Aquat Ecol (2021) 55:955–998
https://doi.org/10.1007/s10452-021-09874-1

Infralittoral ostracoda and benthic foraminifera of the Gulf of Pozzuoli (Tyrrhenian Sea, Italy)

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Received: 17 January 2021 / Accepted: 17 May 2021 / Published online: 15 June 2021

Abstract The shallow water benthic foraminiferal and ostracod assemblages of the Gulf of Pozzuoli, located in the central Tyrrhenian Sea, were studied to investigate the relationship between calcareous meiofaunas and contaminant concentrations in bottom sediments exposed to prolonged industrial pollution. Both benthic foraminifers and ostracods displayed high-diversity and low-dominance, unusual features in highly contaminated environments. High-diversity values were possibly linked to the oligotrophic, well-oxygenated, and $CaCO_3$-supersaturated coastal Mediterranean waters. The comparison with historical data suggested that assemblage composition changed in the last decades, with an increase in the relative abundance of benthic foraminiferal (*Quinqueloculina seminulum, Bulimina elongata*) and ostracod (*Xestoleberis*, *Loxoconcha, Semicytherura rarecostata*) taxa. They probably represent organisms tolerant to the environmental variations in the last decades. The relationships between granulometry and diversity indices, high correlation values between *Quinqueloculina lata* and heavy metal pollution, and the preference of the ostracod genera *Urocythereis* and *Paracytheridea* for very shallow marine waters were highlighted.

Keywords Meiobenthos · Granulometry · Mediterranean Sea · Industrial pollution · High-diversity assemblages

Handling Editor: Télesphore Sime-Ngando.

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Introduction

Benthic foraminifers (Rhizaria) and ostracods (Crustacea) are meiofaunal groups generally provided with calcareous tests and valves, commonly preserved in sea bottom sediments. The composition of their assemblages reflects environmental conditions due to both natural and human causes. Anthropogenic activities produce various effects on shallow marine waters, including organic pollution, changes in sedimentation rates, increase in hydrocarbon and heavy metal concentrations, and eutrophication-induced hypoxia (Gooday et al., 2009; Yasuhara et al., 2012; Wilkinson et al., 2014) that, in turn, lead to an increase in the relative abundance of stress-tolerant foraminiferal species (Hayward et al., 2004; Alve et al., 2009; Frontalini and Coccioni, 2011; Ruiz et al., 2012) and frequently to ostracod diversity decrease (Alve, 1991; Mazzola et al., 1999; Cronin & Vann, 2003; Irizuki et al., 2018). The studies combining the analyses of benthic foraminifers and ostracods in areas where human-induced ecological variations occurred showed the high potential of calcareous meiofaunal assemblages as water quality indicators (Samir, 2000; Triantaphyllou et al., 2003, 2005; Vilela et al., 2003; Bergin et al., 2006; Pascual et al., 2008, Salvi et al., 2015).

In the present study, benthic foraminiferal and ostracod assemblages were studied from eleven samples collected in the infralittoral zone of the Gulf of Pozzuoli, a bay located in the Campania region (Southern Italy) with a narrow continental shelf, a shelf break at about 40 m bsl, a maximum depth of 110 m, and an average depth of ca. 60 m (Fig. 1; Somma et al., 2016). The gulf is mainly exposed to winds and sea waves approaching from the southeast–southwest sector, with a maximum geographic fetch of 665 km for the 205° direction, 0.9–2.2 m average wave height, and a maximum wave height of 4.7 m in winter (De Pippo et al., 2008). The water circulation models (De Maio et al., 1985; Menna et al., 2008; de Ruggiero, 2016) of the gulf generally indicate two main flow patterns: (i) when the open sea currents flow toward the southeast, the inner waters of the bay are cut off in a slow cyclonic gyre; then, the coastal waters slow motion could favor turbidity and a high pollutant concentration; (ii) when the open sea currents flow toward the northwest, some branches enter into the bay; then, a fair renewal of sea waters occurs. Tides are negligible, with a syzygial tide amplitude of 0.35 m (Tammaro et al., 2021); therefore, the gulf is a wave-dominated environment. Salinity, turbidity, and phytoplankton distribution are related to seasonal variation in the sea surface and column temperature, autumn–winter freshwater supply by rainfalls and land runoff, marine currents cell circulation: 37.1–38.6‰ salinity, 27–30° C sea surface temperature, and high phytoplankton biomass (Chl a

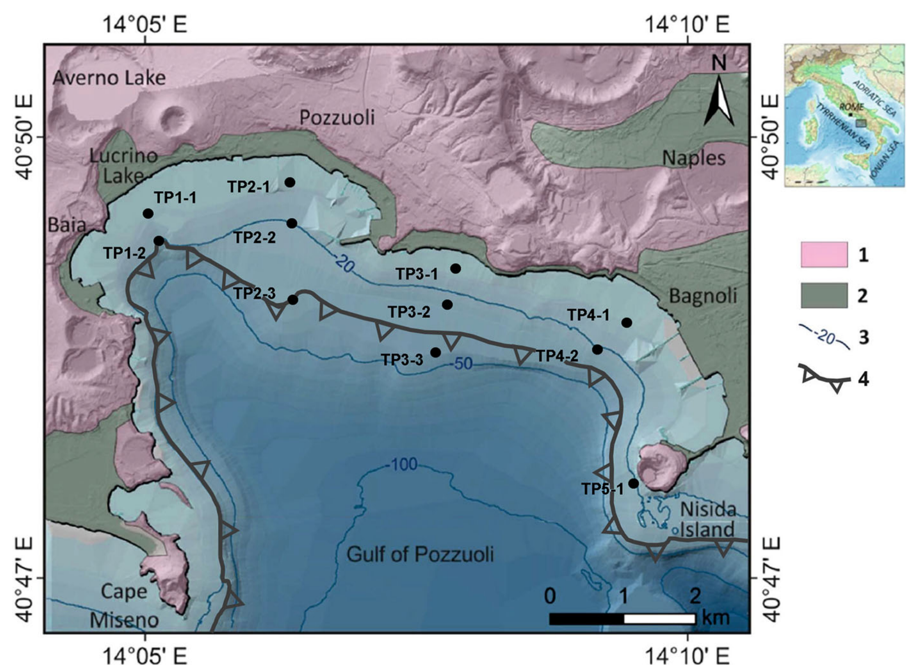

Fig. 1 Location of the sampling stations (black solid circle) in the Gulf of Pozzuoli. Legend: 1, pyroclastics of the Phlegrean Fields (Late Pleistocene–Holocene); 2, deposits of transitional environments (Quaternary); 3, isobath(-m); 4, edge of the continental shelf break, from a depth of about 25 down to 40 m. Depth is in meters b.s.l. (after Somma et al., 2016 and the morphobathymetric and sedimentological surveys carried out for this research). The geographic coordinate system is WGS84

concentration > 2 µg/L) were registered during the spring–summer season (Bolinesi et al., 2020). The bay was exposed to prolonged anthropogenic disturbance, due to urban and industrial wastes, at least since 1885, when an armaments factory was built by the British company Armstrong Mitchell & Co. The eastern part of the gulf was under the influence of the Bagnoli steel plant from 1910 to 1990, to which the high levels of polycyclic aromatic hydrocarbons (Arienzo et al., 2017; Ferrara et al., 2020), trace metals (Trifuoggi et al., 2017), and rare earth elements (Trifuoggi et al., 2018) in the sediment seem to be linked. Recently, some ecological and paleoecological investigations were performed on Recent (Balassone et al., 2016; Mangoni et al., 2016; Arienzo et al., 2020) and late Quaternary (i.e., from ~ 150 ka to historical times; Aiello et al., 2012; 2018; 2020; 2021; Amato et al., 2019; Petrosino et al., 2021) sediments of the Campania region coastal areas focused on benthic foraminiferal and ostracod assemblages. The present study aims to define the characteristics of the calcareous meiofaunal assemblages in the infralittoral zone (Peres & Picard, 1964; Peres, 1982) of an area showing high geoaccumulation values and to test a possible decrease in benthic faunal abundance and diversity in polluted bottom sediments. Our data, compared with the above-mentioned studies and previous investigations on Campanian infralittoral benthic foraminifers (Moncharmont Zei, 1964; Sgarrella & Barra, 1985; Sgarrella et al., 1985; Sgarrella & Moncharmont, 1993) and ostracods (Müller, 1894; Puri et al., 1964, 1969), may contribute to a more complete understanding of the relationship between meiofaunal assemblages and environmental parameters.

Material and methods

Eleven samples of very fine to coarse sands, and very fine gravels, were collected by a Van Veen grab above the shelf break of the Gulf of Pozzuoli (~ 40 m bsl), in a water depth range between 7.5 m and 38 m, within the infralittoral zone. The grab collected superficial sediments, including the first ca. 5 cm of the seabed, related to texture and consistency of silt or sand deposits. Sharp & Nardi (1987) calculated, in this area, a sedimentation rate of about 4 mm/year and consequently the sampled sediments deposited, at most, in the last 15 years. The surface of the sampler is about 150 square cm (10 × 15 cm), while the volume of the sampled sea bottom surface sediment generally is about 750–1000 cubic cm. Samples were taken along one campaign in the spring of 2017 along transects and aboard a motor vessel. Bathymetry, grain size, number, and location of samples are reported in Fig. 1 and Table 1. For meiofaunal analyses, all the samples were oven-dried, and 100 g of dry sediment was taken. They were washed through 230-mesh (63 µm) and 120-mesh (125 µm) sieves, and the residues were oven-dried and examined with a reflected light microscope. A microsplitter was used

Table 1 Coordinates of sampling stations, grain size, and water depth

Sampling stations	Latitude (N)	Longitude (E)	Depth (m)	Gravel %	Sand %	Silt %	Clay %	Class
TP1—1	40°49′27.55“	14°05′02.94”	8.0	4.68	94.9	0.33	0.05	Fine sand
TP1—2	40°49′16.89“	14°05′08.74”	24.8	1.59	97.3	0.96	0.16	Fine sand
TP2—1	40°49′41.34“	14°06′19.46”	8.0	0.69	99.3	–	–	Coarse sand
TP2—2	40°49′23.95“	14°06′21.93”	25.8	1.50	97.0	1.40	0.10	Very fine sand
TP2—3	40°48′42.91“	14°06′29.06”	34.0	6.72	91.8	1.32	0.15	Fine sand
TP3—1	40°49′05.98“	14°07′50.41”	7.5	0.67	99.3	–	–	Medium sand
TP3—2	40°48′53.02“	14°07′46.26”	23.8	5.10	94.9	–	–	Fine sand
TP3—3	40°48′33.38“	14°07′38.47”	38.0	2.89	96.1	0.88	0.12	Fine sand
TP4—1	40°48′46.43“	14°09′30.87”	7.7	0.06	99.9	–	–	Fine sand
TP4—2	40°48′32.74“	14°09′17.63”	21.5	0.57	98.9	0.47	0.07	Fine sand
TP5—1	40°47′33.96“	14°09′28.91”	22.7	49.1	50.8	–	–	Very fine gravel

to obtain subsamples when necessary. About 300 benthic foraminiferal tests and 300 ostracod valves were picked from the coarsest fraction (> 125 µm), classified, and counted. Abundance and diversity indices were calculated using the number of foraminiferal specimens, the ostracod Minimum Number of Individuals (MNI), and the Total Number of Valves (TNV). MNI is the greater number between right and left adult valves plus the number of adult carapace; when only juvenile shells (j) were recorded, the MNI equals one. TNV includes all the adult and young instar valves. Assemblage composition as well as diversity indices was considered for environmental discussion. The following indices were calculated: S (taxa richness), I (individuals per 100 g of sediment), D (dominance), H' (Shannon's diversity index, using natural logarithm), and J (equitability). The species were identified according to classic and modern literature both for benthic foraminifers and ostracods (Aiello & Barra, 2010; Aiello et al., 2018, and references therein). The studied specimens are housed in the Aiello Barra Micropaleontological Collection (A.B.M.C.), Dipartimento di Scienze della Terra, dell'Ambiente e delle Risorse, Università degli Studi di Napoli Federico II. Statistical analyses were performed using abundance values of foraminiferal (I = number of individuals per 100 g) and ostracod (both MNI = minimum number of individuals per 100 g, and TNV = total number of valves per 100 g) assemblages. Q-mode cluster analysis (paired group as an algorithm, Rho as similarity measure) was performed to determine groups of samples with similar meiofaunal composition, using abundance values of all foraminiferal and ostracod (both MNI and TNV) species. Pearson's correlation coefficient was used to test for correlation between assemblage features, depth, major and trace elements, and polycyclic aromatic hydrocarbons of eight fine-grained samples; benthic foraminiferal and ostracod species with relative abundance greater than 5% in at least two samples were considered. The abiotic variables were subject to z-standardization. Analyses were carried out on the same set of samples used by Arienzo et al. (2017), Trifuoggi et al. (2017, 2018), and Ferrara et al. (2020) in their investigations on the distribution of polycyclic aromatic hydrocarbons (PAHs), trace metals (HMs), and rare earth elements (REEs). All the analytical determinations were performed in triplicate for each sample taken at each site. The quality of the analytical results is assured by participation in ring tests for the determination of HMs, PAHs, and REEs from sediments and similar matrices. Mean recoveries ranged from a minimum of 85% to a maximum of 97%. Grain size analyses were performed following the standard methodology of Folk and Ward (1957). Full methodological details on sampling techniques, geochemical and grain size analyses were reported in Arienzo et al. (2017), Trifuoggi et al. (2017, 2018), and Ferrara et al. (2020).

Computation of diversity indices and statistical analysis were performed with STATISTICA 5 (StatSoft Inc., Tulsa, OK, USA).

Table 2 Benthic foraminiferal absolute abundance (I = individuals per 100 g of sediment)

Sampling stations	Latitude (N)	Longitude (E)	Depth (m)	Gravel %	Sand %	Silt %	Clay %	Class
TP1—1	40°49′27.55“	14°05′02.94”	8.0	4.68	94.9	0.33	0.05	Fine sand
TP1—2	40°49′16.89“	14°05′08.74”	24.8	1.59	97.3	0.96	0.16	Fine sand
TP2—1	40°49′41.34“	14°06′19.46”	8.0	0.69	99.3	–	–	Coarse sand
TP2—2	40°49′23.95“	14°06′21.93”	25.8	1.50	97.0	1.40	0.10	Very fine sand
TP2—3	40°48′42.91“	14°06′29.06”	34.0	6.72	91.8	1.32	0.15	Fine sand
TP3—1	40°49′05.98“	14°07′50.41”	7.5	0.67	99.3	–	–	Medium sand
TP3—2	40°48′53.02“	14°07′46.26”	23.8	5.10	94.9	–	–	Fine sand
TP3—3	40°48′33.38“	14°07′38.47”	38.0	2.89	96.1	0.88	0.12	Fine sand
TP4—1	40°48′46.43“	14°09′30.87”	7.7	0.06	99.9	–	–	Fine sand
TP4—2	40°48′32.74“	14°09′17.63”	21.5	0.57	98.9	0.47	0.07	Fine sand
TP5—1	40°47′33.96“	14°09′28.91”	22.7	49.1	50.8	–	–	Very fine gravel

Results

All the samples yielded both benthic foraminiferal and ostracod shells (no barren samples) (Tables 2–8). A total of 4262 foraminiferal individuals and 3607 ostracod valves were collected. The good state of preservation, the distribution data, and the presence of all developmental stages (in ostracods: different young instars and adults) suggested that the calcareous meiofaunal assemblages could be considered entirely autochthonous. The benthic foraminiferal assemblages included 142 species assigned to 74 genera; 127 ostracod species in 49 genera were recorded (Appendix 1; Figs. 2–3). Five benthic foraminiferal species and eight ostracod species were tentatively identified or left in open nomenclature and nine with affinitive status due to the absence of adult specimens, or because of poorly preserved shells. The good state of preservation, the distribution data, and the presence of all developmental stages (in ostracods: different young instars and adults) suggested that the calcareous meiofaunal assemblages could be considered entirely autochthonous.

Benthic foraminifers.

Six benthic foraminiferal species were present in all the samples, that is, *Ammonia aberdoveyensis, Buccella granulata*, *Cibicides lobatulus*, *Elphidium crispum, Quinqueloculina seminulum* and *Triloculina schreiberiana.* Assemblages were characterized by the genera *Quinqueloculina* (19 species) and *Elphidium* (10 species). *Cibicides lobatulus* was the most abundant species, with a Medium Relative Abundance (MRA) of 12.8%, followed by *Tretomphalus concinnus* (MRA = 5.54%), *Siphonaperta aspera* (MRA = 4.30%), *Elphidium crispum* (MRA = 3.97%), *Asterigerinata mamilla* (MRA = 3.75%) and *Q. seminulum* (MRA = 3.53%).

The number of species (S) was between 17 and 82, with discrimination between the three coarse-grained samples (TP2-1 = coarse sand; TP3-1 = medium sand; TP5-1 = very fine gravel) and the remaining eight samples, all made of fine or very fine sands. The former displayed a S range from 17 to 48, with the mean value of 34.33; the eight fine-grained samples had S between 52 and 82 (mean value = 61.25).

