUELLER, 1894)**
(Pl.4, fig.7)
Cytheropteron videns n. sp. Mueller 1894, Fauna und Flora Golf von Neapel und der angrenzenden Meeres-Abschnitte, p.303, pl. 20: figs 2,8.
Hemicytherura videns (Mueller), Uffenorde, 1972, p. 88, pl. 9: fig. 9.
Hemicytherura videns videns (Mueller), Yassini, 1979, p. 385, pl. 5: fig. 19.
Hemicytherura videns videns (Mueller), Lachenal, 1989, Doc. Lab. Geol. Lyon, 108, p. 186.
Hemicytherura videns (Mueller), Barbeito-Gonzalez 1971, Mitt. Hamburg. Zool. Mus. Inst., B. 67 pl. 26: fig. 1b, 2

Genus *Semicytherura* WAGNER, 1957

Semicytherura **sp.**

Semicytherura incongruens **(MUELLER ,1894)**
(Pl.4, fig.9)
Cytherura incongruens n. sp. Mueller, 1894, Fauna und Flora Golf von Neapel und der angrenzenden Meeres-Abschnitte. Berlin, p.296 pl.17: figs 2, 7, 8, Pl. 19: fig. 7.
Semicytherura incongruens (Mueller), Stambolidis 1984, pl.8: fig. 6-8.

Semicytherura reticulata **(MUELLER, 1894)**
(Pl.4, fig.10)
Cytherura reticulata n. sp. Mueller, 1894, Fauna und Flora Golf von Neapel und der angrenzenden Meeres-Abschnitte. Berlin, p. 298, pl.17: figs 12, 13, pl. 19: fig. 17.
Semicytherura reticulata (Mueller), Bonaduce et. al., 1975, Pubbl. Staz. Zool. Napoli, vol. 40, p. 77, pl.41: fig. 16.

Semicytherura amorpha **BONADUCE, CIAMPO & MASOLI, 1975**
(Pl.4, fig.11)
Semicytherura amorpha n. sp. Bonaduce, Ciampo, & Masoli, 1975, Pubbl. Staz. Zool.Napoli, 40 p.54, Pl.32: figs 1-6.

Family Cushmanideidae

Genus *Pontocythere* DUBOWSKY, 1939

Pontocythere turbida **(MUELLER, 1894)**
(Pl. 4, fig. 5)
Cytheridea turbida n. sp. Mueller 1894, Fauna und Flora Golf von Neapel und der angrenzenden Meeres-Abschnitte P.361 , Pl. 30: Figs 28, 31-33, 40-45, 47.
Pontocythere turbida (Mueller) Bonaduce et al. (1975), Pubbl. Staz. Zool.Napoli Pl.35: figs 1-5.

Family Paradoxostomatidae

Genus *Cytherois* MUELLER, 1884

Cytherois fischeri **(SARS, 1866)**
(Pl.4, fig.3)
Paradoxostoma fischeri n.sp. Sars, 1866, 96.
Cytherois fischeri (Sars), Brady & Norman 1889, 228, pl. 21, figs 20-22.
Cytherois fischeri (Sars), Athersuch *et al.* 1989, Synopses of the British Fauna (New Series), p 308-310: text-fig. 134.
Cytherois fischeri (Sars), Cabral et al. 2017, p. 104, pl. 12: Fig.4.

Family Paracytherideidae

Genus *Paracytheridea* MUELLER, 1884

Paracytheridea **sp. (Pl. 4, fig. 6)**

Family Leptocytheridae

Genus *Leptocythere* SARS, 1925

Leptocythere lagunae **HARTMANN, 1958**
(Pl. 3, fig. 7-9)
Leptocythere lagunae n.sp. Hartmann, 1958, p. 226, pl. 34: fig. 105.
Leptocythere lagunae Hartmann, Bonaduce et. al., 1975, Pubbl. Staz. Zool. Napoli, vol. 40, p. 31, pl.15: figs 1-9, text-figs 10, 11.
Leptocythere lagunae Hartmann, Stambolidis 1984, p. 44.

Leptocythere levis **(MUELLER, 1894)**
(Pl. 3, fig. 11-12)
Cythere levis n.sp. Mueller, 1894, Fauna und Flora Golf von Neapel und der angrenzenden Meeres-Abschnitte, p. 357, pl. 27: fig. 31, pl. 28: figs 11-12.

Leptocythere levis (Mueller), Bonaduce et. al., 1975, Pubbl. Staz. Zool. Napoli, vol. 40, p. 32, pl.17: figs 1-3.

Leptocythere multipunctata **(SEGUENZA, 1884)**
(Pl. 3, fig. 10)
Cythere multipunctata n.sp. Seguenza, 1884, p. 29.
Leptocythere multipunctata (Seguenza), Barbeito-Gonzalez 1971, Mitt. Hamburg. Zool. Mus. Inst., B. 67 pl. I: fig. 8.
Leptocythere multipunctata (Seguenza), Doruk, 1980, *Stereo Atlas of Ostracod Shells*, 7/2: 151-154.

Leptocythere rara **(MUELLER, 1894)**
Cythere rara n. sp. Müller, 1894, p. 355, pl. 27 fig. 32, pl. 29 figs 12,14.
Leptocythere rara (Mueller), Bonaduce et al., 1975, Pubbl. Staz. Zool. Napoli, 40, p. 34-35, pl. 15: figs 10-14, text figs 17-18.
Leptocythere rara (Mueller), Lachenal, 1989, Doc. Lab. Geol. Lyon, 108, p. 149, pl. 3: fig. 8.

Genus *Callistocythere* RUGGIERI, 1953

Callistocythere **sp.**

Callistocythere crispata **(BRADY, 1868)**
Cythere crispata n. sp. Brady, 1868, p. 221, Pl. 14: Figs. 14–15.
Callistocythere crispata (Brady), Barbeito-Gonzalez, P.J., 1971, Mitt. Hamburg. Zool. Mus. Inst., B. 67, pl.10: fig. 1a- 3a.
Callistocythere crispata (Brady), Athersuch & Whittaker, 1980, Stereo-Atlas of Ostracod Shells, 7, pp. 67–72.

Family Cytherettidae

Genus *Cytheretta* MUELLER, 1894

Cytheretta **sp.**

Cytheretta subradiosa **(ROEMER, 1838)**

(Pl.4, fig. 12)
Cytherina subradiosa n. sp. Roemer, 1838.
Cytheretta subradiosa (Roemer) Masoli, 1968, p.32, pl. 8: fig. 115-116.
Cytheretta subradiosa (Roemer), Uffenorde, 1972, p. 79.
Cytheretta subradiosa (Roemer), Stambolidis, 1984, p. 104.

Family Cytherideidae

Genus *Cytheridea* BOSQUET, 1852

***Cytheridea* sp.**

Genus *Cyprideis* JONES, 1857

***Cyprideis torosa* (JONES, 1850)**
(Pl. 1, fig. 1-9)
Candona torosa n.sp. Jones 1850, p. 27, pl. 3: fig. 6.
Cyprideis torosa (Jones), Wagner, 1957, p. 39, pl. 14.
Cyprideis torosa (Jones), Athersuch et al. 1989, Synopses of the British Fauna (New Series), p 114-115, text-fig. 44, pl. 3: fig. 1-2.

Family Limnocytheridae

Genus *Limnocythere* BRADY, 1868

***Limnocythere inopinata* (BAIRD, 1850)**
(Pl. 1, fig. 13)
Cythere inopinata n. sp. Baird, 1843, Zoologist, 1, p. 195.
Limnocythere inopinata (Baird 1850), Meisch 2000, Susswasserfauna von Mitteleuropa 8/3, p. 427-432, figs 14B, 175, 176(A-D).

Suborder Cypridocopina
Superfamily Cypridoidea

Family Cyprididae

Genus *Cyprinotus* BRADY, 1868

***Cyprinotus salinus* (BRADY, 1868)**
(Pl. 1, fig. 10)
Cypris salina n. sp. Brady, 1868, p. 368
Cyprinotus salinus (Brady), Barbeito-Gonzalez 1971, Mitt. Hamburg. Zool. Mus. Inst., B. 67, p. 266, pl. V: fig. 1a- 2a.

Cyprinotus salinus (Brady), Stambolidis 1984, p. 149.

Subfamily Cypridopsinae

Genus *Sarscypridopsis* McKENZIE, 1977

***Sarscypridopsis aculeata* (COSTA, 1847)**
(Pl. 1, fig. 11)
Cypris aculeata n. sp. Costa 1847, Fauna Reg. Napoli, Crust. Fol., 1, p. 11, pl. 3, fig. 5.
Sarscypridopsis aculeata (Costa), Meisch 2000, Susswasserfauna von Mitteleuropa 8/3, p. 392-395, fig. 163.

Family Ilyocyprididae

Genus *Ilyocypris* BRADY & NORMAN, 1889

***Ilyocypris bradyi* SARS, 1890**
Ilyocypris bradyi n. sp. Sars, 1890, p. 93, figs 329-332.
Ilyocypris bradyi Sars, Meisch, 2000, Susswasserfauna von Mitteleuropa 8/3, p. 253-255, fig. 107.

***Iliocypris gibba* RAMDOHR, 1808**
(Pl. 1, fig. 12)
Cypris gibba n. sp. Ramdohr, 1808, *Mag. Ges. Naturf. Fr. Berlin*, 2, p. 91, pl. 3, figs 13, 14, 17
Iliocypris gibba Ramdohr, Meisch, 2000, Susswasserfauna von Mitteleuropa 8/3, p. 245-248, fig. 104.