The number of specimens (I) showed a wide range, from 69 to 105,984. The three coarse-grained samples displayed a mean value of 484, whereas a I mean value of 51,540 was recorded for the remaining samples.

The dominance (D) was between 0.04 and 0.20, with high values in the samples TP2-1 (D = 0.20) and TP5-1 (D = 0.16) and low (D(0.06) the remaining ones.

TP2-1 and TP5-1 assemblages showed a Shannon diversity index (H ') less than 3; in the other assemblages H' >3. Mean H' is 3.28. Mean H' is 3.28. A similar trend was observed for equitability (J), low in the samples TP2-1 and TP5-1 (J<0.8) and high (J>0.8) in the other samples.

Ostracods.

The most diversified genera were *Semicytherura* (18 species) and *Xestoleberis* (12 species). Characteristic species were *Urocythereis margaritifera* [MRA(MNI) = 8.10%; MRA(TNV) = 9.94%], *Pontocythere turbida* [MRA(MNI) = 6.00%; MRA(TNV) = 5.64%], *Semicytherura rarecostata* [MRA(MNI) = 5.56%; MRA(TNV) = 3.87%], *Loxoconcha rhomboidea* [MRA(MNI) = 5.08%; MRA(TNV) = 4.83%] and *Loxoconcha ovulata* [MRA(MNI) = 3.68%; MRA(TNV) = 5.55%]. *Loxoconcha affinis* [MRA(MNI) = 3.45%; MRA(TNV) = 3.64%], *Xestoleberis dispar* [MRA(MNI) = 2.93%; MRA(TNV) = 5.26%], *Xestoleberis communis* [MRA(MNI) = 2.25%; MRA(TNV) = 5.22%] and *Aurila convexa* [MRA(MNI) = 1.93%; MRA(TNV) = 4.95%] were considered accessory species.

The three samples with coarser granulometry (TP2-1, TP3-1, TP5-1) yielded relatively poor ostracod assemblages, showing low diversity and high dominance. Conversely, in the fine-grained samples, diversity and abundance were high and the dominance low.

Taxa richness (S) ranged from 4 to 12 in the coarse-grained samples and from 31 to 57 in the remaining ones. In the former samples, abundance (I) was between 9 and 27 (MNI) and between 18 and 40 (TNV); in the latter samples, the mean value of I was 2065.5 (MNI) and 7781 (TNV). Shannon index H' followed a similar trend: in TP2-1, TP3-1, TP5-1 mean H' (MNI) was 1.68 and medium H' (TNV) was 1.56; in the assemblages occurring in the fine-grained sediments, medium H' (MNI) was 3.35 and medium H' (TNV) was 3.10.

Dominance (D) values were high in the assemblages of samples TP2-1, TP3-1, TP5-1 [D (MNI) range = 0.09–0.48; D(TNV) range = 0.14–0.70]; in the fine-grained samples the average D was 0.05 (MNI) and 0.07 (TNV).

Table 3 Benthic foraminiferal relative abundance (RA, %) samples

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Adelosina elegans (Williamson, 1858)									0.49		0.87
Adelosina longirostra (d'Orbigny, 1826)	0.67	2.54		1.19	1.18	1.39		1.56	0.25	0.61	
Adelosina mediterranensis (Le Calvez & Le Calvez, 1958)					2.37						
Adelosina pulchella d'Orbigny, 1826								0.52			
Affinetrina planciana (d'Orbigny, 1839)		0.12									0.43
Ammodiscus planorbis Höglund, 1947					0.30						
Ammonia aberdoveyensis Haynes, 1973 lobate form				1.66			0.81				
Ammonia aberdoveyensis Haynes, 1973 rounded form	3.20	2.90	2.90	5.70	3.25	3.13	0.81	4.68	0.74	0.30	0.87
Ammonia beccarii (Linnaeus, 1758)		0.36	7.25		2.07	0.69		0.52		1.22	
Amphicoryna scalaris (Batsch, 1791)								0.26			
Angulogerina angulosa (Williamson, 1858)							0.27				
Asterigerinata adriatica Haake, 1977					0.89			0.26			
Asterigerinata mamilla (Williamsom, 1858)	1.35	3.86		0.95	6.80	1.04	8.09	8.83	1.47	3.65	5.19
Asterigernata mariae Sgarrella, 1990	0.67										
Astrononion stelligerum (d'Orbigny, 1839)	1.68	0.85			0.30	0.35			0.74	0.91	2.16
Bolivina catanensis Seguenza, 1862	0.34										
Bolivina lowmani Phleger & Parker, 1951	0.51			0.24	0.30	0.35	0.27				
Bolivina pseudoplicata Heron–Allen & Earland, 1930				0.24				0.26			
Bolivina variabilis (Williamson, 1858)							0.27				
Bolivina sp.		0.12									
Brizalina spathulata (Williamson, 1858)		0.24		0.24							
Brizalina striatula (Cushman, 1922)	0.51	0.12									
Buccella granulata (Di Napoli Alliata, 1952)	1.52	1.45	2.90	0.48	2.66	4.17	1.89	6.23	0.49	2.43	2.60
Bulimina aculeata d'Orbigny, 1826	0.17	0.36		1.90	0.59	0.35	0.54	0.26		0.91	
Bulimina elongata d'Orbigny, 1846	0.67	5.07		9.98	3.85		6.20	0.78	0.74	2.43	
Cassidulina carinata Silvestri, 1896		0.60			0.89	1.39		1.04			
Cibicides lobatulus (Walker & Jacob, 1798)	8.59	10.51	4.35	5.46	12.13	7.64	16.98	11.43	12.99	13.98	36.80
Cibicides refulgens Montfort, 1808										0.91	
Cibicidoides pachyderma (Rzehak, 1886)		0.24									
Cibicidoides variabilis (d'Orbigny, 1826)	0.51	0.85		1.19					2.45	0.61	0.87
Conorbella imperatoria (d'Orbigny, 1846)		0.24									
Cornuspira involvens (Reuss, 1850)				2.38					0.49		
Cycloforina contorta (d'Orbigny, 1846)	1.68	1.81		0.24	2.07	3.47	1.35	3.38	0.98	4.26	0.87
Cycloforina rugosa (d'Orbigny, 1826)	0.34								1.23	0.30	
Cycloforina tenuicollis (Wiesner, 1923)									0.25		

Table 3 continued

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Cycloforina villafranca (Le Calvez & Le Calvez, 1958)					0.59		0.54		0.74		
Discorbinella bertheloti (d'Orbigny, 1839)		0.24			5.92	0.35	0.81	6.49		0.61	
Discorbis torrei Bermúdez, 1935										1.52	
Eggerelloides scaber (Williamson, 1858)				2.38		0.35					
Eilohedra vitrea (Parker, 1953)						0.35					
Elphidium articulatum (d'Orbigny, 1839)	1.18			0.71	1.18					0.91	
Elphidium complanatum (d'Orbigny, 1839)	4.55	5.43			0.30		3.77	0.52	2.70	0.61	
Elphidium crispum (Linnaeus, 1758)	1.52	6.04	1.45	6.41	4.14	2.08	3.23	4.68	1.23	1.22	11.69
Elphidium granosum (d'Orbigny, 1846)	0.17	0.24		0.48	4.44		0.27	1.56			
Elphidium incertum (Williamson, 1858)	0.51	0.48									
Elphidium macellum (Fichtel & Moll, 1798)	1.52	1.69	7.25	1.43	3.25	4.86	2.43	1.56	0.98		
Elphidium maioricense Colom, 1942	0.34	0.36		0.71		1.39	1.08		0.98	1.22	1.30
Elphidium poeyanum (d'Orbigny, 1839) DS form		0.60					1.89				
Elphidium poeyanum (d'Orbigny, 1839) FS form		0.48		0.71	3.25		0.81	1.30			
Elphidium pulvereum Todd, 1958	0.84	0.24		1.66		0.35			3.19	1.22	0.43
Elphidium punctatum (Terquem, 1878)	7.74			0.48	1.18	7.29	1.62	0.78	3.68	7.29	0.43
Favulina hexagona(Williamson, 1848)					0.30						
Flintinoides labiosa (d'Orbigny, 1839)	1.85	1.69				0.35	0.54		1.23		
Fursenkoina acuta (d'Orbigny, 1846)		0.48		0.24				0.26			
Gavelinopsis praegeri (Heron-Allen & Earland, 1913)	0.34	0.48		0.95	2.37		1.62	1.30	0.49	0.30	0.43
Glabratella erecta (Sidebottom, 1908)				0.24					0.49	0.61	
Glabratella hexacamerata Seiglie & Bermúdez, 1965	1.01	0.24		0.48					0.98		
Globobulimina sp. 1				0.48							
Globocassidulina subglobosa (Brady, 1881)	0.17										0.43
Globulina gibba (d'Orbigny, 1826)		0.12									
Guttulina sp. 1						2.78					0.43
Gyroidina neosoldanii Brotzen, 1936		0.12									
Gyroidina umbonata (Silvestri, 1898)		0.12									
Haynesina depressula (Walker & Jacob, 1798)	2.02	0.97		4.28	2.07	3.82		0.26	0.98	1.22	
Haynesina germanica (Ehrenberg, 1840)					0.59		0.27		0.74	0.30	
Lachlanella undulata (d'Orbigny, 1852)										0.30	
Lagena semistriata Wiliamson, 1848		0.12		0.48							
Lenticulina cultrata (Montfort, 1808)		0.12									
Lenticulina gibba (d'Orbigny, 1839)										0.30	
Lenticulina rotulata (Lamarck, 1804)	0.17				0.89		0.81				

Table 3 continued

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Massilina secans (d'Orbigny, 1826)	0.67	0.12				0.35	0.54		0.74	1.22	0.87
Melonis affinis (Reuss, 1851)		0.72			0.89		1.62	2.60			
Miliolidae		0.36					0.81	0.52			
Miliolinella elongata Kruit, 1955										1.52	
Miliolinella cf. *M. hybrida* (Terquem, 1878)	1.01										
Miliolinella semicostata (Wiesner, 1923)	0.67	0.24			0.30	1.04	0.27	0.26	0.25		0.43
Miliolinella subrotunda (Montagu, 1803)	0.51	1.93	4.35	4.75		3.47	2.16		4.66	3.04	2.60
Miliolinella webbiana (d'Orbigny, 1839)				0.24			0.27				0.43
Miniacina miniacea (Pallas, 1766)											0.43
Neoconorbina terquemi (Rzehak, 1888)	0.84	0.97		1.66	3.85		3.50	10.39		0.91	0.43
Nonionella turgida (Williamson, 1858)		0.12		0.71	0.30			0.26	1.23		
Nubecularia lucifuga Defrance, 1825	1.52	0.60		1.66	0.30	0.35	1.35	0.52	0.74	2.43	0.87
Palliolatella fasciata (Egger, 1857)										0.30	
Parrina bradyi (Millett, 1898)				0.24						0.30	
Peneroplis pertusus (Forskål, 1775)	2.02	1.09	2.90			2.78	0.27		0.49		
Peneroplis planatus (Fichtel & Moll, 1798)	0.84	0.12									
Planoglabratella opercularis (d'Orbigny, 1846)						0.69			0.49		
Planorbulina mediterranensis d'Orbigny, 1826	2.69	2.05		0.24	2.07	0.69	1.89	2.34	8.09	1.52	5.19
Quinqueloculina agglutinans d'Orbigny, 1839	0.17	0.24									
Quinqueloculina annectens (Schlumberger, 1893)		0.12									
Quinqueloculina berthelotiana d'Orbigny, 1839	3.37	4.35	2.90	2.85	0.30	0.35	1.35	3.38		0.61	0.87
Quinqueloculina bosciana d'Orbigny, 1839	2.02	0.36		1.66	0.30	7.29	0.27		1.23	0.30	
Quinqueloculina bradyana Cushman, 1917	0.34	0.85		0.24	0.30	1.04			1.47		
Quinqueloculina disparilis d'Orbigny, 1826								0.26			
Quinqueloculina irregularis d'Orbigny, 1826	0.34							0.26		0.30	
Quinqueloculina jugosa Cushman, 1944	0.34	0.24						1.04			
Quinqueloculina laevigata d'Orbigny, 1839	0.17	0.24				0.35			0.74		
Quinqueloculina lata Terquem, 1876	2.86	0.97	2.90	1.90	0.30	5.56	0.27		9.80	4.86	1.73
Quinqueloculina limbata d'Orbigny, 1826	0.17	0.36									
Quinqueloculina parvula Schlumberger, 1894	0.84	0.60		1.19	0.30				0.74	0.61	
Quinqueloculina poeyana d'Orbigny, 1839			1.45	0.24						1.22	
Quinqueloculina pygmaea Reuss, 1850	1.68	0.48		0.24	1.48	1.74		0.78	3.19	1.22	
Quinqueloculina seminulum (Linnaeus, 1758)	1.52	1.21	10.14	5.94	0.89	6.60	1.62	1.30	4.17	2.43	3.03
Quinqueloculina stalkeri Loeblich & Tappan, 1953	0.17			0.48		0.35				0.61	
Quinqueloculina stelligera Schlumberger, 1893	1.85	0.85		1.19			0.81		0.49	0.91	4.33

Table 3 continued

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Quinqueloculina ungeriana d'Orbigny, 1846	0.17	0.24									
Quinqueloculina vulgaris d'Orbigny, 1826			1.45			1.04			1.23	0.61	
Quinqueloculina sp.	0.17										
Rectuvigerina phlegeri Le Calvez, 1959	0.17	0.85		2.38	3.85		2.43	2.60			
Reophax fusiformis (Williamson, 1858)				0.24							
Reussella spinulosa (Reuss, 1850)					1.48		0.27	0.78			
Rosalina floridana (Cushman, 1922)	1.35	1.57			0.30	1.04	4.04	0.52	0.49	2.13	1.73
Rosalina macropora (Hofker, 1951)	2.36	2.78		0.48	6.51	2.43	3.23	2.34	1.23	0.91	3.46
Rosalina obtusa d'Orbigny, 1846	1.85	3.02		0.71	2.07	0.69	4.04	3.90	1.23	4.56	
Rotorbis auberii (d'Orbigny, 1839)	0.17	0.12									
Sahulia conica (d'Orbigny, 1839)				0.24				0.52			
Sigmoilina costata Schlumberger, 1893	0.34	0.60		0.48	0.30		0.54	0.52	0.74	0.30	
Sigmoilina grata (Terquem, 1878)		0.24		0.24			0.27		0.74	0.61	
Sigmoilinita distorta (Phleger & Parker, 1951)									0.25		
Siphonaperta aspera (d'Orbigny, 1826)		0.24	40.58	0.48		4.51	0.27			1.22	
Siphonina reticulata (Cžjžek,1884)		0.12					0.54				
Sorites orbicularis (Forskål, 1775)	0.17		1.45						0.74		
Spirillina vivipara Ehrenberg, 1843		0.48		0.24							1.30
Spiroloculina depressa d'Orbigny, 1826										0.30	
Spiroloculina excavata d'Orbigny, 1846								0.26			
Spiroloculina ornata d'Orbigny, 1839	0.17			0.24							
Spiroloculina tricarinata d'Orbigny, 1852	0.34	0.36									
Spiroplectinella wrighti (Silvestri, 1903)							0.27	0.52			
Stainforthia complanata (Egger, 1893)				0.24							
Stomatorbina concentrica (Parker & Jones, 1864)											0.43
Textularia aciculata d'Orbigny, 1826					0.59			0.26			
Textularia agglutinans d'Orbigny, 1839		0.12									
Textularia calva Lalicker, 1940							0.81	0.26			
Textularia pala Cžjžek, 1848							1.08				
Tretomphalus concinnus (Brady, 1884)	11.78	8.09		7.13	1.48	5.56	3.23	1.30	10.29	8.21	3.90
Triloculina eburnea d'Orbigny, 1839	0.17		4.35			1.04					0.43
Triloculina plicata Terquem, 1878	0.34	0.60				0.69	0.81		0.49	0.91	0.43
Triloculina schreiberiana d'Orbigny, 1839	0.34	0.12		0.24		1.04		0.26	0.74	0.30	
Triloculina trigonula (Lamarck, 1804)	4.04	5.80	1.45	5.94	1.48	0.69	3.77	2.60	0.98	3.95	0.43
Trochammina inflata (Montagu, 1808)							0.27				

Table 3 continued

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Uvigerina mediterranea Hofker, 1932		0.24									
Valvulineria complanata (d'Orbigny, 1846)					0.30			0.52			0.43
Vertebralina striata d'Orbigny, 1826	2.86	2.05		1.19				0.26	0.74	1.52	
Wiesnerella auriculata (Egger, 1895)	0.34	0.60		0.24		0.69					0.43

Equitability (J) ranged from 0.72 to 0.99 (MNI) and from 0.46 to 0.94 (TNV). The mean J values were 0.86 (MNI) and 0.79 (TNV).

Statistics.

The cluster analysis (Fig. 4) revealed two clusters of samples, obtained at a similarity cut-off level of 0.45. Cluster B consists of the coarse-grained samples TP2-1, TP3-1, and TP5-1, with low diversity–low abundance assemblages; cluster A includes the remaining eight fine-grained (fine and very fine sands) samples, characterized by high-diversity—high abundance assemblages. The three sediment samples grouped in Cluster B, consisting of medium sand, coarse sand, and very fine gravel, showed low geochemical accumulation. Since both low meiofaunal abundance/diversity values and low pollutant concentrations are highly associated with grain size (v. Discussion section), a correlation analysis including all the samples would provide results strongly influenced by granulometry. Consequently, we opted for performing the Pearson's correlation coefficient analysis on the eight fine-grained samples included in Cluster A. Results of Pearson's correlation coefficient analysis using meiofaunal assemblages, depth, major and trace elements, total organic carbon, and polycyclic aromatic hydrocarbons (Table 9) are reported in Table 10. The foraminiferal species *Cibicides lobatulus* and *Elphidium crispum* are common in all the samples. The assemblages included in Cluster A are characterized by the foraminifers *Tretomphalus concinnus*, *Asterigerinata mamilla*, *Triloculina trigonula,* and *Elphidium punctatum* and by the ostracods *Semicytherura rarecostata*, *Loxoconcha ovulata*, *L. rhomboidea*, *Aurila convexa,* and *Xestoleberis communis*. In Cluster B, the foraminiferal species *Siphonaperta aspera*, *Quinqueloculina seminulum*, *Elphidium macellum,* and the ostracods *Urocythereis margaritifera* and *Pontocythere turbida* characterized the assemblages.Our results show that the anthropogenic impact in the infralittoral zone of the Gulf of Pozzuoli, recorded in the geochemical accumulation (v. Table 9), was not reflected by diversity indices of the calcareous meiofaunal assemblages. The present findings were compared with the results of a previous study by Moncharmont (1964), based on a sampling carried out in 1961 by Harbans S. Puri and the Stazione Zoologica Anton Dohrn, where the characteristic species of the infralittoral zone were *Ammonia beccarii*, *A. mamilla*, *C. lobatulus* and *T. concinnus*

Table 4 Ostracod absolute abundance [I(MNI) = minimal number of individuals per 100 g of sediment]; j indicates juvenile specimens

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Aglaiocypris complanata (Brady & Robertson, 1869)	16	64j		j							
Argilloecia minor Müller, 1894	8	32									
Aurila convexa (Baird, 1850)	16j	32j		32j	32j		48j	48j	32j	8j	1
Aurila prasina Barbeito-Gonzalez, 1971								48j			
Aurila speyeri (Brady, 1858)								48j			
Callistocythere crispata (Brady, 1868)	8j	32j		j	64j		16j	48j	8j	8	
Callistocythere flavidofusca (Ruggieri, 1950)	8				48j		48	48j			
Callistocythere lobiancoi (Müller, 1894)		64j					32j				
Callistocythere aff. *C. protracta* Ruggieri & D'Arpa, 1993	8										
Carinocythereis carinata (Roemer, 1838)				j		j		64j			
Carinocythereis whitei (Baird, 1850)	24j	128j		192j	128j		32j	32j	8	16j	
Cistacythereis turbida (Müller, 1894)		32j		64j	128j		32j	112j	j	8j	
Costa batei (Brady, 1866)		32j			16		48j			8	
Costa edwardsii (Roemer, 1838)	8			32				16	j		
Cyprideis torosa (Jones, 1850)	j	32j								j	
Cytheretta adriatica Ruggieri, 1952	j					4	j		8j	40j	
Cytheretta subradiosa (Roemer, 1838)	16		1	32j	48j		64j	16		32j	
Cytheridea neapolitana Kollmann, 1960	j										
Cytherois frequens Müller, 1894	8	224j		96j			j			8	
Cytherois joachinoi Barra, 1992				32							
Cytherois aff. *C. niger* Schornikov, 1965								16			
Cytherois aff. *C. pontica* Marinov, 1966	8						j				
Cytherois triangularis Bonaduce, Masoli, Minichelli & Pugliese, 1979	32	j		32j	16j		j		j		
Cytherois uffenordei Ruggieri, 1974	80j	544j		64j	16j		64j	16			
Cytherois sp.1		32								8	
Cytheroma variabilis Müller, 1894				32							
Cytheropteron latum Müller, 1894									8		
"Elofsonia" minima (Bonaduce, Ciampo and Masoli, 1976)	32	j		32j			16		24j	j	
Eucytherura gibbera Müller, 1894							48			8	
Hemicytherura defiorei Ruggieri, 1953	16	32j			64j		80	48		8	
Hemicytherura videns (Müller, 1894)	8j	32j		32			16		16	8	

Table 4 continued

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Heterocythereis voraginosa Athersuch, 1979										j	
Leptocythere levis (Müller, 1894)	8										
Leptocythere macella Ruggieri, 1975				32	16j		16j				
Leptocythere ramosa (Rome, 1942)								16			
Loxocauda decipiens (Müller, 1894)					16						
Loxoconcha affinis (Brady, 1866)	136j	608j					96j		56j	40j	
Loxoconcha concentrica Bonaduce, Ciampo & Masoli, 1976		32									
Loxoconcha ovulata (Costa, 1853)		160j		256j	208j		112j	208j		16j	
Loxoconcha rhomboidea (Fischer, 1855)	64j	64j		512	96j		144j	112j	16j		2j
Loxoconcha stellifera Müller, 1894	8j	32j	1						16j	8	
Macrocyprina succinea (Müller, 1894)					32		16				
Microcythere depressa Müller, 1894	8	32j									
Microcythere hians Müller, 1894									8j		
Microcythere ? *rara* Müller, 1894		32									
Microcythere vitrea Bonaduce, Ciampo & Masoli, 1976							j				
Microcytherura fulva (Brady & Robertson, 1874)	16j								16j		
Microcytherura nigrescens Müller, 1894	32j	32j		64j			16j		32j	24j	
"Microcytherura" sp. 1										8j	
Microxestoleberis nana Müller, 1894							16		16	8	1j
Microxestoleberis sp.				32							
Neocytherideis subulata (Brady, 1868)	8	j			64		16	64		16j	
Neonesidea mediterranea (Müller, 1894)	j	32j					16j	j	16		1j
Palmoconcha subrugosa (Ruggieri, 1977)				32j	32j			j	16j		
Palmoconcha turbida (Müller, 1894)		64									
Paracytheridea paulii Dubowsky, 1939	128j	32j		64j			16j		104j	48j	
Paracytheridea triquetra (Reuss, 1850)	64j	384j		32j			48j		8j	40j	1
Paracytherois agigensis Caraion, 1963		32									
Paracytherois flexuosa(Brady, 1867)								16			
Paradoxostoma atrum Müller, 1894				32					8		
Paradoxostoma acuminatum Müller, 1894		64		64							
Paradoxostoma angustum Müller, 1894									8		
Paradoxostoma caecum Müller, 1894				32			16				

Table 4 continued

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Paradoxostoma parallelum Müller, 1894	8										
Paradoxostoma aff. *P. rotundatum* Müller, 1894		32									
Paradoxostoma simile Müller, 1894				32							
Paradoxostoma triste Müller, 1894		32j		32			16		16		
Phlyctocythere pellucida (Müller, 1894)					16			16			
Polycope reticulata Müller, 1894							16				
Pontocypris acuminata (Müller, 1894)		32j									
Pontocypris frequens (Müller, 1894)					16j						
Pontocypris obtusa (Müller, 1894)									j		
Pontocypris pellucida Müller, 1894					16						
Pontocypris aff. *P. pellucida* Müller, 1894				32j							
Pontocythere turbida (Müller, 1894)	16j		1	64j	16j	12	16j	176j	24j	32j	
Procytherideis retifera Ruggieri, 1978	64j	32			1	1			104		
Procytherideis subspiralis (Brady, Crosskey & Robertson, 1874)	8			j			16				
Propontocypris intermedia (Brady, 1868)	16	64j		160j	j		j		8j		
Propontocypris rara (Müller, 1894)		j									
Propontocypris subfusca (Müller, 1894)					48j						
Propontocypris succinea (Müller, 1894)									j	j	1
Propontocypris sp.1		1j									
Pseudocytherura strangulata Ruggieri, 1991									8		
Pseudopsammocythere reniformis (Brady, 1868)		160j		32j	j						
Pterygocythereis jonesii (Baird, 1850)					16j			80			
Sagmatocythere napoliana (Puri, 1963)	16j	32j		j			16j		32j	16j	
Sagmatocythere versicolor (Müller, 1894)					48j			32j			
Sahnicythere retroflexa (Klie, 1936)	16								72j		
Sclerochilus ? aequus Müller, 1894	8	32									
Sclerochilus gewemuelleri Dubowsky, 1939	8										
Sclerochilus levis Müller, 1894				32j						j	
Semicytherura acuta (Müller, 1912)							32		8j	32j	
Semicytherura acuticostata (Sars, 1866)		64j		32	64j		112j	16		16	
Semicytherura alifera Ruggieri, 1959	16	128j		32j	16		48		16		
Semicytherura costata (Müller, 1894)									8		

Table 4 continued

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Semicytherura dispar (Müller, 1894)	16	32					32	16	24		
Semicytherura incongruens (Müller, 1894)	8	160j		352j	48j		112j			48j	
Semicytherura inversa (Seguenza, 1880)	40j	j		j			128j		8j	8j	1
Semicytherura paradoxa (Müller, 1894)	8j	32j			32j		16j		8		
Semicytherura punctata (Müller, 1894)							16		24	16	
Semicytherura quadridentata (Hartmann, 1953)	16	32j		32j			j		16	8	
Semicytherura rarecostata Bonaduce, Ciampo & Masoli, 1976	64	320j		64j	304j	4	176j	192j	16	8j	
Semicytherura reticulata (Müller, 1894)										8	
Semicytherura robusta Bonaduce, Ciampo & Masoli,1976					64j			80j			
Semicytherura ruggierii (Pucci, 1955)	48j	32j		32	48		16				
Semicytherura simplex (Brady & Norman, 1889)							16				
Semicytherura aff. *S. slavonica* Krstić, 1983									8		
Semicytherura sulcata (Müller, 1894)									16	24j	
Semicytherura tergestina Masoli, 1968				32	48j						
Tenedocythere prava (Baird, 1850)		32j		j	32	4	32j	16			
Triebelina raripila (Müller, 1894)	8								j		1
Tuberoloxococncha tuberosa (Hartmann, 1954)									8		
Urocythereis ilariae Aiello, Barra & Parisi, 2016		64				j					
Urocythereis margaritifera (Müller, 1894)	56j	32j	6j	j			16j		64j	16	1
Urocythereis schulzi (Hartmann, 1958)	8			j							
Xestoleberis communis Müller, 1894	16j	192j		64j	48j		64j	16j	16j	16j	j
Xestoleberis decipiens Müller, 1894	8j										
Xestoleberis dispar Müller, 1894	24j	192j		224j	64j		j	80j	16j	16j	1j
Xestoleberis aff. *X. labiata* Brady & Robertson, 1874				j							
Xestoleberis margaritopsis Rome, 1942									16		
Xestoleberis pellucida Müller, 1894	8										
Xestoleberis aff. *X. pellucida* Müller, 1894									8	8	
Xestoleberis cf. *X. perminima* Neviani, 1928									8		

Table 5 Ostracod relative abundance (RA, %) (MNI = Minimal Number of Individuals)

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Aglaiocypris complanata (Brady & Robertson, 1869)	1.19	1.31		0.93							
Argilloecia minor Müller, 1894	0.60	0.65									
Aurila convexa (Baird, 1850)	1.19	0.65		0.93	1.57		2.24	2.78	3.01	1.14	7.69
Aurila prasina Barbeito-Gonzalez, 1971								2.78			
Aurila speyeri (Brady, 1858)								2.78			
Callistocythere crispata (Brady, 1868)	0.60	0.65		0.93	3.15		0.75	2.78	0.75	1.14	
Callistocythere flavidofusca (Ruggieri, 1950)	0.60				2.36		2.24	2.78			
Callistocythere lobiancoi (Müller, 1894)		1.31					1.49				
Callistocythere aff. *C. protracta* Ruggieri & D'Arpa, 1993	0.60										
Carinocythereis carinata (Roemer, 1838)				0.93		11.11		3.70			
Carinocythereis whitei (Baird, 1850)	1.79	2.61		5.61	6.30		1.49	1.85	0.75	2.27	
Cistacythereis turbida (Müller, 1894)		0.65		1.87	6.30		1.49	6.48	0.75	1.14	
Costa batei (Brady, 1866)		0.65			0.79		2.24			1.14	
Costa edwardsii (Roemer, 1838)	0.60			0.93				0.93	0.75		
Cyprideis torosa (Jones, 1850)	0.60	0.65								1.14	
Cytheretta adriatica Ruggieri, 1952	0.60					11.11	0.75		0.75	5.68	
Cytheretta subradiosa (Roemer, 1838)	1.19		11.11	0.93	2.36		2.99	0.93		4.55	
Cytheridea neapolitana Kollmann, 1960	0.60										
Cytherois frequens Müller, 1894	0.60	4.58		2.80			0.75			1.14	
Cytherois joachinoi Barra, 1992				0.93							
Cytherois aff. *C. niger* Schornikov, 1965								0.93			
Cytherois aff. *C. pontica* Marinov, 1966	0.60						0.75				
Cytherois triangularis Bonaduce, Masoli, Minichelli & Pugliese, 1979	2.38	0.65		0.93	0.79		0.75		0.75		
Cytherois uffenordei Ruggieri, 1974	5.95	11.11		1.87	0.79		2.99	0.93			
Cytherois sp.1		0.65								1.14	
Cytheroma variabilis Müller, 1894				0.93							
Cytheropteron latum Müller, 1894									0.75		
"Elofsonia" minima (Bonaduce, Ciampo and Masoli, 1976)	2.38	0.65		0.93			0.75		2.26	1.14	
Eucytherura gibbera Müller, 1894							2.24			1.14	
Hemicytherura defiorei Ruggieri, 1953	1.19	0.65			3.15		3.73	2.78		1.14	
Hemicytherura videns (Müller, 1894)	0.60	0.65		0.93			0.75		1.50	1.14	

Table 5 continued

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Heterocythereis voraginosa Athersuch, 1979										1.14	
Leptocythere levis (Müller, 1894)	0.60										
Leptocythere macella Ruggieri, 1975				0.93	0.79		0.75				
Leptocythere ramosa (Rome, 1942)								0.93			
Loxocauda decipiens (Müller, 1894)					0.79						
Loxoconcha affinis (Brady, 1866)	10.12	12.42					4.48		5.26	5.68	
Loxoconcha concentrica Bonaduce, Ciampo & Masoli, 1976		0.65									
Loxoconcha ovulata (Costa, 1853)		3.27		7.48	10.24		5.22	12.04		2.27	
Loxoconcha rhomboidea (Fischer, 1855)	4.76	1.31		14.95	4.72		6.72	6.48	1.50		15.38
Loxoconcha stellifera Müller, 1894	0.60	0.65	11.11						1.50	1.14	
Macrocyprina succinea (Müller, 1894)					1.57		0.75				
Microcythere depressa Müller, 1894	0.60	0.65									
Microcythere hians Müller, 1894									0.75		
Microcythere ? *rara* Müller, 1894		0.65									
Microcythere vitrea Bonaduce, Ciampo & Masoli, 1976							0.75				
Microcytherura fulva (Brady & Robertson, 1874)	1.19								1.50		
Microcytherura nigrescens Müller, 1894	2.38	0.65		1.87			0.75		3.01	3.41	
"*Microcytherura*" sp. 1										1.14	
Microxestoleberis nana Müller, 1894							0.75		1.50	1.14	7.69
Microxestoleberis sp.				0.93							
Neocytherideis subulata (Brady, 1868)	0.60	0.65			3.15		0.75	3.70		2.27	
Neonesidea mediterranea (Müller, 1894)	0.60	0.65					0.75	0.93	1.50		7.69
Palmoconcha subrugosa (Ruggieri, 1977)				0.93	1.57			0.93	1.50		
Palmoconcha turbida (Müller, 1894)		1.31									
Paracytheridea paulii Dubowsky, 1939	9.52	0.65		1.87			0.75		9.77	6.82	
Paracytheridea triquetra (Reuss, 1850)	4.76	7.84		0.93			2.24		0.75	5.68	7.69
Paracytherois agigensis Caraion, 1963		0.65									
Paracytherois flexuosa(Brady, 1867)								0.93			
Paradoxostoma atrum Müller, 1894				0.93					0.75		
Paradoxostoma acuminatum Müller, 1894		1.31		1.87							
Paradoxostoma angustum Müller, 1894									0.75		
Paradoxostoma caecum Müller, 1894				0.93			0.75				