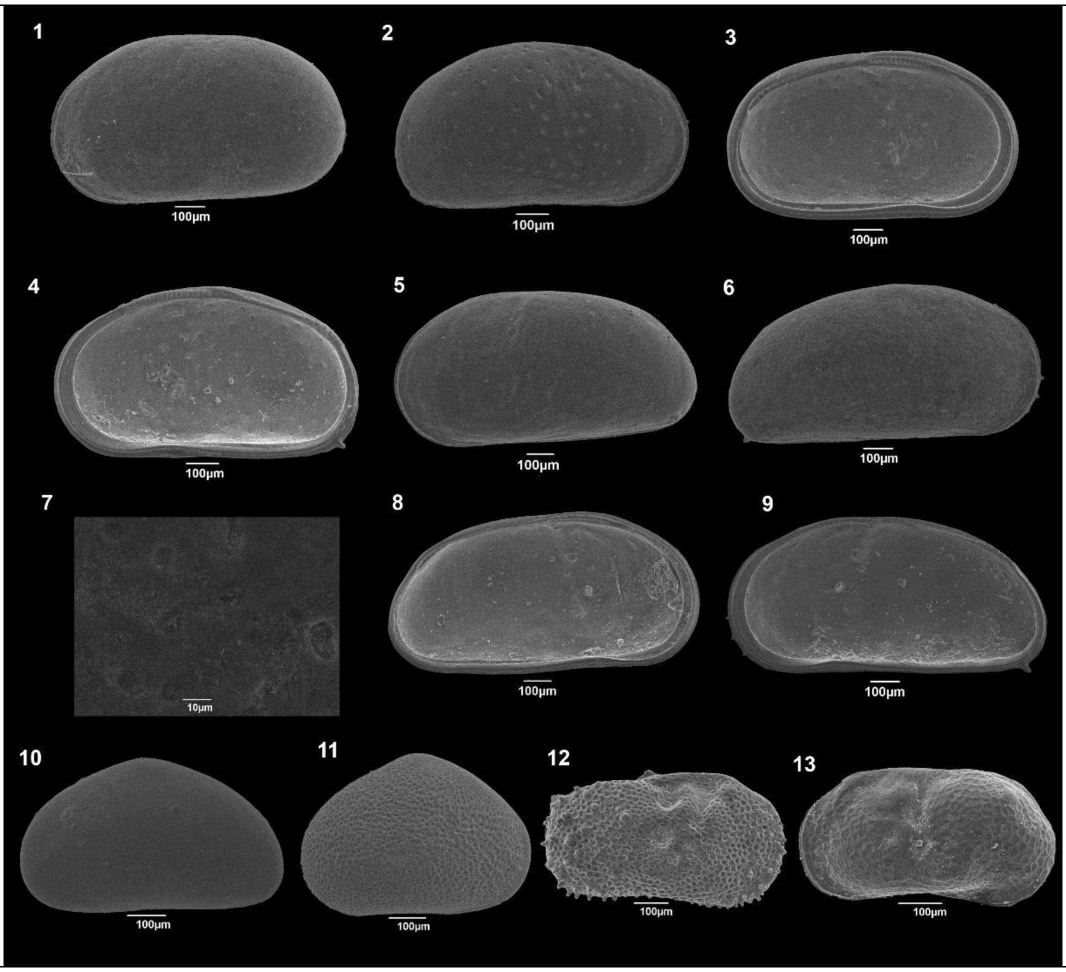

Plate 1. (1-9) *Cyprideis torosa*: (1) lv, female, external view (sample 1.74-1.81), (2) rv, female, external view (sample 3.95-4), (3) lv, female, internal view (sample 13.78-13.85), (4) rv, female, internal view (sample 13.78-13.85), (5) lv, male, external view (sample 1.74-1.81), (6) rv, male, external view (sample 5.85-5.9), (7) lv, male, internal muscle scar detail (sample 5.85-5.9), (8) lv, male, internal (sample 13.78-13.85), (9) rv, male, internal (sample 13.78-13.85). (10) *Cyprinotus salinus*, lv, external view (sample 12.18-12.22). (11) *Sarscypridopsis aculeata*, rv, external view (sample 5.85-5.9). (12) *Iliocypris gibba*, rv, external view (sample 9.90-9.96). (13) *Limnocythere inopinata*, lv, external view (sample 5.85-5.9).
rv: right valve, lv: left valve

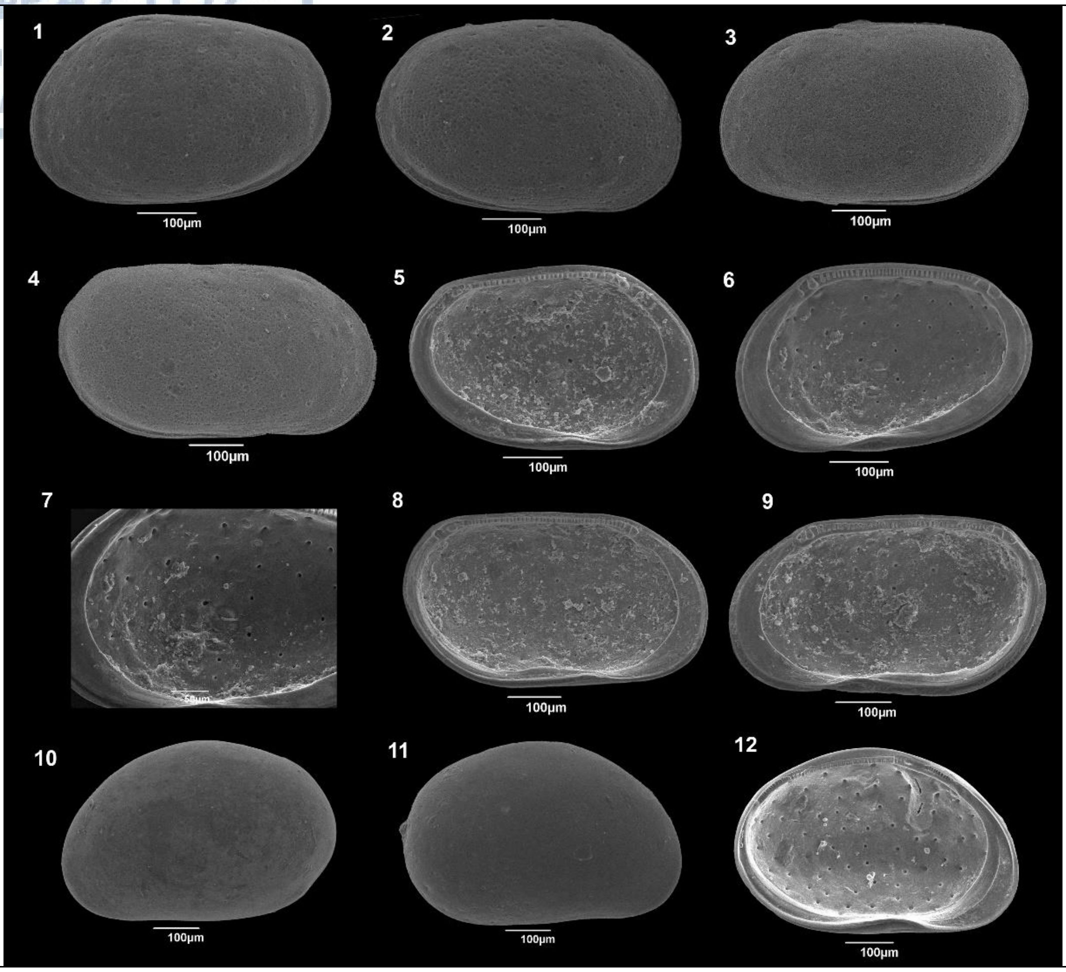

Plate 2. (1-9) *Loxoconcha elliptica* (sample 14.08-14.13): (1) lv, female, external view, (2) rv, female, external view, (3) lv, male, external view, (4) rv, male, external view, (5) lv, female, internal view, (6) rv, female, internal view, (7) detail of (6), (8) lv, male, internal view, (9) rv, male, internal view. (10-12) *Xestoleberis communis*: (10) lv, external view (sample 11.89-12.03), (11) rv, external view (sample 10.9-10.95), (12) lv, internal view (sample 10.9-10.95).
rv: right valve, lv: left valve

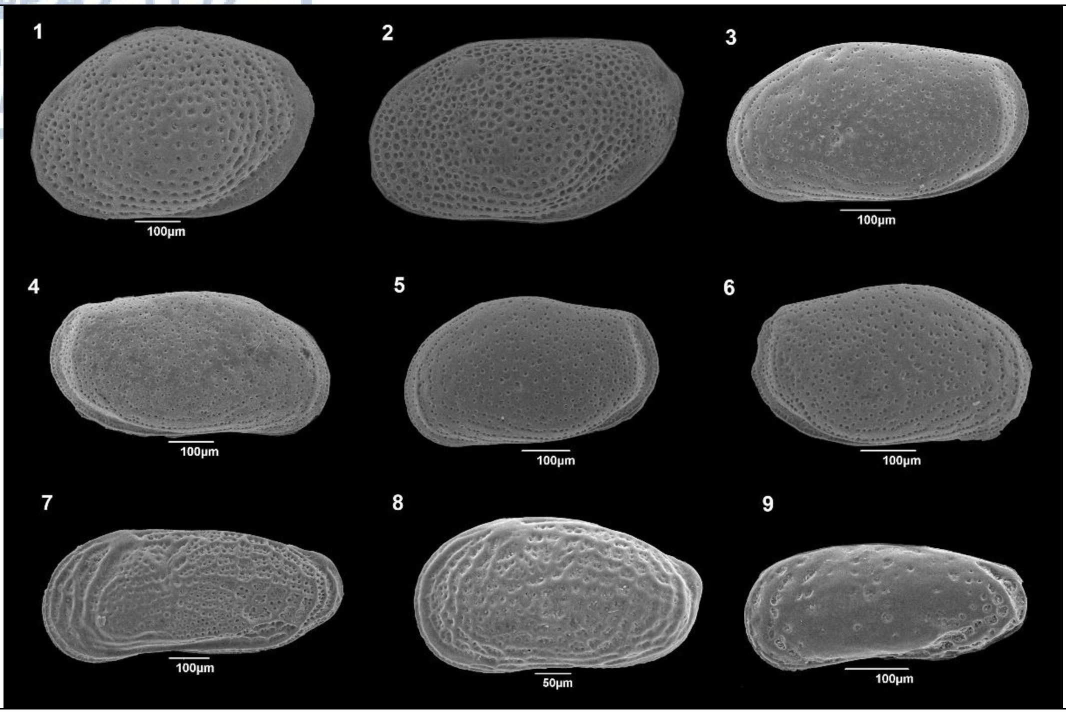

Plate 3. (1) *Loxoconcha affinis*, lv, female, external view (sample 14.35-14.4). (2) *L. affinis*, lv external view male (sample 10.9-10.95). (3-6) *Loxoconcha rubritrincta* (sample 5.95-6): (3) lv, male, external view, (4) rv, male, external view, (5) lv, female, external view, (6) rv, female, external view. (7) *Leptocythere lagunae*, lv external view (sample 5.95-6). (8) *Leptocythere multipunctata*, lv, external view (sample 9.78-9.84). (9) *Leptocythere levis*, lv, external view (sample 10.9-10.95).
rv: right valve, lv left valve