Table 5 continued

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Paradoxostoma parallelum Müller, 1894	0.60										
Paradoxostoma aff. *P. rotundatum* Müller, 1894		0.65									
Paradoxostoma simile Müller, 1894				0.93							
Paradoxostoma triste Müller, 1894		0.65		0.93			0.75		1.50		
Phlyctocythere pellucida (Müller, 1894)					0.79			0.93			
Polycope reticulata Müller, 1894							0.75				
Pontocypris acuminata (Müller, 1894)		0.65									
Pontocypris frequens (Müller, 1894)					0.79						
Pontocypris obtusa (Müller, 1894)									0.75		
Pontocypris pellucida Müller, 1894					0.79						
Pontocypris aff. *P. pellucida* Müller, 1894				0.93							
Pontocythere turbida (Müller, 1894)	1.19		11.11	1.87	0.79	33.33	0.75	10.19	2.26	4.55	
Procytherideis retifera Ruggieri, 1978	4.76	0.65			0.79	11.11			9.77		
Procytherideis subspiralis (Brady, Crosskey & Robertson, 1874)	0.60			0.93			0.75				
Propontocypris intermedia (Brady, 1868)	1.19	1.31		4.67	0.79		0.75		0.75		
Propontocypris rara (Müller, 1894)		0.65									
Propontocypris subfusca (Müller, 1894)					2.36						
Propontocypris succinea (Müller, 1894)									0.75	1.14	7.69
Propontocypris sp.1		0.65									
Pseudocytherura strangulata Ruggieri, 1991									0.75		
Pseudopsammocythere reniformis (Brady, 1868)		3.27		0.93	0.79						
Pterygocythereis jonesii (Baird, 1850)					0.79			4.63			
Sagmatocythere napoliana (Puri, 1963)	1.19	0.65		0.93			0.75		3.01	2.27	
Sagmatocythere versicolor (Müller, 1894)					2.36			1.85			
Sahnicythere retroflexa (Klie, 1936)	1.19								6.77		
Sclerochilus ? aequus Müller, 1894	0.60	0.65									
Sclerochilus gewemuelleri Dubowsky, 1939	0.60										
Sclerochilus levis Müller, 1894				0.93						1.14	
Semicytherura acuta (Müller, 1912)							1.49		0.75	4.55	
Semicytherura acuticostata (Sars, 1866)		1.31		0.93	3.15		5.22	0.93		2.27	
Semicytherura alifera Ruggieri, 1959	1.19	2.61		0.93	0.79		2.24		1.50		
Semicytherura costata (Müller, 1894)									0.75		

Table 5 continued

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Semicytherura dispar (Müller, 1894)	1.19	0.65					1.49	0.93	2.26		
Semicytherura incongruens (Müller, 1894)	0.60	3.27		10.28	2.36		5.22			6.82	
Semicytherura inversa (Seguenza, 1880)	2.98	0.65		0.93			5.97		0.75	1.14	7.69
Semicytherura paradoxa (Müller, 1894)	0.60	0.65			1.57		0.75		0.75		
Semicytherura punctata (Müller, 1894)							0.75		2.26	2.27	
Semicytherura quadridentata (Hartmann, 1953)	1.19	0.65		0.93			0.75		1.50	1.14	
Semicytherura rarecostata Bonaduce, Ciampo & Masoli, 1976	4.76	6.54		1.87	14.96	11.11	8.21	11.11	1.50	1.14	
Semicytherura reticulata (Müller, 1894)										1.14	
Semicytherura robusta Bonaduce, Ciampo & Masoli,1976					3.15			4.63			
Semicytherura ruggierii (Pucci, 1955)	3.57	0.65		0.93	2.36		0.75				
Semicytherura simplex (Brady & Norman, 1889)							0.75				
Semicytherura aff. *S. slavonica* Krstić, 1983									0.75		
Semicytherura sulcata (Müller, 1894)									1.50	3.41	
Semicytherura tergestina Masoli, 1968				0.93	2.36						
Tenedocythere prava (Baird, 1850)		0.65		0.93	1.57	11.11	1.49	0.93			
Triebelina raripila (Müller, 1894)	0.60								0.75		7.69
Tuberoloxococncha tuberosa (Hartmann, 1954)									0.75		
Urocythereis ilariae Aiello, Barra & Parisi, 2016		1.31				11.11					
Urocythereis margaritifera (Müller, 1894)	4.17	0.65	66.67	0.93			0.75		6.02	2.27	7.69
Urocythereis schulzi (Hartmann, 1958)	0.60			0.93							
Xestoleberis communis Müller, 1894	1.19	3.92		1.87	2.36		2.99	0.93	1.50	2.27	7.69
Xestoleberis decipiens Müller, 1894	0.60										
Xestoleberis dispar Müller, 1894	1.79	3.92		6.54	3.15		0.75	4.63	1.50	2.27	7.69
Xestoleberis aff. *X. labiata* Brady & Robertson, 1874				0.93							
Xestoleberis margaritopsis Rome, 1942									1.50		
Xestoleberis pellucida Müller, 1894	0.60										
Xestoleberis aff. *X. pellucida* Müller, 1894									0.75	1.14	
Xestoleberis cf. *X. perminima* Neviani, 1928									0.75		
Xestoleberis aff. *X. perula* Athersuch, 1978	1.19	0.65		0.93	0.79		0.75			1.14	
Xestoleberis plana Müller, 1894	1.19	0.65					1.49		3.76	1.14	7.69
Xestoleberis rara Müller, 1894	0.60										
Xestoleberis sp.1										1.14	

Table 6 Ostracod absolute abundance [I(TNV) = Total Number of Valves per 100 g of sediment]

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Aglaiocypris complanata (Brady & Robertson, 1869)	16	192		64							
Argilloecia minor Müller, 1894	8	32									
Aurila convexa (Baird, 1850)	88	128		768	352		208	208	1504	16	1
Aurila prasina Barbeito-Gonzalez, 1971								416			
Aurila speyeri (Brady, 1858)								64			
Callistocythere crispata (Brady, 1868)	40	96		32	352		48	80	24	8	
Callistocythere flavidofusca (Ruggieri, 1950)	8				96		64	112			
Callistocythere lobiancoi (Müller, 1894)		256					64				
Callistocythere aff. *C. protracta* Ruggieri & D'Arpa, 1993	32										
Carinocythereis carinata (Roemer, 1838)				256		4		288			
Carinocythereis whitei (Baird, 1850)	168	896		1472	512		160	64	8	40	
Cistacythereis turbida (Müller, 1894)		96		352	848		96	608	8	24	
Costa batei (Brady, 1866)		192			16		160			8	
Costa edwardsii (Roemer, 1838)	8			32				16	8		
Cyprideis torosa (Jones, 1850)	8	160								8	
Cytheretta adriatica Ruggieri, 1952	8					4	16		72	88	
Cytheretta subradiosa (Roemer, 1838)	24		1	224	80		80	16		64	
Cytheridea neapolitana Kollmann, 1960	8										
Cytherois frequens Müller, 1894	16	480		288			32			8	
Cytherois joachinoi Barra, 1992				32							
Cytherois aff. *C. niger* Schornikov, 1965								16			
Cytherois aff. *C. pontica* Marinov, 1966	8						32				
Cytherois triangularis Bonaduce, Masoli, Minichelli & Pugliese, 1979	48	192		96	48		16		8		
Cytherois uffenordei Ruggieri, 1974	136	1216		160	32		160	16			
Cytherois sp.1		32								8	
Cytheroma variabilis Müller, 1894				64							
Cytheropteron latum Müller, 1894									8		
"Elofsonia" minima (Bonaduce, Ciampo and Masoli, 1976)	72	32		64			16		88	8	
Eucytherura gibbera Müller, 1894							80			8	
Hemicytherura defiorei Ruggieri, 1953	16	96			96		80	64		16	
Hemicytherura videns (Müller, 1894)	16	64		32			16		32	16	

Table 6 continued

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Heterocythereis voraginosa Athersuch, 1979										8	
Leptocythere levis (Müller, 1894)	8										
Leptocythere macella Ruggieri, 1975				64	208		32				
Leptocythere ramosa (Rome, 1942)								16			
Loxocauda decipiens (Müller, 1894)					16						
Loxoconcha affinis (Brady, 1866)	360	3232					192		192	72	
Loxoconcha concentrica Bonaduce, Ciampo & Masoli, 1976		32									
Loxoconcha ovulata (Costa, 1853)		768		2048	1520		416	816		40	
Loxoconcha rhomboidea (Fischer, 1855)	256	160		512	352		768	240	80		8
Loxoconcha stellifera Müller, 1894	72	64	1						32	8	
Macrocyprina succinea (Müller, 1894)					32		16				
Microcythere depressa Müller, 1894	16	128									
Microcythere hians Müller, 1894									24		
Microcythere ? *rara* Müller, 1894		32									
Microcythere vitrea Bonaduce, Ciampo & Masoli, 1976							16				
Microcytherura fulva (Brady & Robertson, 1874)	32								40		
Microcytherura nigrescens Müller, 1894	136	96		192			64		96	56	
"*Microcytherura*" sp. 1										8	
Microxestoleberis nana Müller, 1894							16		24	8	2
Microxestoleberis sp.				32							
Neocytherideis subulata (Brady, 1868)	8	32			128		16	80		40	
Neonesidea mediterranea (Müller, 1894)	8	192					112	16	16		8
Palmoconcha subrugosa (Ruggieri, 1977)				224	96			48	600		
Palmoconcha turbida (Müller, 1894)		64									
Paracytheridea paulii Dubowsky, 1939	424	64		192			48		304	112	
Paracytheridea triquetra (Reuss, 1850)	272	736		128			208		32	72	1
Paracytherois agigensis Caraion, 1963		32									
Paracytherois flexuosa (Brady, 1867)								32			
Paradoxostoma atrum Müller, 1894				32					8		
Paradoxostoma acuminatum Müller, 1894		64		64							
Paradoxostoma angustum Müller, 1894									8		
Paradoxostoma caecum Müller, 1894				32			32				

Table 6 continued

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Paradoxostoma parallelum Müller, 1894	8										
Paradoxostoma aff. *P. rotundatum* Müller, 1894		32									
Paradoxostoma simile Müller, 1894				32							
Paradoxostoma triste Müller, 1894		64		32			16		16		
Phlyctocythere pellucida (Müller, 1894)					32			16			
Polycope reticulata Müller, 1894							16				
Pontocypris acuminata (Müller, 1894)		96									
Pontocypris frequens (Müller, 1894)					32						
Pontocypris obtusa (Müller, 1894)									8		
Pontocypris pellucida Müller, 1894					16						
Pontocypris aff. *P. pellucida* Müller, 1894				64							
Pontocythere turbida (Müller, 1894)	32		1	448	80	12	224	288	104	104	
Procytherideis retifera Ruggieri, 1978	160	32			16	4			208		
Procytherideis subspiralis (Brady, Crosskey & Robertson, 1874)	8			352			16				
Propontocypris intermedia (Brady, 1868)	24	800		1120	32		64		40		
Propontocypris rara (Müller, 1894)		32									
Propontocypris subfusca (Müller, 1894)					128						
Propontocypris succinea (Müller, 1894)									8	24	2
Propontocypris sp.1		32									
Pseudocytherura strangulata Ruggieri, 1991									8		
Pseudopsammocythere reniformis (Brady, 1868)		960		224	32						
Pterygocythereis jonesii (Baird, 1850)					176			80			
Sagmatocythere napoliana (Puri, 1963)	32	96		128			48		64	32	
Sagmatocythere versicolor (Müller, 1894)					416			112			
Sahnicythere retroflexa (Klie, 1936)	24								184		
Sclerochilus ? aequus Müller, 1894	8	32									
Sclerochilus gewemuelleri Dubowsky, 1939	8										
Sclerochilus levis Müller, 1894				96						8	
Semicytherura acuta (Müller, 1912)							48		40	64	
Semicytherura acuticostata (Sars, 1866)		192		32	112		176	16		24	
Semicytherura alifera Ruggieri, 1959	24	256		96	32		80		24		
Semicytherura costata (Müller, 1894)									8		

Table 6 continued

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Semicytherura dispar (Müller, 1894)	16	32					48	16	32		
Semicytherura incongruens (Müller, 1894)	8	800		1216	256		208			88	
Semicytherura inversa (Seguenza, 1880)	104	32		64			288		16	40	2
Semicytherura paradoxa (Müller, 1894)	16	96			96		32		8		
Semicytherura punctata (Müller, 1894)							16		24	24	
Semicytherura quadridentata (Hartmann, 1953)	16	64		96			48		24	16	
Semicytherura rarecostata Bonaduce, Ciampo & Masoli, 1976	96	480		96	832	4	400	384	24	32	
Semicytherura reticulata (Müller, 1894)										16	
Semicytherura robusta Bonaduce, Ciampo & Masoli,1976					176			160			
Semicytherura ruggierii (Pucci, 1955)	128	128		32	64		16				
Semicytherura simplex (Brady & Norman, 1889)							16				
Semicytherura aff. *S. slavonica* Krstić, 1983									8		
Semicytherura sulcata (Müller, 1894)									24	32	
Semicytherura tergestina Masoli, 1968				32	80						
Tenedocythere prava (Baird, 1850)		96		32	64	4	112	16			
Triebelina raripila (Müller, 1894)	16								8		2
Tuberoloxococncha tuberosa (Hartmann, 1954)									16		
Urocythereis ilariae Aiello, Barra & Parisi, 2016		64				4					
Urocythereis margaritifera (Müller, 1894)	392	352	15	64			64		408	16	1
Urocythereis schulzi (Hartmann, 1958)	8			32							
Xestoleberis communis Müller, 1894	32	768		256	816		1328	336	72	128	2
Xestoleberis decipiens Müller, 1894	16										
Xestoleberis dispar Müller, 1894	144	1600		2016	912		144	192	96	40	7
Xestoleberis aff. *X. labiata* Brady & Robertson, 1874				32							
Xestoleberis margaritopsis Rome, 1942									16		
Xestoleberis pellucida Müller, 1894	8										
Xestoleberis aff. *X. pellucida* Müller, 1894									16	8	
Xestoleberis cf. *X. perminima* Neviani, 1928									8		
Xestoleberis aff. *X. perula* Athersuch, 1978	48	64		128	16		32			24	
Xestoleberis plana Müller, 1894	40	96					128		80	24	4
Xestoleberis rara Müller, 1894	8										
Xestoleberis sp.1										16	

Table 7 Ostracod relative abundance (RA, %) (TNV = Total Number of Valves)

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Aglaiocypris complanata (Brady & Robertson, 1869)	0.43	1.12		0.45							
Argilloecia minor Müller, 1894	0.21	0.19									
Aurila convexa (Baird, 1850)	2.35	0.75		5.42	3.83		3.04	4.30	31.28	1.06	2.50
Aurila prasina Barbeito-Gonzalez, 1971								8.61			
Aurila speyeri (Brady, 1858)								1.32			
Callistocythere crispata (Brady, 1868)	1.07	0.56		0.23	3.83		0.70	1.66	0.50	0.53	
Callistocythere flavidofusca (Ruggieri, 1950)	0.21				1.04		0.94	2.32			
Callistocythere lobiancoi (Müller, 1894)		1.49					0.94				
Callistocythere aff. *C. protracta* Ruggieri & D'Arpa, 1993	0.85										
Carinocythereis carinata (Roemer, 1838)				1.81		11.11		5.96			
Carinocythereis whitei (Baird, 1850)	4.49	5.22		10.38	5.57		2.34	1.32	0.17	2.66	
Cistacythereis turbida (Müller, 1894)		0.56		2.48	9.22		1.41	12.58	0.17	1.60	
Costa batei (Brady, 1866)		1.12			0.17		2.34			0.53	
Costa edwardsii (Roemer, 1838)	0.21			0.23				0.33	0.17		
Cyprideis torosa (Jones, 1850)	0.21	0.93								0.53	
Cytheretta adriatica Ruggieri, 1952	0.21					11.11	0.23		1.50	5.85	
Cytheretta subradiosa (Roemer, 1838)	0.64		5.56	1.58	0.87		1.17	0.33		4.26	
Cytheridea neapolitana Kollmann, 1960	0.21										
Cytherois frequens Müller, 1894	0.43	2.80		2.03			0.47			0.53	
Cytherois joachinoi Barra, 1992				0.23							
Cytherois aff. *C. niger* Schornikov, 1965								0.33			
Cytherois aff. *C. pontica* Marinov, 1966	0.21						0.47				
Cytherois triangularis Bonaduce, Masoli, Minichelli & Pugliese, 1979	1.28	1.12		0.68	0.52		0.23		0.17		
Cytherois uffenordei Ruggieri, 1974	3.63	7.09		1.13	0.35		2.34	0.33			
Cytherois sp.1		0.19								0.53	
Cytheroma variabilis Müller, 1894				0.45							
Cytheropteron latum Müller, 1894									0.17		
"Elofsonia" minima (Bonaduce, Ciampo and Masoli, 1976)	1.92	0.19		0.45			0.23		1.83	0.53	
Eucytherura gibbera Müller, 1894							1.17			0.53	
Hemicytherura defiorei Ruggieri, 1953	0.43	0.56			1.04		1.17	1.32		1.06	
Hemicytherura videns (Müller, 1894)	0.43	0.37		0.23			0.23		0.67	1.06	

Table 7 continued

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Heterocythereis voraginosa Athersuch, 1979										0.53	
Leptocythere levis (Müller, 1894)	0.21										
Leptocythere macella Ruggieri, 1975				0.45	2.26		0.47				
Leptocythere ramosa (Rome, 1942)								0.33			
Loxocauda decipiens (Müller, 1894)					0.17						
Loxoconcha affinis (Brady, 1866)	9.62	18.84					2.81		3.99	4.79	
Loxoconcha concentrica Bonaduce, Ciampo & Masoli, 1976		0.19									
Loxoconcha ovulata (Costa, 1853)		4.48		14.45	16.52		6.09	16.89		2.66	
Loxoconcha rhomboidea (Fischer, 1855)	6.84	0.93		3.61	3.83		11.24	4.97	1.66		20.00
Loxoconcha stellifera Müller, 1894	1.92	0.37	5.56						0.67	0.53	
Macrocyprina succinea (Müller, 1894)					0.35		0.23				
Microcythere depressa Müller, 1894	0.43	0.75									
Microcythere hians Müller, 1894									0.50		
Microcythere ? rara Müller, 1894		0.19									
Microcythere vitrea Bonaduce, Ciampo & Masoli, 1976							0.23				
Microcytherura fulva (Brady & Robertson, 1874)	0.85								0.83		
Microcytherura nigrescens Müller, 1894	3.63	0.56		1.35			0.94		2.00	3.72	
"*Microcytherura*" sp. 1										0.53	
Microxestoleberis nana Müller, 1894							0.23		0.50	0.53	5.00
Microxestoleberis sp.				0.23							
Neocytherideis subulata (Brady, 1868)	0.21	0.19			1.39		0.23	1.66		2.66	
Neonesidea mediterranea (Müller, 1894)	0.21	1.12					1.64	0.33	0.33		20.00
Palmoconcha subrugosa (Ruggieri, 1977)				1.58	1.04			0.99	12.48		
Palmoconcha turbida (Müller, 1894)		0.37									
Paracytheridea paulii Dubowsky, 1939	11.32	0.37		1.35			0.70		6.32	7.45	
Paracytheridea triquetra (Reuss, 1850)	7.26	4.29		0.90			3.04		0.67	4.79	2.50
Paracytherois agigensis Caraion, 1963		0.19									
Paracytherois flexuosa (Brady, 1867)								0.66			
Paradoxostoma atrum Müller, 1894				0.23					0.17		
Paradoxostoma acuminatum Müller, 1894		0.37		0.45							
Paradoxostoma angustum Müller, 1894									0.17		
Paradoxostoma caecum Müller, 1894				0.23			0.47				

Table 7 continued

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Paradoxostoma parallelum Müller, 1894	0.21										
Paradoxostoma aff. *P. rotundatum* Müller, 1894		0.19									
Paradoxostoma simile Müller, 1894				0.23							
Paradoxostoma triste Müller, 1894		0.37		0.23			0.23		0.33		
Phlyctocythere pellucida (Müller, 1894)					0.35			0.33			
Polycope reticulata Müller, 1894							0.23				
Pontocypris acuminata (Müller, 1894)		0.56									
Pontocypris frequens (Müller, 1894)					0.35						
Pontocypris obtusa (Müller, 1894)									0.17		
Pontocypris pellucida Müller, 1894					0.17						
Pontocypris aff. *P. pellucida* Müller, 1894				0.45							
Pontocythere turbida (Müller, 1894)	0.85		5.56	3.16	0.87	33.33	3.28	5.96	2.16	6.91	
Procytherideis retifera Ruggieri, 1978	4.27	0.19			0.17	11.11			4.33		
Procytherideis subspiralis (Brady, Crosskey & Robertson, 1874)	0.21			2.48			0.23				
Propontocypris intermedia (Brady, 1868)	0.64	4.66		7.90	0.35		0.94		0.83		
Propontocypris rara (Müller, 1894)		0.19									
Propontocypris subfusca (Müller, 1894)					1.39						
Propontocypris succinea (Müller, 1894)									0.17	1.60	5.00
Propontocypris sp.1		0.19									
Pseudocytherura strangulata Ruggieri, 1991									0.17		
Pseudopsammocythere reniformis (Brady, 1868)		5.60		1.58	0.35						
Pterygocythereis jonesii (Baird, 1850)					1.91			1.66			
Sagmatocythere napoliana (Puri, 1963)	0.85	0.56		0.90			0.70		1.33	2.13	
Sagmatocythere versicolor (Müller, 1894)					4.52			2.32			
Sahnicythere retroflexa (Klie, 1936)	0.64								3.83		
Sclerochilus ? *aequus* Müller, 1894	0.21	0.19									
Sclerochilus gewemuelleri Dubowsky, 1939	0.21										
Sclerochilus levis Müller, 1894				0.68						0.53	
Semicytherura acuta (Müller, 1912)							0.70		0.83	4.26	
Semicytherura acuticostata (Sars, 1866)		1.12		0.23	1.22		2.58	0.33		1.60	
Semicytherura alifera Ruggieri, 1959	0.64	1.49		0.68	0.35		1.17		0.50		
Semicytherura costata (Müller, 1894)									0.17		

Table 7 continued

Samples	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Semicytherura dispar (Müller, 1894)	0.43	0.19					0.70	0.33	0.67		
Semicytherura incongruens (Müller, 1894)	0.21	4.66		8.58	2.78		3.04			5.85	
Semicytherura inversa (Seguenza, 1880)	2.78	0.19		0.45			4.22		0.33	2.66	5.00
Semicytherura paradoxa (Müller, 1894)	0.43	0.56			1.04		0.47		0.17		
Semicytherura punctata (Müller, 1894)							0.23		0.50	1.60	
Semicytherura quadridentata (Hartmann, 1953)	0.43	0.37		0.68			0.70		0.50	1.06	
Semicytherura rarecostata Bonaduce, Ciampo & Masoli, 1976	2.56	2.80		0.68	9.04	11.11	5.85	7.95	0.50	2.13	
Semicytherura reticulata (Müller, 1894)										1.06	
Semicytherura robusta Bonaduce, Ciampo & Masoli,1976					1.91			3.31			
Semicytherura ruggierii (Pucci, 1955)	3.42	0.75		0.23	0.70		0.23				
Semicytherura simplex (Brady & Norman, 1889)							0.23				
Semicytherura aff. *S. slavonica* Krstić, 1983									0.17		
Semicytherura sulcata (Müller, 1894)									0.50	2.13	
Semicytherura tergestina Masoli, 1968				0.23	0.87						
Tenedocythere prava (Baird, 1850)		0.56		0.23	0.70	11.11	1.64	0.33			
Triebelina raripila (Müller, 1894)	0.43								0.17		5.00
Tuberoloxococncha tuberosa (Hartmann, 1954)									0.33		
Urocythereis ilariae Aiello, Barra & Parisi, 2016		0.37				11.11					
Urocythereis margaritifera (Müller, 1894)	10.47	2.05	83.33	0.45			0.94		8.49	1.06	2.50
Urocythereis schulzi (Hartmann, 1958)	0.21			0.23							
Xestoleberis communis Müller, 1894	0.85	4.48		1.81	8.87		19.44	6.95	1.50	8.51	5.00
Xestoleberis decipiens Müller, 1894	0.43										
Xestoleberis dispar Müller, 1894	3.85	9.33		14.22	9.91		2.11	3.97	2.00	2.66	17.50
Xestoleberis aff. *X. labiata* Brady & Robertson, 1874				0.23							
Xestoleberis margaritopsis Rome, 1942									0.33		
Xestoleberis pellucida Müller, 1894	0.21										
Xestoleberis aff. *X. pellucida* Müller, 1894									0.33	0.53	
Xestoleberis cf. *X. perminima* Neviani, 1928									0.17		
Xestoleberis aff. *X. perula* Athersuch, 1978	1.28	0.37		0.90	0.17		0.47			1.60	
Xestoleberis plana Müller, 1894	1.07	0.56					1.87		1.66	1.60	10.00
Xestoleberis rara Müller, 1894	0.21										
Xestoleberis sp.1										1.06	

Table 8 Benthic foraminiferal and ostracod assemblage indices

	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1
Foraminifers											
Taxa (S)	71	82	17	63	52	48	56	53	55	58	38
Individuals (I)	19,008	105,984	69	26,944	43,264	1152	94,976	98,560	13,056	10,528	231
Dominance (D)	0.04	0.04	0.20	0.04	0.04	0.04	0.06	0.05	0.06	0.05	0.16
Shannon (H')	3.64	3.66	2.21	3.52	3.45	3.41	3.42	3.32	3.39	3.51	2.60
Equitability (J)	0.85	0.83	0.78	0.85	0.87	0.88	0.85	0.84	0.85	0.86	0.72
Ostracod MNI											
Taxa (S)	57	57	4	50	39	7	54	31	52	44	12
Individuals (I)	1330	4710	9	3114	1972	27	2009	1698	1022	669	13
Dominance (D)	0.04	0.05	0.48	0.07	0.06	0.27	0.04	0.06	0.04	0.04	0.09
Shannon (H')	3.56	3.38	1.00	3.21	3.20	1.58	3.50	3.02	3.49	3.47	2.46
Equitability (J)	0.88	0.84	0.72	0.82	0.87	0.81	0.88	0.88	0.88	0.92	0.99
Ostracod TNV											
Individuals (I)	3744	17,152	18	14,176	9200	36	6832	4832	4808	1504	40
Dominance (D)	0.06	0.07	0.70	0.07	0.07	0.19	0.07	0.08	0.13	0.04	0.14
Shannon (H')	3.28	3.21	0.63	3.06	2.97	1.83	3.26	2.84	2.77	3.43	2.21
Equitability (J)	0.81	0.79	0.46	0.78	0.81	0.94	0.82	0.83	0.70	0.91	0.89

(splitted by Moncharmont in *T. concinnus* and *Rosalina globularis*); conversely, *Q. seminulum, S. aspera, Bulimina elongata* were very rare. Our data suggested that *Q. seminulum* and *B. elongata,* stress-tolerant species (Aiello et al., 2018; Debenay et al., 2009), and *S. aspera* may have increased their abundance in the last decades.

The 1961 sampling campaign also provided bottom sediments of the adjacent Gulf of Naples. Their ostracofaunas were analyzed by Puri et al. (1964). In the infralittoral zone, the ostracod assemblages were dominated by *Aurila*, *Urocythereis, Carinocythereis, Costa* and *Pontocythere* (*Cushmanidea* in Puri et al., 1964) species, *Tenedocythere prava* (= *Quadracythere* (?) *prava* plus «*Cythereis*» *polygonata*, the latter name including the juveniles, in Puri et al., 1964) and *S. incongruens*. In the present infralittoral ostracofauna of the Gulf of Pozzuoli *U. margaritifera* and *P. turbida* are very common, but overall the assemblages are not dominated by trachyleberid species, being characterized by the genera *Loxoconcha* and *Xestoleberis* and by the species *S. rarecostata.*

It can be hypothesized that industrial and urban contaminants caused a meiofaunal change, more apparent in ostracod than in benthic foraminifers. Conversely, the high-diversity and low-dominance values showed that in oligotrophic and well-oxygenated waters (e.g., Hyams-Kaphzan et al., 2009, in a coastal area under the influence of sewage sludge with organic matter input), the diversity indices were not negatively influenced by the high concentration of pollutants in bottom sediments.

The sensitivity of ostracod and benthic foraminifers was also displayed by statistical analysis. Noteworthy correlations between ostracod dominance and sediment contaminants (polycyclic aromatic hydrocarbons, rare earth elements) encourage the use of calcareous meiofaunal assemblages as environmental bioindicators. The analysis confirmed the results of previous investigations, such as the tolerance of *Q. lata* to high heavy metal concentrations (Romano et al., 2009) testified by high correlations (≥ 0.76) with Ni, Pb, and Zn. *Quinqueloculina lata* was considered a pollution-tolerant species, by Elshanawany et al. (2011; 2018) and by Romano et al. (2013) in environment under strong anthropogenic pressure. The study of Mangoni et al. (2016) showed a correlation of this species with high concentrations of inorganic nutrients.

The strong anticorrelations (≤ -0.80) between both TNV and MNI abundances of the typical shallow marine (Aiello et al., 2016, 2018) species *P. paulii* and *U. margaritifera*, and water depth suggested the preferences of these taxa for the uppermost part of

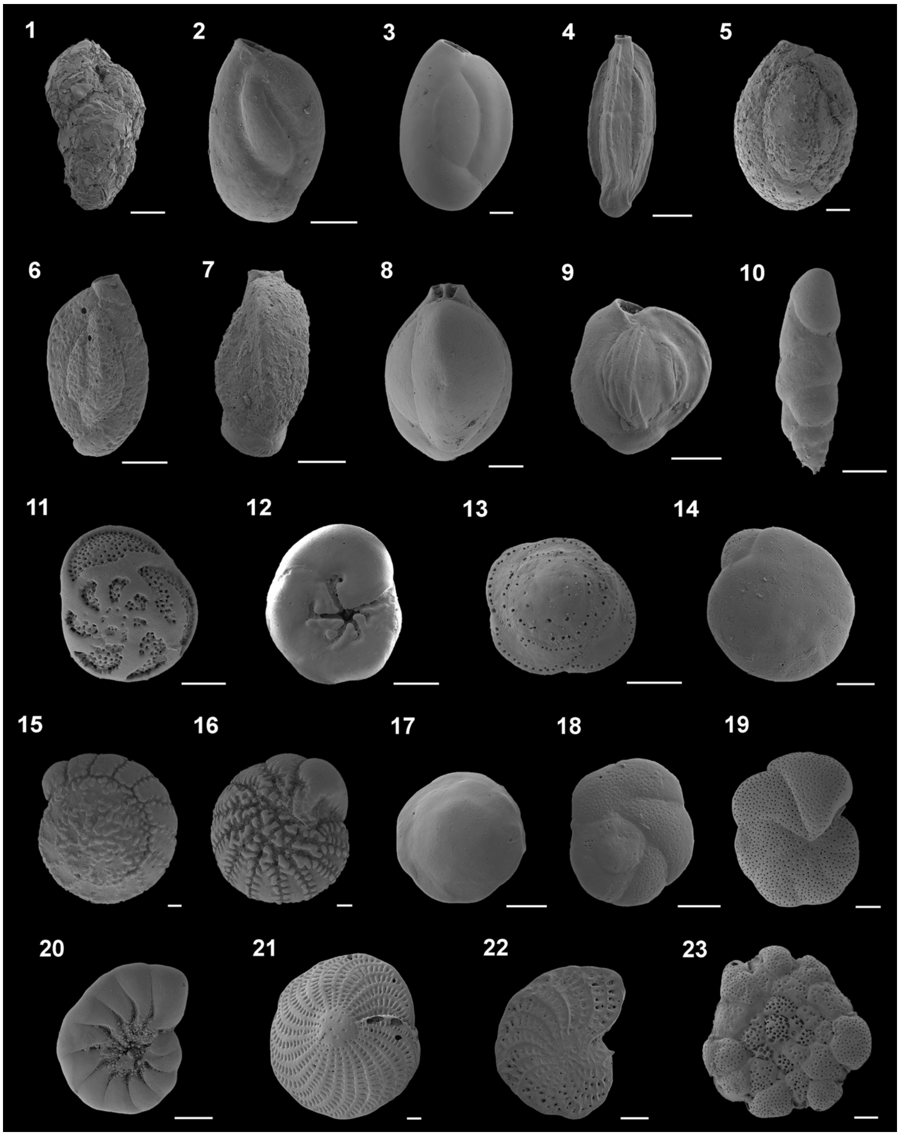

Fig. 2 1 *Eggerelloides scaber* (Williamson, 1858), lateral view, sample TP2—2, ABMC 2019/042 2 *Quinqueloculina lata* Terquem, 1876, four chamber side, sample TP1—1, ABMC 2019/054 3 *Quinqueloculina seminulum* (Linnaeus, 1758), four chamber side, sample TP2—2, ABMC 2019/045 4 *Quinqueloculina stelligera* Schlumberger, 1893, peripheral view, sample TP1—2, ABMC 2019/044 5 *Siphonaperta aspera* (d'Orbigny, 1826), side view, sample TP2—1, ABMC 2019/040 6 *Cycloforina contorta* (d´Orbigny, 1846), four chamber side, sample TP1—2, ABMC 2019/058 7 *Cycloforina contorta* (d´Orbigny, 1846), peripheral view, sample TP1—2, ABMC 2019/059 8 *Triloculina trigonula* (Lamarck, 1804), peripheral view, sample TP1—2, ABMC 2019/046 9 *Miliolinella semicostata* (Wiesner, 1923), side view, sample TP1—1, ABMC 2019/048 10 *Bulimina elongata* d'Orbigny, 1846, lateral view, sample TP3—2, ABMC 2019/047 11 *Rosalina macropora* (Hofker, 1951), spiral side, sample TP1—2, ABMC 2019/055 12 *Rosalina macropora* (Hofker, 1951), umbilical side, sample TP1—2, ABMC 2019/056 13 *Asterigerinata mamilla* (Williamsom, 1858), spiral side, sample TP1—2, ABMC 2019/051 14 *Ammonia aberdoveyensis* Haynes, 1973, spiral side, sample TP1—1, ABMC 2019/039 15 *Ammonia beccarii* (Linnaeus, 1758), spiral side, sample TP2—3, ABMC 2019/060 16 *Ammonia beccarii* (Linnaeus, 1758), umbilical side, sample TP2—3, ABMC 2019/061 17 *Buccella granulata* (Di Napoli Alliata, 1952), spiral side, sample TP2—3, ABMC 2019/043 18 *Tretomphalus concinnus* (Brady, 1884), spiral side, sample TP1—1, ABMC 2019/052 19 *Cibicides lobatulus* (Walker & Jacob, 1798), umbilical side, sample TP1—2, ABMC 2019/053 20 *Haynesina depressula* (Walker & Jacob, 1798), side view, sample TP1—1, ABMC 2019/050 21 *Elphidium crispum* (Linnaeus, 1758), side view, sample TP2—3, ABMC 2019/041 22 *Elphidium maioricense* Colom, 1942, side view, sample TP3—2, ABMC 2019/049 23 *Planorbulina mediterranensis* d'Orbigny, 1826, unattached side, sample TP3—2, ABMC 2019/057 Scale bar 100 μm