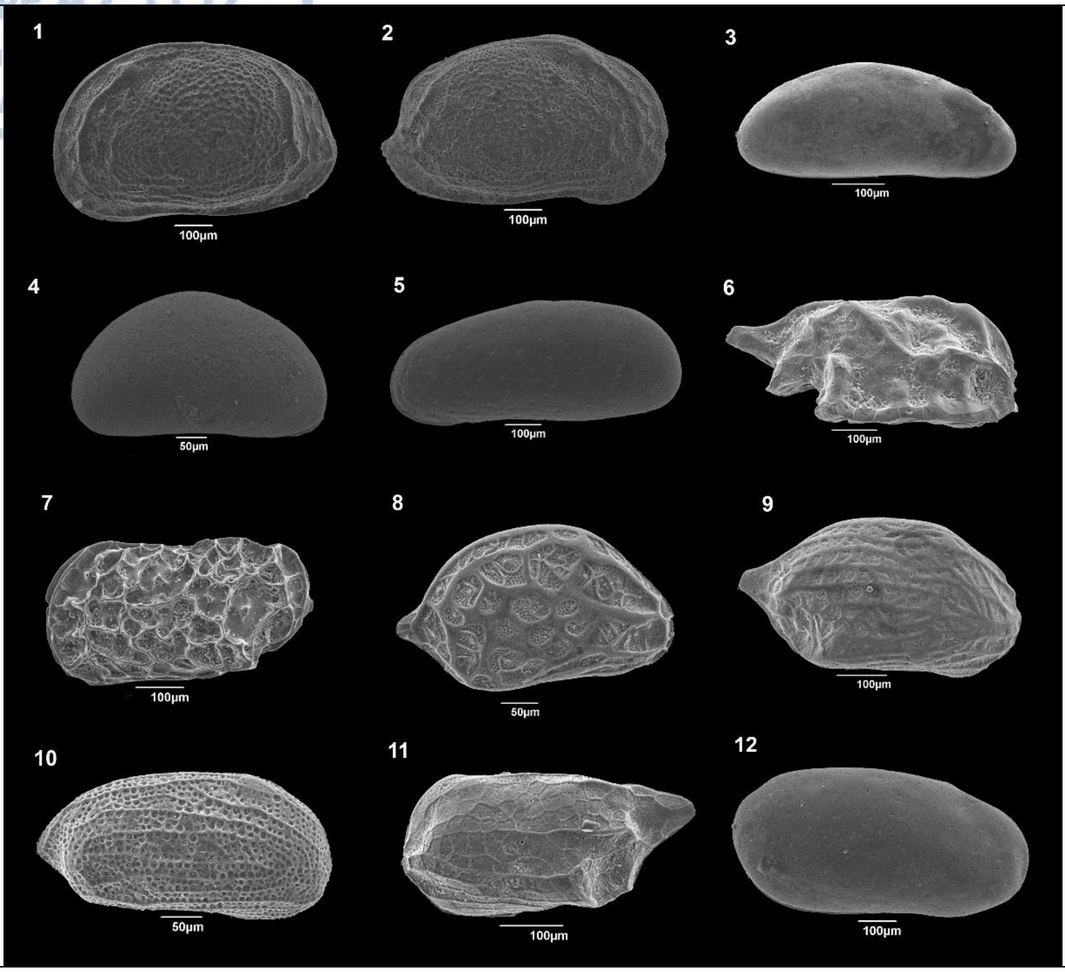

Plate 4. (1) *Aurila woodwardii*, lv, external view (sample 14.35-14.4). (2) *A. woodwardii*, rv, external view (sample 9.66-9.72). (3) *Cytherois fisheri*, lv, external view (sample 13.78-13.85). (4) *Xestoleberis* sp., rv, external view (sample 5.6-5.65). (5) *Pontocythere turbida*, lv, external view (7.1-7.2). (6) *Paracytheridea* sp., rv, external view (10.9-10.95). (7) *Sagmatocythere napoliana*, lv, external view (sample 7.1-7.2). (8) *Hemicytherura videns*, rv, external view (sample 9.9-9.96). (9) *Semicytherura incongruens*, rv, external view (sample 5.95-6). (10) *Semicytherura reticulata*, rv, external view (sample 5.95-6). (11) *Semicytherura amorpha*, lv, external view (sample 9.9-9.96). (12) *Cytheretta subradiosa*, rv, external view (sample 7.1-7.2). rv: right valve, lv left valve

5. Results

5.1 Distribution and abundance of ostracods along P5

41 samples were studied from the borehole P5. Samples 25P5, 36P5 and 38P5, corresponding to depths 8.82-8.91m, 4.5-4.55m and 4.06-4.1m respectively, presented very low number of valves (3-5) representing juveniles, therefore they were considered as barren of ostracods. Furthermore, 10 samples bear a small number of specimens, namely below 50 valves.

In the series of 38 samples 31 ostracod species were identified belonging to 20 genera. The number of taxa per sample ranges from 18 in 22P5 to 2 in 26P5 and 37P5, but generally ostracod assemblages present low number of species, usually 3-6 species per sample. Furthermore, the number of individuals is characteristically high in the samples for the intervals 14.40-12.03 m and 7.70-5.50 m, ranging from 34944 in 06P5 to 948 in 29P5.

Assemblage structure indices provide information about the population structure of each assemblage. Diversity indices display generally low values with significant fluctuations in the studied samples. Shannon-Wiener index is used to equally calculate eveness and and species richness ranges between H’= 0,112 in 31P5 and H’= 2.091 in 22P5. Simpson index varies between D’= 0,0345 in 31P5 and D’= 0,8214 in 22P5. Dominance index varies from 1 in 25P5, 36P5 and 39P5 to 0.18 in 22P5, mostly following the distribution pattern of the species *Cyprideis torosa* along P5. The highest values of diversity, the highest number of species and and the lowest values of dominance are observed mainly in two intervals of the sediment core: 10.95-9.66 m and 7.80-5.85 m.

The most abundant species is *C. torosa*, dominating the assemblages in most of the samples. It has its’ maximum concentration of 98.25% in sample 31P05. The second and third most abundant species are *X. communis* and *L. elliptica* respectively. The relative frequency of *X. communis* reached its maximum value (61.18%) in sample 15P5, while *L. elliptica* reached its maximum value in sample 06P5 (38.1%). In 19 out 41 samples (samples 01P5, 02P5, 04P5, 05P5, 07P5, 12P5, 13P5, 14P5, 25P5, 26P5, 31P5, 32P5, 33P5, 34P5, 35P5, 36P5, 38P5, 40P5, 41P5) the 3 most dominant species constituted over 90% of the total assemblage.

The genus *Xestoleberis* is represented by two species in the samples *X. communis*, and *Xestoleberis* sp., but the latter is present in very low percentages from 0.15 % to 1.63% in samples 22P5, 23P5, 27P5, 28P5, 30P5, 34P5 and 39P5. Accordingly, the genus *Loxoconcha* is represented by four species throughout the samples such as *L. elliptica*, *L. affinis*, *L. rubritrincta* and *Loxoconcha* sp. Apart from *L. elliptica*, the other species appear in the samples with lower percentages. To be more accurate, *L. rubritrincta* has a more prominent presence throughout the samples and reaches up to 16.92% in sample 28P5, while the maximum concentration of *L.affinis* is 7.06% in sample 22P5 and *Loxoconcha* sp. reaches 1.54% in sample 28P5.

Although *C. torosa* is the most abundant species over the largest part of P5, the composition of the total ostracod assemblages varies in terms of the accompanying species. In particular, the ostracod assemblages from the bottom to about 9.5 m are characterized by fluctuations of the participation rates of *C. torosa* (from 22.5% up to 95.56%). The accompanying fauna is mainly composed of *L. elliptica* (present in all samples, 0.48-38.10%), *C. salinus* (0.57-27.02%) and *X. communis* (0.10-67.18%), as well as the species *Pontocythere turbida* (0.39-21.20%), *Loxoconcha affinis* (0.47-7.07%) and *Leptocythere multipunctata* (0.36-7.69%) mainly at the upper part of this interval.

The samples from the middle part of the borehole reveal *C. torosa* (46.15-98.25%) as the dominant species, which is accompanied mainly by *L. elliptica*, *C. salinus, X. communis, L. rubritincta*, *P. turbida*, but none of these species is constantly present in this part of the core. Furthermore, the interval 5.90-5.70m is characterized by the presence of *S. aculeata, Ilyocypris* spp. and *L. inopinata.*

The upper part of the borehole is characterized by oligospecific assemblages and the high dominance of *C. torosa* (68.52-85.71%). Ostracod associations are completed with *L. elliptica* (2.22-17.59%), *C. salinus* (7.56-14.29%) and *X. communis* (3.11-14.29%).

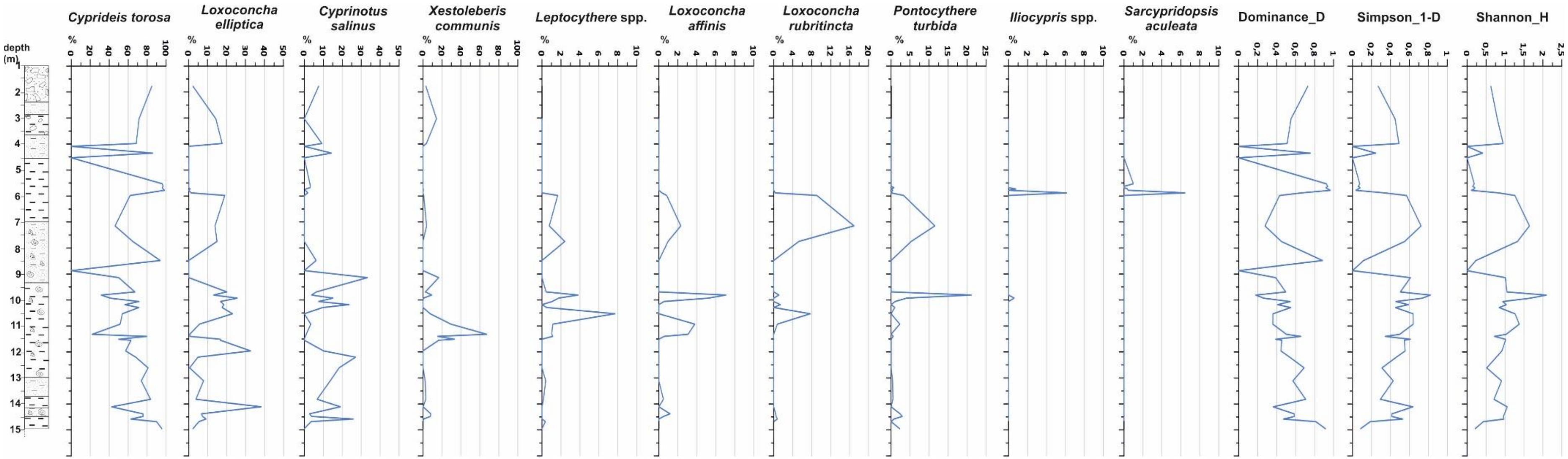

Figure 5. Distribution of the relative abundances of the most common ostracod species along sediment core P5.

5.2 Discrimination of ostracod assemblages

Q-mode hierarchical cluster analysis was applied in order to distinguish the ostracod assemblages of the core P5 and to determine their distribution along this core. The clustering method was applied excluding samples 25P5,36P5 and 38P5 (see chapter 5.1).