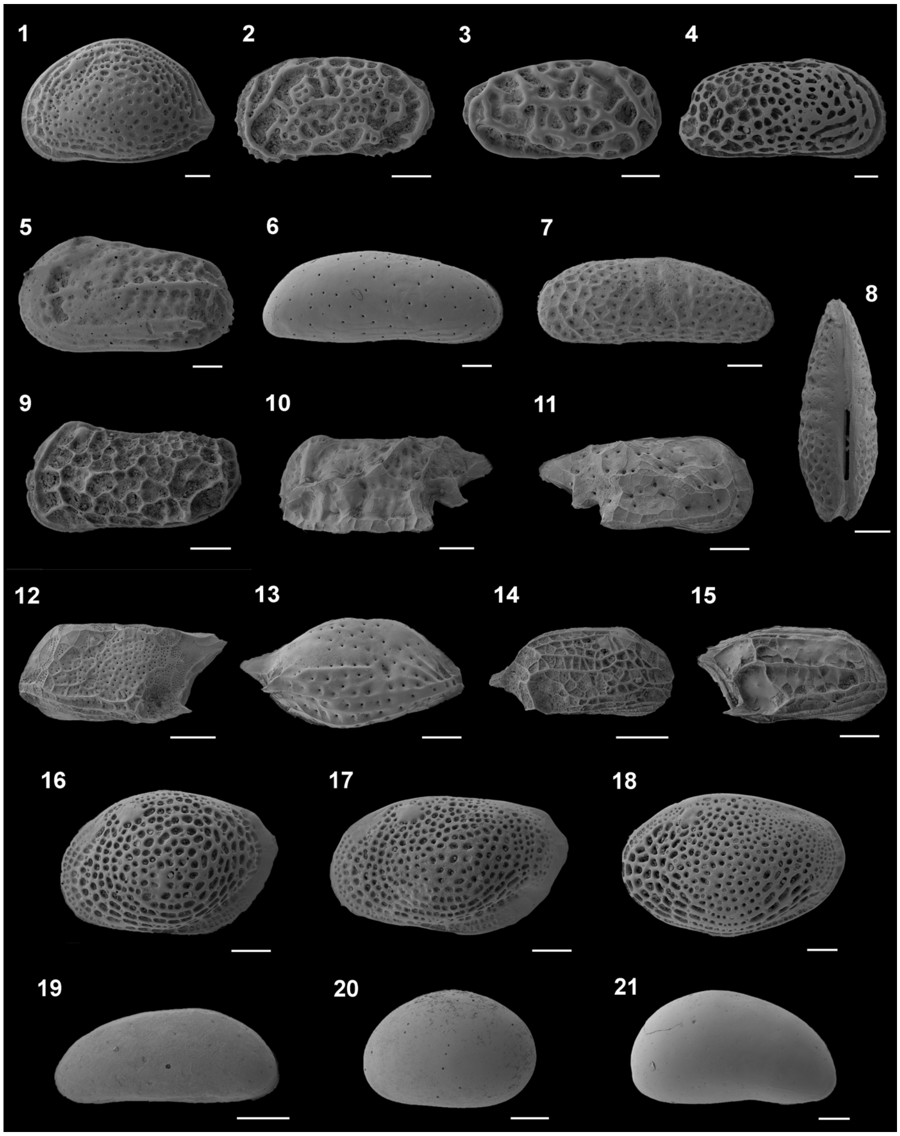

Fig. 3 1 *Aurila convexa* (Baird, 1850), left valve, sample TP2—3, ABMC 2019/065 2 *Callistocythere lobiancoi* (Müller, 1894), left valve, sample TP1—2, ABMC 2019/078 3*Callistocythere flavidofusca* (Ruggieri, 1950), right valve, sample TP2—3, ABMC 2019/067 4 *Urocythereis margaritifera* (Müller, 1894), right valve, sample TP2—1, ABMC 2019/068 5 *Cistacythereis turbida* (Müller, 1894), left valve, sample TP2—3, ABMC 2019/074 6 *Pontocythere turbida* (Müller, 1894), right valve, sample TP2—2, ABMC 2019/072 7 *Procytherideis retifera* Ruggieri, 1978, right valve, sample TP1—1, ABMC 2019/081 8 *Procytherideis retifera* Ruggieri, 1978, carapace in dorsal view, sample TP1—1, ABMC 2019/082 9 *Sagmatocythere napoliana*, left valve, sample TP3—2, ABMC 2019/075 10 *Paracytheridea triquetra* (Reuss, 1850), left valve, sample TP1—1, ABMC 2019/066 11 *Paracytheridea paulii* Dubowsky, 1939, right valve, sample TP1—1, ABMC 2019/062 12 *Semicytherura robusta* Bonaduce, Ciampo & Masoli,1976, left valve, sample TP2—3, ABMC 2019/077 13 *Semicytherura incongruens* (Müller, 1894), right valve, sample TP2—2, ABMC 2019/070 14 *Semicytherura rarecostata* Bonaduce, Ciampo & Masoli, 1976, right valve, sample TP1—2, ABMC 2019/076 15 *Semicytherura ruggierii* (Pucci, 1955), right valve, sample TP1—1, ABMC 2019/080 16 *Loxoconcha affinis* (Brady, 1866), left valve, sample TP1—1, ABMC 2019/063 17 *Loxoconcha rhomboidea* (Fischer, 1855), left valve, sample TP1—1, ABMC 2019/069 18 *Loxoconcha ovulata* (Costa, 1853), left valve, sample TP2—2, ABMC 2019/071 19 *Cytherois uffenordei* Ruggieri, 1974, left valve, sample TP1—2, ABMC 2019/064 20 *Xestoleberis communis* Müller, 1894, left valve, sample TP1—2, ABMC 2019/073 21 *Xestoleberis dispar* Müller, 1894, right valve, sample TP2—2, ABMC 2019/079 Scale bar 100 μm

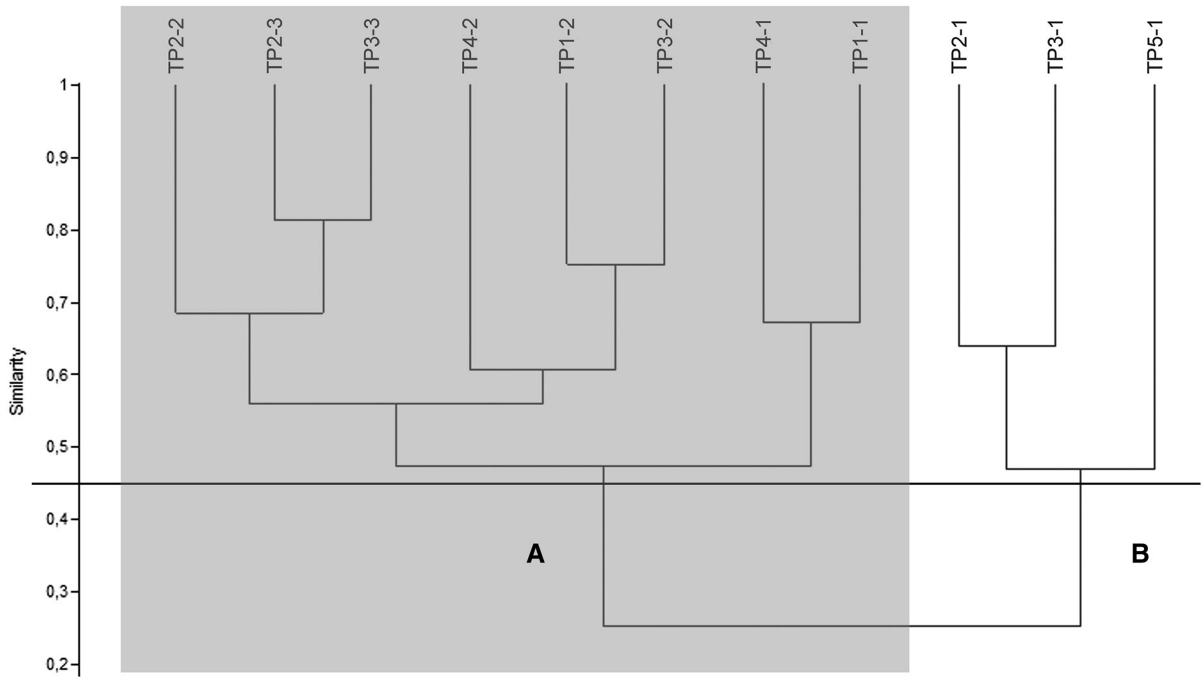

Fig. 4 Dendrogram based on cluster analysis of benthic foraminiferal and ostracod (MNI and TNV) abundance data (I)

the upper infralittoral zone. From a paleoecological point of view, the refining of the distribution range of paleobathymetric indicators is a primary objective. The paleodepth estimates of sedimentary successions, or levels, using benthic foraminifers and ostracods, may contribute to the reconstruction of the dynamics of volcanic areas (Aiello et al., 2007, 2012; Marturano et al., 2009; 2011a; 2011b; 2013; 2018; Di Vito et al., 2016; Isaia et al., 2019). The present results showed that high abundance values of the genera *Paracytheridea* and *Urocythereis*, and specifically of *P. paulii* and *U. margaritifera*, are characteristic of upper shoreface environments in waters shallower than 23 m.

Pearson's correlation coefficient analysis of benthic foraminifers revealed that *T. concinnus* and taxa richness (S) correlated with As; foraminiferal dominance with Fe and Zn; *Q. lata* correlated with Ni, Pb, Zn, TOC and anticorrelated with water depth.

The Pearson's correlation coefficient analysis of ostracods showed that Cr and Cu displayed high correlations with *Carinocythereis whitei*, *Semicytherura incongruens* (both MNI and TNV), *L. rhomboidea* (MNI), *L. ovulata*, and *X. dispar* and an inverse correlation with equitability J (TNV). Water depth correlated with *C. turbida* and taxa richness S (MNI and TNV), *L. ovulata* and Shannon Index H' (MNI), and anticorrelated with *Paracytheridea paulii* and *U. margaritifera* (MNI and TNV) and with *Procytherideis retifera* (MNI).

Total PAHs and total PD PAHs (Priority Dangerous PAHs) correlated with *P. retifera* (MNI), *A. convexa* and D and showed an inverse correlation with J (TNV). Rare earth elements correlated with *A. convexa* and D (TNV).

Ni correlated with *P. paulii, P. retifera,* and *U. margaritifera* (MNI); As showed correlation with *L. affinis* (MNI and TNV), *Cytherois uffenordei*, *Paracytheridea triquetra* (MNI); Hg anticorrelated with H' (TNV); TOC correlated with D(TNV).

Discussion

The study of shallow water samples of the Gulf of Pozzuoli allowed us to investigate the distribution of meiofaunal calcareous assemblages in an area subject

Table 9 Concentrations (%) of TOC = total organic carbon; concentrations (mg/kg) of heavy metals, REE + Y = rare earth elements + Y, LREE (light rare earth elements), HREE (heavy rare earth elements), total PAHs (polycyclic aromatic hydrocarbons) and total PD PAHs (PD: Priority Dangerous PAHs: naphthalene (NAP), anthracene (ANT), benzo(b)fluoranthene (BbF), benzo(k)fluoranthene (BkF), benzo(ghi)perylene (BgP), benzo(a)pyrene (BaP); (Arienzo et al., 2017; Trifuoggi et al., 2017; 2018; Ferrara et al., 2020); concentrations of national regulatory guidelines (Ministero dell'Ambiente e della Tutela del Territorio, 2003; Ministero dell'Ambiente e della Tutela del Territorio e del Mare, 2009); background concentrations for the study area (Damiani et al., 1987)

	TP1—1	TP1—2	TP2—1	TP2—2	TP2—3	TP3—1	TP3—2	TP3—3	TP4—1	TP4—2	TP5—1	Damiani et al. 1987	D.M. 367/2003	D.M. 56/2009
TOC %	1.34	1.51	1.75	1.84	0.98	0.09	0.64	1.17	9.20	2.60	0.34			
As	59.02	100.4	18.83	25.4	22.58	26.12	38.51	35.35	61.27	69.03	12.31		12	
Cr	11.58	14.27	4.80	27.15	19.73	10.22	15.49	1.99	1.85	1.59	0.55	0.30	50	
Cu	15.48	16.40	5.88	24.62	15.93	5.16	9.72	13.32	14.59	10.23	3.53	0.20		
Fe	13,784	14,882	12,835	21,132	18,666	37,320	25,588	29,442	32,449	37,495	10,498	25,000		
Hg	1.14	1.40	0	3.00	3.44	0.59	1.52	3.00	3.35	2.01	0.51	0.25	0.30	
Ni	14.82	10.5	3.72	8.47	6.36	14.85	3.56	4.45	35.45	14.52	0	0.20	30	
Pb	45.67	55.81	20.32	86.46	72.93	29.94	74.98	71.19	110.82	107.57	20.60	60	30	
Zn	107.4	114.7	46.7	178.9	135.7	96.70	187.3	132	247.9	232.3	42.10	80	80	
Total PAHs	17	52	7.20	230	58	7.10	42	42	840	130	17			
Total PD PAHs	6.10	21	2.70	74	32	2.80	13	13	250	39	5.40			200 E-3
REE + Y	16.96	44.71	31.4	42.64	27.8	31.67	46.51	50.08	142.46	59.3	73.93			
LREE	15.53	42.92	30.38	40.85	25.6	30.41	43.68	48.82	125.71	53.73	64			
HREE	0.93	1.20	0.69	1.15	1.18	0.92	1.65	0.92	6.12	2.60	4.84			

Table 10 Bivariate correlation with the Pearson's correlation coefficient. TOC = total organic carbon; TTPAH = total polycyclic aromatic hydrocarbons; TTPD = total priority dangerous polycyclic aromatic hydrocarbons; REE + Y = rare earth elements + Y; LREE = light rare earth elements; HREE = heavy rare earth elements