The Q mode cluster analysis grouped samples according to the similarities of their ostracod assemblages. The resulted dendrogram (Figure 6) differentiated between two main clusters, which present the following characteristics:

Cluster 1 is characterized by the absolute dominance of the species *C.torosa* and presents the highest values of Dominance-D and the lowest values of the diversity indices.

The clustered samples in **Cluster 1a** present almost monospecific ostracod associations, with *C.torosa* ranging from 98.25% in sample 31P5 (5.75-5.8 m) to 93.75% in sample 26P5 (8.43-8.52 m). The Dominance index bear its higher values (from 0,883 in sample 26P5 to 0,965 in sample 31P5) and the diversity indices present their lowermost values and in particular Shannon-H ranges from 0.112 (31P5) to 0.234 (26P5) and Simpson from 0.035 (31P5) to 0.117 (26P5). *C. torosa* is accompanied, in most of the samples, by *C.salinus* but with very low relative frequencies from 6.25% in 26P5 (8.43-8.52) to 0,44% in 31P5 (5.75-5.8). Other species but with scarce presence in the samples and very low participation rates are *L.elliptica*, *X.communis*, *I.bradyi*, *S.aculeata*, *C. fischeri* and *P. turbida*.

Ostracod assemblages of **Cluster 1b** are also highly dominated by *C.torosa* with relative frequencies from 73.83% in sample 08P5 (13.08-13.13 m) to 89.93% in sample 02P5 (14.65-14.7 m), that is about 10-20% lower participation rates than in Cluster 1a. Accordingly, assemblage structure indices are relatively better with the Dominance index ranging from 0,570 in sample 08P5 to 0,813 in sample 02P5, Shannon-H from 0,410 (37P5) to 0,908 (08P5) and Simpson from 0,187 (02P5) to 0,429 (08P5). *C. torosa* is accompanied mainly by *C.salinus* (from 1.93% in sample 30P5 to 18.38% in sample 09P5) and secondarily by *L.elliptica* (from 0.48% in sample 09P5 to 7.81% in sample 08P5)and *X.communis* (from 0.16% in sample 09P5 to 3.11% in sample 41P5). It has to be mentioned that sample 30P5 is characterized by the strong presence of the species *S.aculeata*, *I.bradyi*, *I. gibba, L. inopinata*, which species together make up 15,11% of the total assemblage, but they are absent from the other samples of this cluster. Other species but with scarce presence in the samples and very low participation rates are *Leptocythere* spp., *C. fischeri*, *P. turbida, L. affinis, L. rubritincta, Loxoconcha* sp., *A. convexa* and *A. woodwardii*.

Ostracod assemblages in **Cluster 2** are also characterized by the strong presence of *C.torosa,* which is the most or one of the most abundant species in all the samples of this cluster. Additionally, diversity indices present its highest values, while the dominance index the lower ones. These samples are discriminated in three subclusters based on the synthesis of the fauna that complements the assemblages.

The association of **Cluster 2a** is marked by the lowest participation rates of *C.torosa* (ranging from 22.05% in sample 15P5 to 46.15% in sample 28P5) in all the samples of P5 and the strong presence of

L. elliptica, *C. salinus*, *X. communis*, *P. turbida*, *L. affinis* and *Leptocythere* spp. Additionally, these samples comprise the highest values of the diversity indices. In particular, *L. elliptica* ranges from 0.51% in 15P5 to 25.58% in 21P5 and *C. salinus* ranges from 1.03% in 15P5 to 15.12% in 21P5. *X. communis* ranges from 0.58% in 21P5 to 9.24% in 22P5 but in sample 15P5 (11.29-11.34 m) is the most abundant species representing 67.8% of the total assemblage. *P. turbida* ranges from 4.08% in 21P5 to 21.20% in 22P5, *L. affinis* ranges from 2.31% in 28P5 to 7.07% in 22P5 and *Leptocythere* spp. range from 0.77% in 28P5 to 3.80% in 22P5. *L. rubritincta* is a species with significant participation rate (16.92%) in sample 28P5 (7.1-7.2 m), while at least 11 other species are present but scarcely and with low relative abundances in the samples, such as *C. fischeri, Semicytherura* spp., *Callistocythere* spp., *A. convexa, A. woodwardii, Xestoleberis* sp., *H. videns*. Finally, Dominance presents its lower value (0.179) in sample 22P5 where Shannon-H and Simpson indices present their higher values, that is 2.091 and 0.821 accordingly. Sample 15P5 (11.29-11.34 m) bears the lower values for the diversity indices (Shannon-H: 1.029; Simpson: 0.498), while dominance is as high as 0.502.

The samples clustered in **Cluster 2b** demonstrate ostracod faunas where *C.torosa* is present with higher percentages than in Cluster 2a. It is the most abundant species in all the clustered samples. As far as the diversity indices are concerned, they present significantly higher values than the ones of Cluster 1, but lower values than the ones of Cluster 2a. In particular, Dominance index ranging from 0,359 in sample 16P5 to 0,655 in sample 14P5, Shannon-H from 0,721 (14P5) to 1,375 (16P5) and Simpson from 0,345 (14P5) to 0,641 (16P5).

Ostracod assemblage of **Cluster 2b1** are discriminated from the one of **Cluster 2b2** by changes in the participation rates of the most abundant species.

The associations of **Cluster 2b1** were composed mainly of *C.torosa* (ranging from 50.00% in sample 13P5 to 79.43% in sample 14P5), *X.communis* (ranging from 7.80% in sample 04P5 to 33.33% in sample 13P5) and *L.elliptica* (ranging from 0.57% in sample 14P5 to 16.67% in samples 12P5, 13P5). Other species are also present but scarcely and with low relative abundances, such as *C. fisheri*, *Leptocythere* spp., *L. affinis*, *L. rubritincta*, *Loxconcha* sp., *A. convexa*, *A. woodwardii*, *P. turbida*.

The associations of **Cluster 2b2** were composed mainly of *C.torosa* (ranging from 42.67% in sample 06P5 to 71.35% in sample 20P5), *C. salinus* ranging from 6.41% in sample 23P5 to 33.33% in sample 24P5 but absent from three samples and *L.elliptica* ranging from 4.87% in sample 10P5 to 38.10% in sample 06P5. Species that are present with significant participation rates in certain samples are *X. communis* (ranging from 0.10% in sample 10P5 to 16.67% in sample 24P5), *Leptocythere* spp. (ranging from 0.43% in sample 23P5 to 7.69% in sample 17P5) and *L. rubritincta* (ranging from 0.76% in sample 03P5 to 9.09% in sample 29P5). Other species are also present but scarcely and with low relative abundances, such as *L. affinis*, , *Loxconcha* sp., *A. convexa*, *A. woodwardii*, *P. turbida, Cytheridea* sp., *C. crispata*, *U. neapolitana*, *Semicytherura* spp., *C. fisheri*.

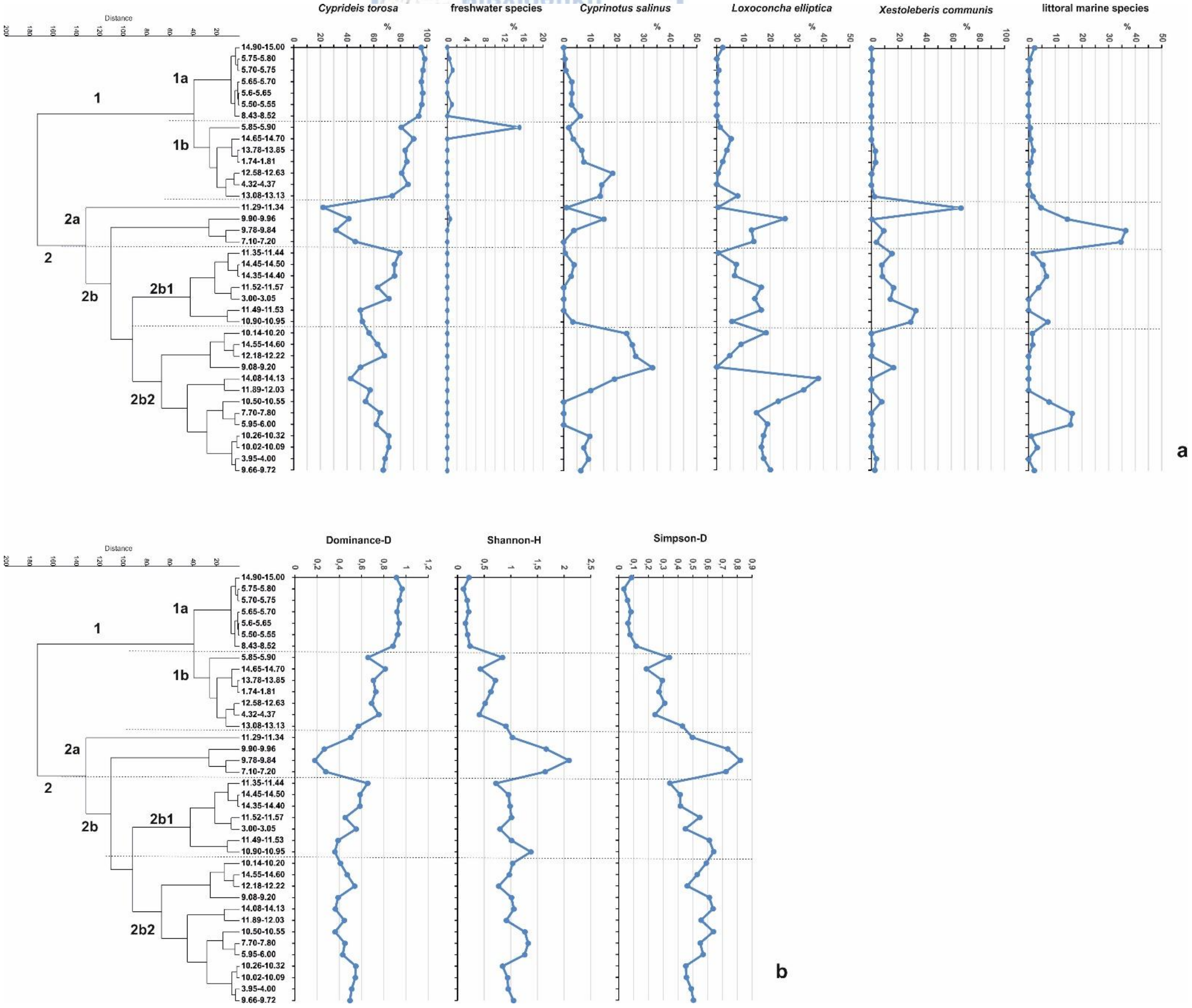

Figure 6. Dendrogram resulted from Q-mode cluster analysis compared to (a) the relative frequencies of the most abundant species and (b) the assemblage structure indices in the studied samples.

6. Discussion

6.1 Ecological analysis of the identified ostracod species

This chapter presents the main ecological characteristics of the identified ostracod species, in order to contribute to the interpretation of the assemblages resulted from the Q-mode clustering (chapter 5.2). The ostracod species were separated in four major groups based on their salinity preferences, as salinity is the main factor affecting the distribution patterns of ostracods in marginal marine environments (see chapter 1.2).

According to Por (1972) salinity is divided in three basic categories in the athalassic series: hypersaline waters (from 60 to over 300 ppt), saline waters (from 5 to 60 ppt) and oligohaline to fresh waters (from 0 to 5 ppt). While in the thalassic series water is divided in six categories. Those categories include: oligohaline (from 0.5 to 5 ppt), mesohaline (from 5 to 18 ppt), polyhaline (from 18 to 30 ppt), mixoeuhaline (from 30 to 40 ppt), metahaline lagoons (from 40 to 80 ppt) and hypersaline lagoons (from 80 to 180 ppt).

6.1.1 Fresh water to oligohaline species

Limnocythere inopinata inhabits mainly shallow, fresh to oligohaline water bodies like ponds, swamps, lakes, streams, and rivers, but it is also found in oligohaline inland coastal waters (Meisch, 2000).

Iliocypris gibba prefers shallow permanent water bodies with clayey, fine-mudded or sandy substrate (Meisch, 2000), but It is also recorded from oligohaline shallow brackish coastal environments (Carbonel, 1980; Clavé et al., 2001; Pavlopoulos et al., 2010).

Iliocypris bradyi : *I. bradyi* is a freshwater species which lives on muddy and sandy substrates in springs, ponds swamps and brackish oligohaline coastal waters (Wouters, 1983; Meisch, 2000).

Sarscypridopsis aculeata is common in coastal rockpools and ponds influenced by marine water. It has an optimum salinity range of 5–10‰ (Meisch & Broodbakker, 1993; Meisch, 2000).

6.1.2 Brackish water species

Generally, *Cyprideis torosa* is a highly euryhaline species showing adaptability to salinities from 0.4‰ to 150‰ (Neale, 1988), but it is primarily associated with areas of lowered salinity (Athersuch, 1979) and it occurs in dense populations when salinity ranges between 2-17‰ (Morkhoven, 1962). It occurs in shallow (<30m) marginal marine environments like lagoons and estuaries and it is found on sediment substrates and on algae (Athersuch et al. 1989).

Loxoconcha elliptica is an euryhaline species and a periphytal dweller and limivore (Carbonel et al., 1988), inhabiting the shallow waters of lagoons estuaries and salt marsh sediments (Ruiz et al, 2000; Athersuch et al., 1989; Cabral et al., 2006).

Cyprinotus salinus lives in fresh water to oligohaline environments (Mazzini et al., 1999; Triantaphyllou et al., 2003; Pavlopoulos et al., 2006) and in mesohaline waters as a species resistant to salinity fluctuations (Ruiz et al., 2006; Triantaphyllou et al., 2010; Pavlopoulos et al., 2007).

Cytherois fischeri is a brackish water marine littoral species and is tolerant to a wide range of salinities (4-35‰) and prefers muddy or sandy substrates with plants (Montenegro et al., 1998; Carboni et al., 2002; Cabral et al. 2017).

6.1.3 Marine species tolerating salinity fluctuations/lower salinities

Xestoleberis communis: Is a marine littoral species which lives on algae and sandy - muddy substrates (Athersuch et al., 1989; Ruiz et al., 2000; Cabral et al., 2006; Tsourou, 2012). It tolerates salinity fluctuations and it occurs in mesohaline brackish environments (Carboni et al., 2002; Ruiz et al., 2006).

Leptocythere lagunae is considered a marine brackish littoral species common in mesohaline lagoonal environments (Stambolidis, 1984; Ruiz et al., 2006; Aguzzi, et al., 2007; Tsourou, 2008) and intern estuaries (Nachite et al., 2010).

Leptocythere multipunctata is a shallow marine species (Doruk, 1980) tolerating lowering of salinity in mesohaline lagoons (Tsourou et al., 2021).

Leptocythere rara : Is a coastal shallow marine species which prefers muddy substrates (Bracone et al., 2012; Lachenal, 1989), also present in brackish waters (Ruiz et al., 2006).

6.1.4 Littoral marine species

L. rubritincta is a common marine species from the littoral zone, inhabiting fine to medium sands (Bonaduce et al., 1975; Tsourou, 2012).

L.affinis is a marine epiphytal species, inhabiting also fine sandsand prefers shallow water environments (Athersuch, 1979; Stambolidis, 1984; Tsourou, 2012), tolerating slightly reduced salinities (Athersuch, 1979).

Pontocythere turbida is a marine littoral species which occurs in sandy substrates (Tsourou, 2012) and it has been also found in lagoonal environments (Ruiz et al., 2006).

Aurila woodwardii is a littoral marine epibenthic and epiphytal species (Athersuch, 1979; Triantaphyllou et al., 2005; Tsourou, 2012), found also in brackish lagoonal environments (Athersuch, 1980; Sciuto, 2011) such as outer estuarine environments (Cabral et al., 2006) and deltaic-related settings (Carboni et al., 2002).

The marine species *Aurila convexa*, *Hemicytherura videns*, *Semicytherura* spp., *Callistocythere* spp., *Leptocythere levis, Caudites calceolatus*, *Sagmatocythere napoliana*, *Urocythereis neapolitana*, *Cytheridea* sp., *Paracytheridea* sp., *Cytheretta* spp. are typical littoral/coastal species, most of them prefer shallow sandy to silty substrates (Bonaduce et. al., 1975, Athersuch et al., 1989; Lachenal, 1989;

Tsourou, 2008; Loureiro et al., 2009; Tsourou, 2012). These species are of very low abundance in the studied samples and their presence in them is scarce.

6.2 Ostracod assemblages and their palaeoecological interpretation

The Q mode cluster analysis resulted to the distinction of five ostracod assemblages, each one corresponding to different palaeoenvironmental conditions, as it is indicated by the ecological analysis of the identified ostracod species (Chapter 6.1).

Overall, the high dominance and the large populations of *C.torosa* in the studied samples indicate the existence of a shallow brackish lagoonal environment. The composition of the accompanied ostracod faunas varies among the samples, pointing to salinity fluctuations in the lagoonal environment and, therefore, suggesting changes in the communication with the sea and/or changes of the freshwater inflow into the lagoon.

The **ostracod associations of Cluster 1**, which are dominated by the species *C.torosa*, present the lowest diversity and they are the only assemblages that include freshwater species, demonstrate a **restricted-closed lagoon**.

The **ostracod assemblage of Cluster 1a** with the total dominance of *C.torosa*, the lowermost values of the diversity indices and the low presence of *C.salinus*, a freshwater to oligohaline species common in brackish environments, point to a **closed oligohaline lagoonal environment**. The scarce presence of other freshwater species (*I.bradyi*, *S. aculeata*), other brackish water species (*L.elliptica*, *C. fischeri*) , as well as marine species (*X. communis*, *P. turbida*) confirm freshwater influx and minor marine influence.

The **ostracod assemblage of Cluster 1b** are dominated by *C.torosa*, accompanied mainly by *C.salinus*. The species *L.elliptica* and *X.communis* show significant relative frequencies in some samples pointing to a greater marine influence. This assemblage represents an **oligohaline to lower(?) mesohaline lagoonal environment**. The scarce presence of other brackish water species (*C. fischeri*) , as well as marine species (*Leptocythere* spp., *P. turbida, L. affinis, L. rubritincta, Loxoconcha* sp., *A. convexa* and *A. woodwardii*) confirm a minor marine influence. **Freshwater species** (*S.aculeata*, *I.bradyi*, *I. gibba, L. inopinata*) are present only in sample 30P5, where they constitute 15,11% of the total assemblage, demonstrating a significant **freshwater input at this level (5.85-5.90 m)** of P5.

Ostracod associations in Cluster 2 are composed mainly of *C.torosa,* brackish mesohaline to polyhaline species and marine species tolerating salinity fluctuations. Additionally, diversity indices' values are elevated and there are no freshwater species. Consequently, these assemblages reflect **higher marine influence in the lagoon**.

The **ostracod assemblage of Cluster 2a** is marked by the lowest participation rates of *C.torosa* and the strong presence of brackish mesohaline to polyhaline species (*L. elliptica*, *C. salinus*), marine species tolerating salinity fluctuations and lowering of salinity (*X. communis*, *Leptocythere* spp.) and marine littoral species (*P. turbida*, *L. affinis*). This assemblage demonstrates the highest diversity values. Furthermore, at certain levels other marine species present significant participation rates as *L. rubritincta* in sample 28P5 (7.1-7.2 m) and at least 10 other marine species are present but scarcely and with low relative abundances. Marine species represent 4.62%-36.41% of the total ostracod association. Overall, this assemblage represents an **euhaline shallow and vegetated environment, with open communication with the sea**.

Ostracod associations in Cluster 2b demonstrate ostracod faunas where *C.torosa* is present with higher percentages than in Cluster 2a, accompanied mainly by brackish water species and *X.communis*. Diversity indices present significantly higher values than the ones of Cluster 1, but lower values than the ones of Cluster 2a. These assemblages correspond to a **lagoonal brackish environment with communication with the sea**.

The **ostracod assemblage of Cluster 2b1** is composed mainly of *C.torosa*, *X.communis* and *L.elliptica* (ranging from 0.57% in sample 14P5 to 16.67% in samples 12P5, 13P5). These faunal composition suggests a **high mesohaline vegetated lagoonal environment, with permanent communication with the sea**. The scarce presence of other brackish water species (*C. fischeri*) , as well as marine species (*Leptocythere* spp., *L. affinis*, *L. rubritincta*, *Loxoconcha* sp., *A. convexa*, *A. woodwardii*, *P. turbida*) strengthen the palaeoenvironmental interpretation. Littoral marine species represent 1.71%-7.20% of the total ostracod association and in certain levels demonstrate strong marine influence.

The **ostracod assemblage of Cluster 2b2** is composed mainly of *C.torosa* and other brackish oligohaline (*C. salinus*) and mesohaline-euryhaline (*L. elliptica*) species. Marine species tolerating lower salinities are also participating in this assemblage (*X. communis*, *Leptocythere* spp.) as well as *L. rubritincta*. The aforementioned faunal characteristics indicate a **mesohaline probably vegetated lagoonal environment, with limited but stable communication with the sea.** The scarce presence of other brackish water species (*C. fischeri*) , as well as marine species (*L. affinis*, *Loxconcha* sp., *A. convexa*, *A. woodwardii*, *P. turbida, Cytheridea* sp., *C. crispata*, *U. neapolitana*, *Semicytherura* spp.) strengthen the palaeoenvironmental interpretation. Littoral marine species represent 1.39%-16.35% of the total ostracod association and in certain levels demonstrate strong marine influence..