	DEPTH	TOC	As	Cr	Cu	Fe	Hg	Ni	Pb	Zn	TTPAH	TTPD	REE+Y	LREE	Cr
Asterigerinata mamilla	0.65	−0.46	−0.19	−0.26	−0.30	−0.35	−0.39	−0.44	−0.49	−0.53	−0.44	−0.45	−0.21	−0.18	−0.38
Bulimina elongata	0.27	−0.42	0.15	0.01	0.01	0.01	0.02	0.02	0.02	0.02	−0.35	−0.34	−0.26	−0.24	−0.34
Cibicides lobatulus	0.49	−0.45	0.02	−0.13	−0.15	−0.17	−0.19	−0.21	−0.23	−0.25	−0.43	−0.44	−0.20	−0.18	−0.34
Discorbinella bertheloti	0.74	−0.30	−0.42	−0.30	−0.36	−0.43	−0.50	−0.56	−0.63	−0.70	−0.30	−0.30	−0.16	−0.14	−0.33
Elphidium crispum	0.59	−0.44	0.26	0.15	0.15	0.16	0.16	0.17	0.17	0.18	−0.43	−0.42	−0.26	−0.23	−0.46
Elphidium punctatum	−0.27	−0.24	−0.20	−0.22	−0.22	−0.22	−0.22	−0.23	−0.23	−0.23	−0.29	−0.32	−0.24	−0.26	−0.12
Planorbulina mediterranensis	0.39	−0.15	0.22	0.04	0.04	0.04	0.04	0.04	0.04	0.04	−0.18	−0.19	0.04	0.07	−0.13
Quinqueloculina lata	−0.71	0.74	0.70	0.45	0.53	0.61	0.69	0.76	0.84	0.92	0.70	0.69	0.65	0.64	0.69
Quinqueloculina seminulum	0.43	−0.31	−0.17	−0.24	−0.28	−0.33	−0.37	−0.41	−0.46	−0.50	−0.17	−0.18	−0.11	−0.07	−0.32
Tretomphalus concinnus	−0.03	−0.19	0.71	0.20	0.10	−0.51	−0.57	−0.13	−0.49	−0.41	−0.23	−0.23	−0.15	−0.13	−0.23
Triloculina trigonula	0.32	−0.42	0.44	0.21	−0.01	−0.39	−0.48	−0.45	−0.50	−0.45	−0.41	−0.42	−0.26	−0.23	−0.41
Carinocythereis whitei MNI	0.42	−0.35	−0.22	0.86	0.82	−0.54	0.23	−0.39	−0.21	−0.34	−0.21	−0.17	−0.38	−0.37	−0.45
Cistacythereis turbida MNI	0.89	−0.45	−0.64	0.32	0.23	−0.15	0.59	−0.61	−0.19	−0.41	−0.36	−0.32	−0.36	−0.35	−0.48
Cytheretta adriatica MNI	−0.29	0.19	0.33	−0.53	−0.44	0.63	−0.18	0.29	0.53	0.55	0.08	0.05	0.17	0.16	0.29
Cytherois uffenordei MNI	0.03	−0.21	0.72	0.22	0.18	−0.55	−0.50	−0.14	−0.50	−0.47	−0.25	−0.25	−0.20	−0.18	−0.27
Loxoconcha affinis MNI	−0.11	−0.12	0.82	0.07	0.02	−0.49	−0.58	−0.01	−0.47	−0.40	−0.19	−0.19	−0.11	−0.10	−0.15
Loxoconcha ovulata MNI	0.83	−0.51	−0.49	0.63	0.55	−0.31	0.40	−0.68	−0.24	−0.41	−0.37	−0.34	−0.41	−0.38	−0.58
Loxoconcha rhomboidea MNI	0.26	−0.26	−0.54	0.76	0.79	−0.25	0.24	−0.36	−0.02	−0.06	−0.08	−0.07	−0.26	−0.24	−0.35
Paracytheridea paulii MNI	−0.92	0.52	0.29	−0.13	0.23	−0.11	−0.23	0.71	0.05	0.19	0.48	0.46	0.29	0.26	0.42
Paracytheridea triquetra MNI	−0.03	−0.18	0.79	0.14	0.10	−0.48	−0.56	−0.08	−0.45	−0.40	−0.24	−0.24	−0.16	−0.15	−0.22
Pontocythere turbida MNI	0.55	−0.14	−0.41	−0.29	0.05	0.33	0.40	−0.29	0.04	−0.12	−0.11	−0.13	−0.01	0.02	−0.22
Procytherideis retifera MNI	−0.83	0.78	0.42	−0.36	0.02	−0.05	−0.02	0.89	0.09	0.20	0.72	0.71	0.62	0.60	0.70
Semicytherura incongruens MNI	0.19	−0.26	−0.15	0.78	0.73	−0.30	0.01	−0.32	−0.01	−0.02	−0.11	−0.09	−0.23	−0.22	−0.31
Semicytherura inversa MNI	−0.18	−0.25	−0.14	0.12	−0.48	−0.03	−0.52	−0.26	−0.17	0.08	−0.22	−0.24	−0.14	−0.15	−0.08
Semicytherura rarecostata MNI	0.63	−0.52	0.03	0.34	0.01	−0.54	−0.03	−0.57	−0.58	−0.66	−0.51	−0.47	−0.44	−0.42	−0.52
Urocythereis margaritifera MNI	−0.92	0.64	0.57	−0.39	−0.14	−0.08	−0.32	0.80	0.00	0.16	0.54	0.52	0.48	0.46	0.60
Xestoleberis dispar MNI	0.35	−0.24	0.07	0.60	0.82	−0.45	0.11	−0.28	−0.23	−0.35	−0.15	−0.13	−0.25	−0.22	−0.39

Table 10 continued

	DEPTH	TOC	As	Cr	Cu	Fe	Hg	Ni	Pb	Zn	TTPAH	TTPD	REE+Y	LREE	Cr
Aurila convexa TNV	−0.39	0.86	−0.16	−0.04	0.35	0.26	0.64	0.74	0.58	0.57	0.94	0.95	0.82	0.81	0.79
Carinocythereis carinata TNV	0.53	−0.20	−0.49	0.14	0.48	0.10	0.42	−0.36	0.01	−0.15	−0.10	−0.11	−0.12	−0.08	−0.33
Carinocythereis whitei TNV	0.25	−0.28	−0.11	0.83	0.87	−0.52	0.10	−0.30	−0.19	−0.26	−0.14	−0.12	−0.32	−0.31	−0.39
Cistacythereis turbida TNV	0.81	−0.38	−0.67	0.31	0.25	−0.15	0.65	−0.52	−0.14	−0.37	−0.30	−0.26	−0.34	−0.33	−0.42
Cytheretta adriatica TNV	−0.49	0.66	0.32	−0.65	−0.46	0.80	0.08	0.68	0.81	0.85	0.58	0.56	0.67	0.66	0.77
Loxoconcha affinis TNV	−0.03	−0.11	0.80	0.09	0.09	−0.47	−0.48	−0.02	−0.43	−0.40	−0.17	−0.16	−0.09	−0.08	−0.15
Loxoconcha ovulata TNV	0.64	−0.39	−0.56	0.78	0.75	−0.36	0.48	−0.52	−0.12	−0.29	−0.23	−0.19	−0.37	−0.36	−0.47
Loxoconcha rhomboidea TNV	0.26	−0.48	−0.59	0.67	0.13	−0.31	−0.10	−0.58	−0.28	−0.16	−0.33	−0.32	−0.38	−0.37	−0.41
Paracytheridea paulii TNV	−0.90	0.46	0.20	−0.09	0.24	−0.17	−0.23	0.65	−0.02	0.11	0.42	0.40	0.22	0.19	0.35
Pontocythere turbida TNV	0.39	−0.15	−0.67	0.36	0.44	0.22	0.40	−0.34	0.25	0.19	0.02	0.01	−0.03	0.00	−0.18
Semicytherura incongruens TNV	0.23	−0.24	−0.01	0.77	0.79	−0.42	0.03	−0.28	−0.10	−0.16	−0.11	−0.09	−0.24	−0.22	−0.33
Semicytherura rarecostata TNV	0.68	−0.50	−0.25	0.35	−0.06	−0.42	0.17	−0.58	−0.43	−0.54	−0.47	−0.43	−0.43	−0.43	−0.46
Urocythereis margaritifera TNV	−0.80	0.52	0.64	−0.17	0.11	−0.35	−0.35	0.68	−0.22	−0.08	0.44	0.43	0.35	0.33	0.41
Xestoleberis communis TNV	0.45	−0.48	−0.14	0.40	−0.27	−0.25	−0.20	−0.58	−0.28	−0.21	−0.41	−0.40	−0.29	−0.28	−0.33
Xestoleberis dispar TNV	0.31	−0.25	−0.02	0.78	0.84	−0.54	0.13	−0.28	−0.21	−0.31	−0.14	−0.10	−0.28	−0.27	−0.37
Taxa (S) F	−0.30	−0.20	0.73	0.23	0.30	−0.63	−0.68	−0.01	−0.57	−0.49	−0.25	−0.26	−0.30	−0.30	−0.29
Individuals (I) F	0.58	−0.48	0.12	0.07	−0.21	−0.24	−0.25	−0.59	−0.49	−0.49	−0.47	−0.48	−0.27	−0.23	−0.45
Dominance (D) F	−0.23	0.52	−0.03	−0.55	−0.63	0.72	0.10	0.37	0.57	0.70	0.51	0.48	0.69	0.70	0.66
Shannon (H') F	−0.29	−0.22	0.49	0.22	0.38	−0.30	−0.53	−0.02	−0.20	−0.17	−0.27	−0.28	−0.36	−0.37	−0.30
Equitability (J) F	0.02	0.02	−0.56	0.13	−0.10	0.22	0.39	0.02	0.37	0.32	0.04	0.07	−0.08	−0.11	0.11
Taxa (S) O	−0.74	0.17	0.52	0.28	0.14	−0.42	−0.63	0.32	−0.21	0.02	0.16	0.15	0.06	0.05	0.17
Individuals (I) O MNI	0.31	−0.35	0.30	0.59	0.51	−0.63	−0.21	−0.36	−0.47	−0.50	−0.28	−0.26	−0.30	−0.28	−0.43
Dominance (D) O MNI	0.69	−0.34	−0.54	0.58	0.74	−0.27	0.56	−0.47	−0.12	−0.34	−0.20	−0.17	−0.32	−0.30	−0.47
Shannon (H') O MNI	−0.85	0.31	0.51	−0.17	−0.36	0.00	−0.62	0.49	0.07	0.32	0.23	0.21	0.21	0.18	0.40
Equitability (J) O MNI	−0.18	0.16	0.11	−0.77	−0.86	0.64	−0.13	0.21	0.34	0.39	0.02	−0.01	0.19	0.17	0.31
Individuals (I) O TNV	0.30	−0.24	0.14	0.71	0.66	−0.61	−0.01	−0.29	−0.34	−0.39	−0.14	−0.11	−0.22	−0.21	−0.33
Dominance (D) O TNV	−0.29	0.80	−0.04	−0.23	0.12	0.17	0.53	0.66	0.33	0.33	0.84	0.84	0.80	0.80	0.73

Table 10 continued

	DEPTH	TOC	As	Cr	Cu	Fe	Hg	Ni	Pb	Zn	TTPAH	TTPD	REE+Y	LREE	Cr
Shannon (H') O TNV	−0.19	−0.49	0.38	0.11	−0.28	−0.11	−0.81	−0.31	−0.21	−0.07	−0.56	−0.58	−0.51	−0.52	−0.38
Equitability (J) O TNV	0.39	−0.64	0.00	−0.16	−0.44	0.24	−0.36	−0.58	−0.07	−0.10	−0.72	−0.73	−0.57	−0.56	−0.52

to long-term industrial and urban pollution. All the sediments were collected within the infralittoral zone where previous researches displayed high geoaccumulation levels, especially in the eastern part of the bay (Arienzo et al., 2017; Trifuoggi et al., 2017, 2018). Anthropogenic and natural environmental pressure may influence both the meiofaunal features (abundance, diversity indices, dominance) and the taxonomic composition of foraminiferal and ostracod assemblages. In the sediments of the Gulf of Pozzuoli, their diversity was strongly related to the grain size of the bottom sediments, being low in the coarse-grained samples and high in fine and very fine sands. The relationship between granulometry and meiofaunal diversity in shallow marine waters was investigated by several researchers, who identified indicative trends. Pokorný (1978) stated, as a general rule, that coarse sediments (e.g., oolites and clean sands), can hold only a limited number of ostracod species, whereas on pelitic bottoms and mud-mixed sands the diversity of the assemblages increases. A number of studies corroborated this relationship, showing high ostracod diversity in fine-grained sands and low diversity in coarser sediments (Hazel, 1975; Aiello et al., 2006), higher diversity on silts or mud-mixed sands, and lower in clean sands (Puri 1966, 1971) and negative correlation with granulometry in Quaternary sandy successions (Aiello et al., 2020). On the other hand, on muddy bottoms, ostracod diversity frequently diminishes (Benson & Maddocks, 1964; Hong, 2016); consequently, it was suggested that the relationship between "ostracod diversity and particle size fractionation is not unimodal but rather hump shape" (Hong, 2016).

A similar trend was observed concerning benthic foraminifers. Investigations on assemblages collected on muddy bottom recorded low diversity, increasing in sandy sediments (Diz et al., 2004; Debenay et al., 2005); in large-grain sands and coarser bottom sediments a decrease was observed (Samir & El-Din, 2001; Temelkov, 2008; Delaine et al., 2015). It has to be noted that some studies reported apparently contradictory results, showing, for example, high foraminiferal diversity in sheltered areas with fine-grained sediments and high ostracod diversity in more exposed coarser-grained sediments (Morley & Hayward, 2014).

The characteristic of the assemblages occurring in the study samples supported the link between granulometry and calcareous meiofaunal diversity. Coarse-grained sediments were present in the samples TP3-1 (medium sand), TP2-1 (coarse sand), and TP5-1 (very fine gravel), where the ostracod dominance is high, whereas abundance and diversity are low; foraminiferal taxa richness and abundance are low. In the infralittoral zone of the bay, muddy sediments were virtually absent, and Pokorný's statement was confirmed by higher diversity and lower dominance displayed by ostracod, and, to a lesser extent, by benthic foraminiferal assemblages in fine and very fine sandy samples.

Chemical analyses revealed lower concentrations of pollutants in coarse-grained samples. Arsenic, copper, mercury, lead, zinc, total polycyclic aromatic hydrocarbons (pahs; in particular anthracene, benzo(a)anthracene, benzo(b)fluoranthene, and chrysene) and priority dangerous pahs were significantly higher in fine and very fine sands. The recognized inverse relationship between grain size and anthropogenic chemical contaminants (Horowitz, 1985, 1991; Herut & Sandler, 2006) and the above-mentioned link between meiofaunal remains and granulometry, could erroneously suggest the preference of ostracod and benthic foraminiferal assemblages for polluted bottom sediments. Consequently, to achieve reliable results, we considered separately the fine sandy samples and the coarser-grained sediments.

Calcareous meiofaunal assemblages exhibit different responses to anthropogenic inputs, including the decrease in diversity and increase in the abundance of tolerant taxa or morphotypes typical of polluted waters (Frontalini & Coccioni, 2008, 2011; Yasuhara et al., 2012; Wilkinson et al., 2014). As regards the presence of pollutants in the bottom sediments, researchers assumed that the geochemical nature of the substrate exerts only a modest influence on benthic foraminiferal and ostracod assemblages (Albani et al., 1998; Eagar, 1999; Irizuki et al., 2015); conversely, some investigations suggested negative effects (Schornikov, 2000; Mostafawi, 2001; Martins et al., 2015) or displayed controversial results (Coccioni, 2000; Debenay & Fernandez, 2009; Choi & An, 2012).

Our point of view is that neither the contaminants accumulated in the bottom sediments nor the dead assemblages are representative of the ecological conditions at the time of sampling. Instead, they are indicative of the environmental history of the bay during the last years or decades. On the base of the present data, it is hypothesized that the continued anthropogenic disturbance, primarily due to industrial wastes, had not resulted in a decrease in ostracod and benthic foraminiferal diversity and had its effect by changing the taxonomic composition of the assemblages. In Table 11, the mean values of diversity indices of the infralittoral assemblages of Monte di Procida (Mangoni et al., 2016) and Falerno-Domitio (Balassone et al., 2016) were reported. Both ostracod and benthic foraminiferal assemblages of the Gulf of Pozzuoli showed higher diversity and lower dominance in comparison with the nearby areas. The expected response to contaminant input was the decrease in meiofaunal diversity, nonetheless, some investigations on benthic foraminifers reported inverse trends (Debenay & Fernandez, 2009 and Li et al., 2015, in metal-contaminated waters) and highly diversified assemblages in polluted waters (Romano et al., 2009 and Choi & An, 2012, in metal-contaminated waters; Armynot du Châtelet et al., 2011, in metal-contaminated, rich organic carbon waters).

Table 11 Comparative table of diversity/dominance indices mean values of benthic foraminiferal and ostracod infralittoral assemblages of northwestern Campanian coastal areas (only fine and very fine sands); MDP = Monte di Procida (Mangoni et al., 2016), FD = Litorale Falerno Domitio (Balassone et al., 2016), GPI = infralittoral assemblages of the Gulf of Pozzuoli (this paper)

	MDP	FD	GPI
Foraminifera			
Taxa (S)	51	36	61
Individuals (I)	7376	12,356	51,540
Dominance (D)	0.08	0.12	0.05
Shannon (H')	3.25	2.73	3.49
Equitability (J)	0.83	0.77	0.85
Ostracoda MNI			
Taxa (S)	35	21	48
Individuals (I)	268	865	2066
Dominance (D)	0.09	0.17	0.05
Shannon (H')	2.93	2.25	3.35
Equitability (J)	0.84	0.77	0.87
Ostracoda TNV			
Individuals (I)	822	3447	7781
Dominance (D)	0.13	0.18	0.07
Shannon (H')	2.64	2.17	3.10
Equitability (J)	0.76	0.74	0.81

Barras et al. (2014) suggested that in oligotrophic environments the diversity indices are not appropriate to describe water quality. Moreover, the common presence of miliolids implies coastal waters supersaturated in calcium carbonate (Aiello et al., 2018, and references therein) where the presence of industrial wastes did not result in a pH lowering.

Reports of high-diversity ostracod assemblages in stressed environments are very rare (Amato et al., 2019; Aiello et al., 2020) which hampers to perform a proper comparison with the present study.

Conclusions

A quantitative study of benthic foraminiferal and ostracod assemblages, integrated with chemical and sedimentological parameters, was carried out along the coast of the Gulf of Pozzuoli. A total of 11 samples were collected within the infralittoral zone, to investigate the relationship between meiofaunal calcareous remains and pollution indicators preserved in the shallow marine bottom sediments of the bay. Assemblages were characterized by species typical of infralittoral Mediterranean environments such as the benthic foraminifers *A. aberdoveyensis, B. granulata,* and *C. lobatulus*, and the ostracods *U. margaritifera* and *P. turbida*. The genera *Elphidium* and *Quinqueloculina* (Foraminifera), and *Semicytherura* and *Xestoleberis* (Ostracoda) were highly diversified.