6.3 Palaeoenvironmental evolution of P5

The palaeoenvironmental interpretation resulted from the detailed qualitative and quantitative analysis of the ostracod faunas indicates that a shallow brackish lagoon with rich subaquatic vegetation existed in the area of Piraeus coastal plain for the largest part of Holocene. The distribution pattern of the microfaunas points to alternations of mainly oligo-mesohaline to high mesohaline waterbodies.

Figure 7 shows the results of the micropalaeontological analysis of this study in relation to the lithology of the core and the lithostratigraphic units as they were distinguished by Goiral et al. (2011),

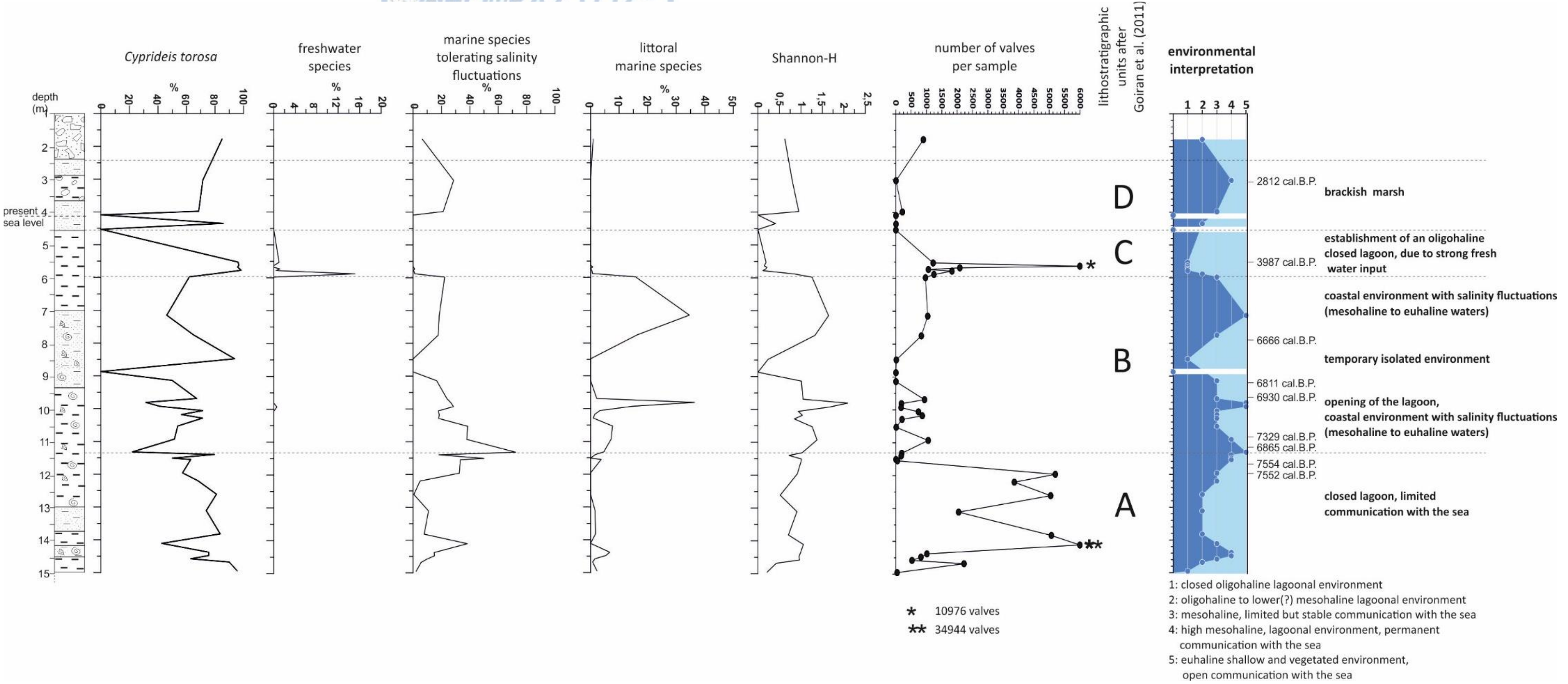

Figure 7. Palaeoenvironmental interpretation of P5 based on the palaeoecological data of the distinguished ostracod assemblages.

the number of the ostracod valves per sample and the overall assesment of the palaeoenvironments that alternate along P5. The abundance of the ostracod specimen is significant for the estimation of the palaeoenvironmental conditions. Ostracods are usually very abundant, more abundant than benthic foraminifera, in the freshwater to marine transitional environments, especially the oligohaline to mesohaline ones. They are usually present in these environments with oligospecific faunas but with a great number of individuals (e.g. Tsourou et al., 2015).

From the bottom of the sediment core P5 and along Unit A (up to about 7554 cal BP) a restricted-closed lagoon with limited communication with the sea is indicated by the prevalence of oligo-mesohaline and mesohaline assemblages. This isolated waterbody seems to open towards the top of this unit, as it is demonstrated by a gradual increase of the marine influence.

The interval of Unit B (after 7554 cal BP - before 3987 cal BP) is characterized by the prevalence of high mesohaline to euhaline ostracod assemblages which present their highest diversity, indicating that an open coastal environment was formed with salinity fluctuations.

The oligohaline ostracod assemblages in Unit C reflect a time period where the lagoon was closed and an oligohaline palaeoenvironment was established.

Finally, the upper part of core P5, which is represented by Unit D (up to about 2812 cal BP) is characterized by the presence of oligo-mesohaline and mesohaline assemblages as in Unit A, but with significantly lower abundances. A shallow isolated brackish waterbody, a marsh,is indicated.

The above mentioned environmental changes probably reflect sea level changes, which could be caused by climatic oscillations.The sea level rise trends during Holocene the sea level have been a combination of eustatic, isostatic as well as tectonic contributions (Lambeck,1995; Poulos et al., 2007). Until 5500 yrs BP there was a rapid sea level rise for the Aegean Sea while afterwards there was a slow and steady rise of 0.9mm/a up to the present shape (Poulos et al., 2007). Between 20000 yrs BP and 6000 yrs BP there was a rapid sea level rise while, glacioeustatic processes for the Mediterranean Sea had finished at 6000 yrs BP (Pirazzoli, 2005). Lambeck in 1995 calculated the sea level surface position of Greece in 18000 yrs BP,10000 yrs BP, 6000 yrs BP and 2000 years BP witch was below todays position 110 -130 m, 44-60m, 2-8 m and 1- 1.75 m respectively. Pizzaroli disagreed with Lambeck's theory and supported that global eustacy was stable over the last 6000 yrs and during the last 2000-3000 yrs the sea level changes were below 0.5 m. At 4500 yrs BP a low saline influx of the Black Sea happened in the Aegean (Kuhnt et al., 2008; Peyron et al., 2017).

The climate during the Holocene period in the Mediterranean basin differed regionally and presented variety (Mayewski et al.,2004; Peyron et al., 2017). From 9000 yrs BP to 8000 yrs BP volcanism caused a significant increase in volcanic aerosol witch caused global bipolar cooling and the intensification of atmospheric circulation (Mayewki et al., 2004). Pollen records proved that in the early Holocene the climate at the central and eastern parts of the Mediterranean was wet during the late Holocene (Finne et al., 2011; Peyron et al., 2017). From 6500 yrs BP to 6000 yrs BP the climatic conditions in the Mediterranean were dry. From 6000 yrs BP to 5000 yrs BP the marine isotope record from the

Mediterranean displayed cooler conditions in the Aegean (Finne et al., 2011). Due to geographical factors the SE Aegean climatic conditions were warm from 5500 yrs BP to 4000 yrs BP (Triantaphyllou et al.,2009). A warm humid period between 5400 yrs BP and 4300 yrs BP is inferred from marine sediments from the SE Aegean (Triantaphyllou et al.,2009; Finne et al.,2011). Generally, continuous warm and humid climatic conditions are recorded between 5500 Yrs Bp and 4000 yrs BP, which are indicated by a relatively stratified water column in the N.Aegean , the SE Aegean and the N.Levantine Sea (Triantaphyllou et al., 2014). In 4800 yrs BP sea level temperatures had a positive incline which was disrupted by the 4200 yrs BP climate event which trigerred a major low latitude drought (Triantaphyllou et al., 2013). The 4200 4.2 event refers to a universal dry and cool climatic anomaly that took place 4,200 yrs BP (Mayewski et al., 2004; Finne et al., 2011). Records from Lebanon suggest that between 4000 yrs BP and 3000 yrs BP wetter climatic conditions occurred (Kaniewski et al.,2008; Verheyden, et al.,2008; Finne et al., 2011).

Based on the aforementioned data, the sedimentary archive of P5 corresponds to a time span that sea level was lower than today, about -13m at 7500 BP (Lambeck, 1996; Lambeck & Purcell, 2005). The sea level rise explains the gradual opening, that is the sea intrusion, of the brackish lagoonal environment. Furthermore, an episode of freshwater input is indicated at the base of Unit C, signaling the beginning of the formation of an oligohaline waterbody (it began before 3987 cal BP). The latter could reflect the wetter period that began by the end of the 4.2 event.

7. Conclusions

Ostracods have been proven to be excellent palaeoenvironmental proxies in reconstructing the landscape evolution of the Piraeus coastal plain during the last 7500 years, as it is recorded along the P5 sedimentary archive.

The detailed qualitative and quantitative analyses revealed 31 ostracod species, while 5 assemblages were distinguished representing different palaeoenvironments which alternate along P5.

These assemblages recorded at least four stages in the palaeoenvironmental evolution of the study area:

- From the bottom of P5 up to about 7545 cal BP, the study area represented a brackish oligohaline to mesohaline lagoon with limited communication with the sea.
- After 7554 to about 3987 cal BP, a coastal environment was formed with salinity fluctuations. This is in accordance with Goiran et al. (2011), verifying Strabos hypothesis for the Island of Piraeus.
- Upwards, a closed oligohaline palaeoenvironment is indicated, as a strong freshwater influence is recoded, beginning at about 3987 cal BP. This could be associated with the wet period that started after the 4.2 dry event.
- Finally, after 2812 cal BP a brackish marsh was formed.

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Appendices

Appendix 1a. Absolute abundances of the ostracod species in the studied samples.

SAMPLES	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	14.9-15	**14.65- 14.7**	**14.55 - 14.6**	**14.45-14.5**	**14.35-14.4**	**14.08-14.13**	**13.78-13.85**	**13.08-13.13**	**12.58-12.63**	**12.18-12.22**	**11.89-12.03**	**11.52-11.57**	**11.49-11.53**	**11.35-11.44**
Aurila convexa	0	0	0	0	0	0	24	0	0	0	0	0	0	1
Aurila woodwardii	0	16	0	0	16	0	16	0	0	0	0	2	0	0
Callistocythere **sp.**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Callistocythere crispata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caudites calceolatus	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cytheridea **sp.**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cytheretta subradiosa	0	0	0	4	0	0	0	0	0	0	0	0	0	0
Cytheretta **sp.**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cytherois fischeri	0	0	0	0	0	0	48	8	0	0	0	0	0	2
Cyprideis torosa	43	2000	332	620	768	14912	4240	1512	4088	2628	2976	34	3	139
Cyprinotus salinus	0	80	136	32	28	6656	344	280	928	1044	528	0	0	1
Hemicytherura videns	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iliocypris bradyi	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iliocypris gibba	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leptocythere lagunae	0	0	0	0	0	0	8	0	0	0	0	0	0	2
Leptocythere rara	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leptocythere multipunctata	0	8	0	0	0	0	0	8	0	0	0	0	0	0
Leptocythere levis	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Limnocythere inopinata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loxoconcha elliptica	1	120	48	60	68	13312	192	160	24	188	1696	9	1	1
Loxoconcha **sp.**	0	0	0	0	8	0	0	16	0	0	0	0	0	0
Loxoconcha affinis	0	0	0	4	12	0	24	0	0	0	0	0	0	1
Loxoconcha rubritrincta	0	0	4	4	4	0	0	0	0	0	0	0	0	0
Paracytheridea **sp.**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pontocythere turbida	1	0	4	24	24	0	24	8	0	0	0	0	0	1
Sagmatocythere napoliana	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sarcypridopsis aculeata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Semicytherura **spp.**	0	0	0	0	0	0	0	8	0	0	0	0	0	0
Urocythereis neapolitana	0	0	0	8	4	0	0	0	0	0	0	0	0	0
Xestoleberis communis	0	0	4	64	84	64	152	48	8	4	0	9	2	27
Xestoleberis **sp.**	0	0	0	0	0	0	0	0	0	0	0	0	0	0
total	45	2224	528	820	1016	34944	5072	2048	5048	3864	5200	54	6	175

Appendix 1b. Absolute abundances of the ostracod species in the studied samples.

SAMPLES	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	11.29-11.34	**10.9-10.95**	**10.5-10.55**	**10.26-10.32**	**10.14-10.2**	**10.02-10.09**	**9.90-9.96**	**9.78-9.84**	**9.66-9.72**	**9.08-9.2**	**8.82-8.91**	**8.43-8.52**	**7.7-7.8**	**7.1-7.2**
Aurila convexa	0	0	0	0	0	8	3	0	4	0	0	0	0	0
Aurila woodwardii	2	0	0	0	0	0	0	1	12	0	0	0	16	8
***Callistocythere* sp.**	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Callistocythere crispata	0	0	0	0	0	0	1	2	0	0	0	0	4	0
Caudites calceolatus	0	0	0	0	0	0	0	0	0	0	0	0	0	8
***Cytheridea* sp.**	0	0	0	0	0	0	0	0	0	0	0	0	4	0
Cytheretta subradiosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0
***Cytheretta* sp.**	0	0	0	0	0	0	0	1	0	0	0	0	4	0
Cytherois fischeri	7	16	0	0	0	0	1	1	8	0	0	0	4	0
Cyprideis torosa	43	544	7	146	488	528	71	58	628	3	5	15	540	480
Cyprinotus salinus	2	36	0	20	204	56	26	7	60	2	0	1	0	0
Hemicytherura videns	0	0	0	0	0	0	1	2	0	0	0	0	0	0
Iliocypris bradyi	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iliocypris gibba	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Leptocythere lagunae	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Leptocythere rara	0	4	0	0	0	8	0	5	4	0	0	0	12	0
Leptocythere multipunctata	1	4	1	1	0	0	3	1	0	0	0	0	8	0
Leptocythere levis	0	4	0	0	0	0	0	1	0	0	0	0	0	8
Limnocythere inopinata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loxoconcha elliptica	1	60	3	36	160	124	44	24	188	0	0	0	124	144
***Loxoconcha* sp.**	0	0	0	0	0	0	0	2	4	0	0	0	4	16
Loxoconcha affinis	6	40	0	0	0	4	9	13	0	0	0	0	8	24
Loxoconcha rubritrincta	0	8	1	0	12	0	0	2	0	0	0	0	44	176
***Paracytheridea* sp.**	0	4	0	0	0	0	0	0	0	0	0	0	0	0
Pontocythere turbida	0	24	0	2	0	8	7	39	0	0	0	0	44	120
Sagmatocythere napoliana	0	0	0	0	0	0	0	0	0	0	0	0	0	8
Sarcypridopsis aculeata	0	0	0	0	0	0	0	0	0	0	0	0	0	0
***Semicytherura* spp.**	0	0	0	0	0	4	4	5	0	0	0	0	4	0
Urocythereis neapolitana	0	0	0	0	0	0	0	0	0	0	0	0	4	0
Xestoleberis communis	131	312	1	0	0	0	1	17	24	1	0	0	0	40
***Xestoleberis* sp.**	0	0	0	0	0	0	0	3	4	0	0	0	8	8
total	195	1056	13	205	864	740	172	184	936	6	5	16	832	1040

Appendix 1c. Absolute abundances of the ostracod species in the studied samples.

SAMPLES	29	30	31	32	33	34	35	36	37	38	39	40	41
	5.95-6	**5.85-5.9**	**5.75-5.8**	**5.7-5.75**	**5.65-5.7**	**5.6-5.65**	**5.5-5.55**	**4.5-4.55**	**4.32-4.37**	**4.06-4.1**	**3.95-4**	**3-3.05**	**1.74-1.81**
Aurila convexa	8	0	0	0	0	0	0	0	0	0	0	0	8
Aurila woodwardii	0	0	0	0	0	0	0	0	0	0	0	0	0
***Callistocythere* sp.**	0	0	0	0	0	0	0	0	0	0	0	0	0
Callistocythere crispata	0	0	0	0	0	0	0	0	0	0	0	0	0
Caudites calceolatus	0	0	0	0	0	0	0	0	0	0	0	0	0
***Cytheridea* sp.**	0	0	0	0	0	0	0	0	0	0	0	0	0
Cytheretta subradiosa	0	0	0	0	0	0	0	0	0	0	0	0	0
***Cytheretta* sp.**	0	0	0	0	0	0	0	0	0	0	0	0	0
Cytherois fischeri	8	0	0	0	8	0	0	0	0	0	0	0	12
Cyprideis torosa	600	1004	1800	1032	2000	10624	1168	3	6	5	148	5	764
Cyprinotus salinus	0	24	8	8	64	336	36	0	1	0	20	0	68
Hemicytherura videns	0	0	0	0	0	0	0	0	0	0	0	0	0
Iliocypris bradyi	0	44	0	8	0	0	0	0	0	0	0	0	0
Iliocypris gibba	0	32	0	0	0	0	0	0	0	0	0	0	0
Leptocythere lagunae	8	0	0	0	0	0	0	0	0	0	0	0	0
Leptocythere rara	8	0	0	0	0	0	0	0	0	0	0	0	0
Leptocythere multipunctata	0	0	0	0	0	0	0	0	0	0	0	0	0
Leptocythere levis	0	0	0	0	0	0	0	0	0	0	0	0	0
Limnocythere inopinata	0	32	0	0	0	0	0	0	0	0	0	0	0
Loxoconcha elliptica	184	16	0	8	0	0	0	0	0	0	38	1	20
***Loxoconcha* sp.**	0	0	0	0	0	0	0	0	0	0	0	0	0
Loxoconcha affinis	8	4	0	0	0	0	0	0	0	0	0	0	0
Loxoconcha rubritrincta	88	4	0	0	0	0	0	0	0	0	0	0	0
***Paracytheridea* sp.**	0	0	0	0	0	0	0	0	0	0	0	0	0
Pontocythere turbida	32	0	8	0	16	0	0	0	0	0	0	0	0
Sagmatocythere napoliana	0	0	0	0	0	0	0	0	0	0	0	0	0
Sarcypridopsis aculeata	0	80	8	4	0	0	12	0	0	0	0	0	0
***Semicytherura* spp.**	8	0	0	0	0	0	0	0	0	0	0	0	0
Urocythereis neapolitana	8	0	0	0	0	0	0	0	0	0	0	0	0
Xestoleberis communis	8	0	8	4	0	0	0	0	0	0	8	1	28
***Xestoleberis* sp.**	0	4	0	0	0	16	0	0	0	0	2	0	0
total	968	1244	1832	1064	2088	10976	1216	3	7	5	216	7	900

Appendix 2a. Relative abundances of the ostracod species in the studied samples.

SAMPLES	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	14.9-15	**14.65- 14.7**	**14.55 - 14.6**	**14.45-14.5**	**14.35-14.4**	**14.08-14.13**	**13.78-13.85**	**13.08-13.13**	**12.58-12.63**	**12.18-12.22**	**11.89-12.03**	**11.52-11.57**	**11.49-11.53**	**11.35-11.44**
Aurila convexa	0,00	0,00	0,00	0,00	0,00	0,00	0,47	0,00	0,00	0,00	0,00	0,00	0,00	0,57
Aurila woodwardii	0,00	0,72	0,00	0,00	1,57	0,00	0,32	0,00	0,00	0,00	0,00	3,70	0,00	0,00
***Callistocythere* sp.**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Callistocythere crispata	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Caudites calceolatus	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
***Cytheridea* sp.**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Cytheretta subradiosa	0,00	0,00	0,00	0,49	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
***Cytheretta* sp.**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Cytherois fischeri	0,00	0,00	0,00	0,00	0,00	0,00	0,95	0,39	0,00	0,00	0,00	0,00	0,00	1,14
Cyprideis torosa	95,56	89,93	62,88	75,61	75,59	42,67	83,60	73,83	80,98	68,01	57,23	62,96	50,00	79,43
Cyprinotus salinus	0,00	3,60	25,76	3,90	2,76	19,05	6,78	13,67	18,38	27,02	10,15	0,00	0,00	0,57
Hemicytherura videns	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Iliocypris bradyi	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Iliocypris gibba	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Leptocythere lagunae	0,00	0,00	0,00	0,00	0,00	0,00	0,16	0,00	0,00	0,00	0,00	0,00	0,00	1,14
Leptocythere rara	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Leptocythere multipunctata	0,00	0,36	0,00	0,00	0,00	0,00	0,00	0,39	0,00	0,00	0,00	0,00	0,00	0,00
Leptocythere levis	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Limnocythere inopinata	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Loxoconcha elliptica	2,22	5,40	9,09	7,32	6,69	38,10	3,79	7,81	0,48	4,87	32,62	16,67	16,67	0,57
***Loxoconcha* sp.**	0,00	0,00	0,00	0,00	0,79	0,00	0,00	0,78	0,00	0,00	0,00	0,00	0,00	0,00
Loxoconcha affinis	0,00	0,00	0,00	0,49	1,18	0,00	0,47	0,00	0,00	0,00	0,00	0,00	0,00	0,57
Loxoconcha rubritrincta	0,00	0,00	0,76	0,49	0,39	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
***Paracytheridea* sp.**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Pontocythere turbida	2,22	0,00	0,76	2,93	2,36	0,00	0,47	0,39	0,00	0,00	0,00	0,00	0,00	0,57
Sagmatocythere napoliana	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Sarcypridopsis aculeata	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
***Semicytherura* spp.**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,39	0,00	0,00	0,00	0,00	0,00	0,00
Urocythereis neapolitana	0,00	0,00	0,00	0,98	0,39	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Xestoleberis communis	0,00	0,00	0,76	7,80	8,27	0,18	3,00	2,34	0,16	0,10	0,00	16,67	33,33	15,43
***Xestoleberis* sp.**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	100	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Appendix 2b. Relative abundances of the ostracod species in the studied samples.