Despite the continued anthropogenic disturbance, testified by high geoaccumulation levels, the shallow bottom sediments of the Gulf of Pozzuoli yielded high-diversity, low-dominance assemblages. It was here hypothesized that the oligotrophic, well-oxygenated, and supersaturated in $CaCO_3$ shallow Tyrrhenian waters may promote "complex trophic relationship" and "full exploitation of ecological niches" as stated by Holbourn et al. (2013) in their investigations on foraminiferal deep-water assemblages. The diversity was linked to the grain size of the bottom sediments, being higher on fine and very fine sands, and lower on coarser sediments.

On the other hand, the comparison with the assemblages collected in 1961 in the Gulf of Pozzuoli and the Gulf of Naples showed an increase in the abundance of taxa that are suggested to tolerate to geochemical pollution (*Q. seminulum*, *B. elongata*, *Xestoleberis*, *Loxoconcha, S. rarecostata*). Statistical analysis confirmed the tolerance of *Q. lata* to a high level of heavy metals contaminants and the preference of *U. margaritifera* and *P. paulii* for the shallow part of the infralittoral zone.

Acknowledgements The authors thank Roberto de' Gennaro (DiSTAR, Università di Napoli Federico II) who took the SEM micrographs. We also acknowledge the kind collaboration of the Lega Navale di Pozzuoli, Italy, for providing us the motor vessel Antilia, the skipper Raffaele Donadio, the Captaincy of Port of Pozzuoli and Lieutenant Commander Angelo Benedetto Gonnella for assistance to the operations at sea. Finally, we are grateful to the University of Naples Federico II for supporting our research in the APC for open access.

Author contributions Giuseppe Aiello involved in conceptualization, writing—original draft preparation, investigation; Diana Barra took part in conceptualization, investigation, writing—review & editing; Roberta Parisi participated in formal analysis, investigation; Carlo Donadio took part in data curation, investigation; Michele Arienzo involved in formal analysis, investigation, resources; Luciano Ferrara took part in formal analysis, investigation, resources; Maria Toscanesi involved in investigation, resources; Marco Trifuoggi participated in investigation, resources.

Funding Open access funding provided by Università degli Studi di Napoli Federico II within the CRUI-CARE Agreement. No funding was received for conducting this study.

Data availability All data generated or analyzed during this study are included in this published article [and its supplementary information files].

Declaration

Conflicts of interest The authors have no financial or proprietary interests in any material discussed in this article.

Appendix 1

Benthic foraminiferal and ostracod list of species.

List of benthic foraminiferal species

Adelosina elegans (Williamson, 1858)
Adelosina longirostra (d'Orbigny, 1826).
Adelosina mediterranensis (Le Calvez & Le Calvez, 1958).
Adelosina pulchella d'Orbigny, 1826.
Affinetrina planciana (d´Orbigny, 1839).
Ammodiscus planorbis Höglund, 1947.
Ammonia aberdoveyensis Haynes, 1973 lobate form.
Ammonia aberdoveyensis Haynes, 1973 rounded form.
Ammonia beccarii (Linnaeus, 1758).
Amphicoryna scalaris (Batsch, 1791).
Angulogerina angulosa (Williamson, 1858).
Asterigerinata adriatica Haake, 1977.
Asterigerinata mamilla (Williamsom, 1858).
Asterigerinata mariae Sgarrella, 1990.
Astrononion stelligerum (d'Orbigny, 1839).
Bolivina catanensis Seguenza, 1862.
Bolivina lowmani Phleger & Parker, 1951.
Bolivina pseudoplicata Heron-Allen & Earland, 1930.
Bolivina variabilis (Williamson, 1858).
Bolivina sp.
Brizalina spathulata (Williamson, 1858).
Brizalina striatula (Cushman, 1922).
Buccella granulata (Di Napoli Alliata, 1952).
Bulimina aculeata d'Orbigny, 1826.
Bulimina elongata d'Orbigny, 1846.
Cassidulina carinata Silvestri, 1896.
Cibicides lobatulus (Walker & Jacob, 1798).
Cibicides refulgens Montfort, 1808.
Cibicidoides pachyderma (Rzehak, 1886).
Cibicidoides variabilis (d'Orbigny, 1826).
Conorbella imperatoria (d'Orbigny, 1846).
Cornuspira involvens (Reuss, 1850).
Cycloforina contorta (d´Orbigny, 1846).
Cycloforina rugosa (d'Orbigny, 1826).
Cycloforina tenuicollis (Wiesner, 1923).
Cycloforina villafranca (Le Calvez & Le Calvez, 1958).
Discorbinella bertheloti (d'Orbigny, 1839).
Discorbis torrei Bermúdez, 1935.
Eggerelloides scaber (Williamson, 1858).
Eilohedra vitrea (Parker, 1953).
Elphidium articulatum (d´Orbigny, 1839).
Elphidium complanatum (d´Orbigny, 1839).
Elphidium crispum (Linnaeus, 1758).
Elphidium granosum (d'Orbigny, 1846).
Elphidium incertum (Williamson, 1858).
Elphidium macellum (Fichtel & Moll, 1798).
Elphidium maioricense Colom, 1942.
Elphidium poeyanum (d'Orbigny, 1839) DS form.
Elphidium poeyanum (d'Orbigny, 1839) FS form.
Elphidium pulvereum Todd, 1958.
Elphidium punctatum (Terquem, 1878).
Favulina hexagona (Williamson, 1848).
Flintinoides labiosa (d'Orbigny, 1839).
Fursenkoina acuta (d'Orbigny, 1846).
Gavelinopsis praegeri (Heron-Allen & Earland, 1913).
Glabratella erecta (Sidebottom, 1908).
Glabratella hexacamerata Seiglie & Bermúdez, 1965.
Globobulimina sp. 1
Globocassidulina subglobosa (Brady, 1881).
Globulina gibba (d´Orbigny, 1826).
Guttulina sp. 1
Gyroidina neosoldanii Brotzen, 1936.
Gyroidina umbonata (Silvestri, 1898).
Haynesina depressula (Walker & Jacob, 1798).
Haynesina germanica (Ehrenberg, 1840).
Lachlanella undulata (d'Orbigny, 1852).
Lagena semistriata Wiliamson, 1848.
Lenticulina cultrata (Montfort, 1808).
Lenticulina gibba (d'Orbigny, 1839).
Lenticulina rotulata (Lamarck, 1804).
Massilina secans (d'Orbigny, 1826).
Melonis affinis (Reuss, 1851).
Miliolidae.
Miliolinella elongata Kruit, 1955.
Miliolinella cf. *hybrida* (Terquem, 1878).
Miliolinella semicostata (Wiesner, 1923).
Miliolinella subrotunda (Montagu, 1803).
Miliolinella webbiana (d'Orbigny, 1839).
Miniacina miniacea (Pallas, 1766).
Neoconorbina terquemi (Rzehak, 1888).
Nonionella turgida (Williamson, 1858).
Nubecularia lucifuga Defrance, 1825.
Palliolatella fasciata (Egger, 1857).
Parrina bradyi (Millett, 1898).

Peneroplis pertusus (Forskål, 1775).
Peneroplis planatus (Fichtel & Moll, 1798).
Planoglabratella opercularis (d'Orbigny, 1846).
Planorbulina mediterranensis d'Orbigny, 1826.
Quinqueloculina agglutinans d'Orbigny, 1839.
Quinqueloculina annectens (Schlumberger, 1893).
Quinqueloculina berthelotiana d'Orbigny, 1839.
Quinqueloculina bosciana d'Orbigny, 1839.
Quinqueloculina bradyana Cushman, 1917.
Quinqueloculina disparilis d'Orbigny, 1826.
Quinqueloculina irregularis d'Orbigny, 1826.
Quinqueloculina jugosa Cushman, 1944.
Quinqueloculina laevigata d'Orbigny, 1839.
Quinqueloculina lata Terquem, 1876.
Quinqueloculina limbata d'Orbigny, 1826.
Quinqueloculina parvula Schlumberger, 1894.
Quinqueloculina poeyana d'Orbigny, 1839.
Quinqueloculina pygmaea Reuss, 1850.
Quinqueloculina seminulum (Linnaeus, 1758).
Quinqueloculina stalkeri Loeblich & Tappan, 1953.
Quinqueloculina stelligera Schlumberger, 1893.
Quinqueloculina ungeriana d'Orbigny, 1846.
Quinqueloculina vulgaris d'Orbigny, 1826.
Quinqueloculina sp.
Rectuvigerina phlegeri Le Calvez, 1959.
Reophax fusiformis (Williamson, 1858).
Reussella spinulosa (Reuss, 1850).
Rosalina floridana (Cushman, 1922).
Rosalina macropora (Hofker, 1951).
Rosalina obtusa d'Orbigny, 1846.
Rotorbis auberii (d'Orbigny, 1839).
Sahulia conica (d'Orbigny, 1839).
Sigmoilina costata Schlumberger, 1893.
Sigmoilina grata (Terquem, 1878).
Sigmoilinita distorta (Phleger & Parker, 1951).
Siphonaperta aspera (d'Orbigny, 1826).
Siphonina reticulata (Cžjžek, 1884).
Sorites orbicularis (Forskål, 1775).
Spirillina vivipara Ehrenberg, 1843.
Spiroloculina depressa d'Orbigny, 1826.
Spiroloculina excavata d'Orbigny, 1846.
Spiroloculina ornata d'Orbigny, 1839.
Spiroloculina tricarinata d'Orbigny, 1852.
Spiroplectinella wrighti (Silvestri, 1903).
Stainforthia complanata (Egger, 1893).
Stomatorbina concentrica (Parker & Jones, 1864).
Textularia aciculata d'Orbigny, 1826.
Textularia agglutinans d'Orbigny, 1839.
Textularia calva Lalicker, 1940.
Textularia pala Cžjžek, 1848.
Tretomphalus concinnus (Brady, 1884).
Triloculina eburnea d'Orbigny, 1839.
Triloculina plicata Terquem, 1878.
Triloculina schreiberiana d'Orbigny, 1839.
Triloculina trigonula (Lamarck, 1804).
Trochammina inflata (Montagu, 1808).
Uvigerina mediterranea Hofker, 1932.
Valvulineria complanata (d'Orbigny, 1846).
Vertebralina striata d'Orbigny, 1826.
Wiesnerella auriculata (Egger, 1895).

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Aglaiocypris complanata (Brady & Robertson, 1869).
*Argilloecia min*or Müller, 1894
Aurila convexa (Baird, 1850).
Aurila prasina Barbeito-Gonzalez, 1971.
Aurila speyeri (Brady, 1858).
Callistocythere crispata (Brady, 1868).
Callistocythere flavidofusca (Ruggieri, 1950).
Callistocythere lobiancoi (Müller, 1894).
Callistocythere aff. *C. protracta* Ruggieri & D'Arpa, 1993.
Carinocythereis carinata (Roemer, 1838).
Carinocythereis whitei (Baird, 1850).
Cistacythereis turbida (Müller, 1894).
Costa batei (Brady, 1866).
Costa edwardsii (Roemer, 1838).
Cyprideis torosa (Jones, 1850).
Cytheretta adriatica Ruggieri, 1952.
Cytheretta subradiosa (Roemer, 1838).
Cytheridea neapolitana Kollmann, 1960.
Cytherois frequens Müller, 1894
Cytherois joachinoi Barra, 1992.
Cytherois aff. *C. niger* Schornikov, 1965.
Cytherois aff. *C. pontica* Marinov, 1966.
Cytherois triangularis Bonaduce, Masoli, Minichelli & Pugliese, 1979.
Cytherois uffenordei Ruggieri, 1974.
Cytherois sp. 1
Cytheroma variabilis Müller, 1894
Cytheropteron latum Müller, 1894
"*Elofsonia*" *minima* (Bonaduce, Ciampo & Masoli, 1976).
Eucytherura gibbera Müller, 1894
Hemicytherura defiorei Ruggieri, 1953.

Hemicytherura videns (Müller, 1894).
Heterocythereis voraginosa Athersuch, 1979.
Leptocythere levis (Müller, 1894).
Leptocythere macella Ruggieri, 1975.
Leptocythere ramosa (Rome, 1942).
Loxocauda decipiens (Müller, 1894).
Loxoconcha affinis (Brady, 1866).
Loxoconcha concentrica Bonaduce, Ciampo & Masoli, 1976.
Loxoconcha ovulata (Costa, 1853).
Loxoconcha rhomboidea (Fischer, 1855).
Loxoconcha stellifera Müller, 1894
Macrocyprina succinea (Müller, 1894).
Microcythere depressa Müller, 1894
Microcythere hians Müller, 1894
Microcythere ? *rara* Müller, 1894
Microcythere vitrea Bonaduce, Ciampo & Masoli, 1976.
Microcytherura fulva (Brady & Robertson, 1874).
Microcytherura nigrescens Müller, 1894
"*Microcytherura*" sp. 1
Microxestoleberis nana Müller, 1894
Microxestoleberis sp.
Neocytherideis subulata (Brady, 1868).
Neonesidea mediterranea (Müller, 1894).
Palmoconcha subrugosa (Ruggieri, 1977).
Palmoconcha turbida (Müller, 1894).
Paracytheridea paulii Dubowsky, 1939.
Paracytheridea triquetra (Reuss, 1850).
Paracytherois agigensis Caraion, 1963.
Paracytherois flexuosa (Brady, 1867).
Paradoxostoma atrum Müller, 1894
Paradoxostoma acuminatum Müller, 1894
Paradoxostoma angustum Müller, 1894
Paradoxostoma caecum Müller, 1894
Paradoxostoma parallelum Müller, 1894
Paradoxostoma aff. *P. rotundatum* Müller, 1894
Paradoxostoma simile Müller, 1894
Paradoxostoma triste Müller, 1894
Phlyctocythere pellucida (Müller, 1894).
Polycope reticulata Müller, 1894
Pontocypris acuminata (Müller, 1894).
Pontocypris frequens (Müller, 1894).
Pontocypris obtusa (Müller, 1894).
Pontocypris pellucida Müller, 1894
Pontocypris aff. *P. pellucida* Müller, 1894
Pontocythere turbida (Müller, 1894).
Procytherideis retifera Ruggieri, 1978.
Procytherideis subspiralis (Brady, Crosskey & Robertson, 1874).
Propontocypris intermedia (Brady, 1868).
Propontocypris rara (Müller, 1894).
Propontocypris subfusca (Müller, 1894).
Propontocypris succinea (Müller, 1894).
Propontocypris sp. 1
Pseudocytherura strangulata Ruggieri, 1991.
Pseudopsammocythere reniformis (Brady, 1868).
Pterygocythereis jonesii (Baird, 1850).
Sagmatocythere napoliana (Puri, 1963).
Sagmatocythere versicolor (Müller, 1894).
Sahnicythere retroflexa (Klie, 1936).
Sclerochilus ? *aequus* Müller, 1894
Sclerochilus gewemuelleri Dubowsky, 1939.
Sclerochilus levis Müller, 1894
Semicytherura acuta (Müller, 1912).
Semicytherura acuticostata (Sars, 1866).
Semicytherura alifera Ruggieri, 1959.
Semicytherura costata (Müller, 1894).
Semicytherura dispar (Müller, 1894).
Semicytherura incongruens (Müller, 1894).
Semicytherura inversa (Seguenza, 1880).
Semicytherura paradoxa (Müller, 1894).
Semicytherura punctata (Müller, 1894).
Semicytherura quadridentata (Hartmann, 1953)
Semicytherura rarecostata Bonaduce, Ciampo & Masoli, 1976.
Semicytherura reticulata (Müller, 1894).
Semicytherura robusta Bonaduce, Ciampo & Masoli, 1976.
Semicytherura ruggierii (Pucci, 1955).
Semicytherura simplex (Brady & Norman, 1889).
Semicytherura aff. *S. slavonica* Krstić, 1983.
Semicytherura sulcata (Müller, 1894).
Semicytherura tergestina Masoli, 1968.
Tenedocythere prava (Baird, 1850).
Triebelina raripila (Müller, 1894).
Tuberoloxococncha tuberosa (Hartmann, 1954).
Urocythereis ilariae Aiello, Barra & Parisi, 2016
Urocythereis margaritifera (Müller, 1894).
Urocythereis schulzi (Hartmann, 1958).
Xestoleberis communis Müller, 1894
Xestoleberis decipiens Müller, 1894
Xestoleberis dispar Müller, 1894
Xestoleberis aff. *X. labiata* Brady & Robertson, 1874.
Xestoleberis margaritopsis Rome, 1942.
Xestoleberis pellucida Müller, 1894

Xestoleberis aff. *X. pellucida* Müller, 1894
Xestoleberis cf. *X. perminima* Neviani, 1928.
Xestoleberis aff. *X. perula* Athersuch, 1978.
Xestoleberis plana Müller, 1894
Xestoleberis rara Müller, 1894
Xestoleberis sp. 1

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