SAMPLES	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	11.29-11.34	**10.9-10.95**	**10.5-10.55**	**10.26-10.32**	**10.14-10.2**	**10.02-10.09**	**9.90-9.96**	**9.78-9.84**	**9.66-9.72**	**9.08-9.2**	**8.82-8.91**	**8.43-8.52**	**7.7-7.8**	**7.1-7.2**
Aurila convexa	0,00	0,00	0,00	0,00	0,00	1,08	1,74	0,00	0,43	0,00	0,00	0,00	0,00	0,00
Aurila woodwardii	1,03	0,00	0,00	0,00	0,00	0,00	0,00	0,54	1,28	0,00	0,00	0,00	1,92	0,77
***Callistocythere* sp.**	0,51	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Callistocythere crispata	0,00	0,00	0,00	0,00	0,00	0,00	0,58	1,09	0,00	0,00	0,00	0,00	0,48	0,00
Caudites calceolatus	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,77
***Cytheridea* sp.**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,48	0,00
Cytheretta subradiosa	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
***Cytheretta* sp.**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,54	0,00	0,00	0,00	0,00	0,48	0,00
Cytherois fischeri	3,59	1,52	0,00	0,00	0,00	0,00	0,58	0,54	0,85	0,00	0,00	0,00	0,48	0,00
Cyprideis torosa	22,05	51,52	53,85	71,22	56,48	71,35	41,28	31,52	67,09	50,00	100,00	93,75	64,90	46,15
Cyprinotus salinus	1,03	3,41	0,00	9,76	23,61	7,57	15,12	3,80	6,41	33,33	0,00	6,25	0,00	0,00
Hemicytherura videns	0,00	0,00	0,00	0,00	0,00	0,00	0,58	1,09	0,00	0,00	0,00	0,00	0,00	0,00
Iliocypris bradyi	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Iliocypris gibba	0,00	0,00	0,00	0,00	0,00	0,00	0,58	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Leptocythere lagunae	0,51	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Leptocythere rara	0,00	0,38	0,00	0,00	0,00	1,08	0,00	2,72	0,43	0,00	0,00	0,00	1,44	0,00
Leptocythere multipunctata	0,51	0,38	7,69	0,49	0,00	0,00	1,74	0,54	0,00	0,00	0,00	0,00	0,96	0,00
Leptocythere levis	0,00	0,38	0,00	0,00	0,00	0,00	0,00	0,54	0,00	0,00	0,00	0,00	0,00	0,77
Limnocythere inopinata	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Loxoconcha elliptica	0,51	5,68	23,08	17,56	18,52	16,76	25,58	13,04	20,09	0,00	0,00	0,00	14,90	13,85
***Loxoconcha* sp.**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,09	0,43	0,00	0,00	0,00	0,48	1,54
Loxoconcha affinis	3,08	3,79	0,00	0,00	0,00	0,54	5,23	7,07	0,00	0,00	0,00	0,00	0,96	2,31
Loxoconcha rubritrincta	0,00	0,76	7,69	0,00	1,39	0,00	0,00	1,09	0,00	0,00	0,00	0,00	5,29	16,92
***Paracytheridea* sp.**	0,00	0,38	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Pontocythere turbida	0,00	2,27	0,00	0,98	0,00	1,08	4,07	21,20	0,00	0,00	0,00	0,00	5,29	11,54
Sagmatocythere napoliana	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,77
Sarcypridopsis aculeata	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
***Semicytherura* spp.**	0,00	0,00	0,00	0,00	0,00	0,54	2,33	2,72	0,00	0,00	0,00	0,00	0,48	0,00
Urocythereis neapolitana	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,48	0,00
Xestoleberis communis	67,18	29,55	7,69	0,00	0,00	0,00	0,58	9,24	2,56	16,67	0,00	0,00	0,00	3,85
***Xestoleberis* sp.**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,63	0,43	0,00	0,00	0,00	0,96	0,77
total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Appendix 2c. Relative abundances of the ostracod species in the studied samples.

SAMPLES	29	30	31	32	33	34	35	36	37	38	39	40	41
	5.95-6	**5.85-5.9**	**5.75-5.8**	**5.7-5.75**	**5.65-5.7**	**5.6-5.65**	**5.5-5.55**	**4.5-4.55**	**4.32-4.37**	**4.06-4.1**	**3.95-4**	**3-3.05**	**1.74-1.81**
Aurila convexa	0,83	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,89
Aurila woodwardii	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
***Callistocythere* sp.**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Callistocythere crispata	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Caudites calceolatus	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
***Cytheridea* sp.**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Cytheretta subradiosa	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
***Cytheretta* sp.**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Cytherois fischeri	0,83	0,00	0,00	0,00	0,38	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,33
Cyprideis torosa	61,98	80,71	98,25	96,99	95,79	96,79	96,05	100,00	85,71	100,00	68,52	71,43	84,89
Cyprinotus salinus	0,00	1,93	0,44	0,75	3,07	3,06	2,96	0,00	14,29	0,00	9,26	0,00	7,56
Hemicytherura videns	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Iliocypris bradyi	0,00	3,54	0,00	0,75	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Iliocypris gibba	0,00	2,57	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Leptocythere lagunae	0,83	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Leptocythere rara	0,83	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Leptocythere multipunctata	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Leptocythere levis	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Limnocythere inopinata	0,00	2,57	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Loxoconcha elliptica	19,01	1,29	0,00	0,75	0,00	0,00	0,00	0,00	0,00	0,00	17,59	14,29	2,22
***Loxoconcha* sp.**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Loxoconcha affinis	0,83	0,32	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Loxoconcha rubritrincta	9,09	0,32	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
***Paracytheridea* sp.**	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Pontocythere turbida	3,31	0,00	0,44	0,00	0,77	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Sagmatocythere napoliana	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Sarcypridopsis aculeata	0,00	6,43	0,44	0,38	0,00	0,00	0,99	0,00	0,00	0,00	0,00	0,00	0,00
***Semicytherura* spp.**	0,83	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Urocythereis neapolitana	0,83	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Xestoleberis communis	0,83	0,00	0,44	0,38	0,00	0,00	0,00	0,00	0,00	0,00	3,70	14,29	3,11
***Xestoleberis* sp.**	0,00	0,32	0,00	0,00	0,00	0,15	0,00	0,00	0,00	0,00	0,93	0,00	0,00
total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Appendix 3. The community structure indices calculated for the studied samples in both cores.

SAMPLES		Taxa_S	Individuals	Dominance_D	Simpson_1-D	Shannon_H
1	**14.9-15**	3	45	0,9141	0,08593	0,2126
2	**14.65- 14.7**	5	2224	0,813	0,187	0,4283
3	**14.55 - 14.6**	6	528	0,4702	0,5298	0,9701
4	**14.45-14.5**	9	820	0,5857	0,4143	0,9548
5	**14.35-14.4**	10	1016	0,5845	0,4155	0,9856
6	**14.08-14.13**	4	34944	0,3635	0,6365	1,058
7	**13.78-13.85**	10	5072	0,7059	0,2941	0,7098
8	**13.08-13.13**	9	2048	0,5705	0,4295	0,9078
9	**12.58-12.63**	4	5048	0,6896	0,3104	0,5178
10	**12.18-12.22**	4	3864	0,5379	0,4621	0,7699
11	**11.89-12.03**	3	5200	0,4442	0,5558	0,9171
12	**11.52-11.57**	4	54	0,4534	0,5466	1,011
13	**11.49-11.53**	3	6	0,3889	0,6111	1,011
14	**11.35-11.44**	9	175	0,6551	0,3449	0,7211
15	**11.29-11.34**	10	195	0,5025	0,4975	1,029
16	**10.9-10.95**	12	1056	0,3594	0,6406	1,375
17	**10.5-10.55**	5	13	0,3609	0,6391	1,264
18	**10.26-10.32**	5	205	0,5477	0,4523	0,8454
19	**10.14-10.2**	4	864	0,4093	0,5907	1,035
20	**10.02-10.09**	8	740	0,5433	0,4567	0,9388
21	**9.90-9.96**	13	172	0,2644	0,7356	1,663
22	**9.78-9.84**	18	184	0,1786	0,8214	2,091
23	**9.66-9.72**	10	936	0,4956	0,5044	1,05
24	**9.08-9.2**	3	6	0,3889	0,6111	1,011
25	**8.82-8.91**	1	5	1	0	0
26	**8.43-8.52**	2	16	0,8828	0,1172	0,2338
27	**7.7-7.8**	16	832	0,4501	0,5499	1,326
28	**7.1-7.2**	12	1040	0,2767	0,7233	1,644
29	**5.95-6**	12	968	0,4302	0,5698	1,26
30	**5.85-5.9**	10	1244	0,6586	0,3414	0,8435
31	**5.75-5.8**	5	1832	0,9654	0,03455	0,1122
32	**5.7-5.75**	6	1064	0,941	0,05905	0,1819
33	**5.65-5.7**	4	2088	0,9185	0,0815	0,2067
34	**5.6-5.65**	3	10976	0,9378	0,06217	0,1478
35	**5.5-5.55**	3	1216	0,9236	0,07642	0,1885
36	**4.5-4.55**	1	3	1	0	0
37	**4.32-4.37**	2	7	0,7551	0,2449	0,4101
38	**4.06-4.1**	1	5	1	0	0
39	**3.95-4**	5	216	0,5105	0,4895	0,9505
40	**3-3.05**	3	7	0,551	0,449	0,7963
41	**1.74-1.81**	6	900	0,728	0,272	0,6263