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Meiobenthic communities in the shallow subtidal of three Italian Marine Protected Areas

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Abstract

Meiofauna assemblages of three Italian Marine Protected Areas (MPAs), Miramare (Trieste, Friuli-Venezia Giulia), Porto Cesareo (Lecce, Apulia) and Capo Caccia (Sassari, Sardinia), were investigated. Sediment samples were collected during summer 2005 in the shallow subtidal (1–4 m depth). The meiofauna was primarily represented by Nematoda and Copepoda. The results showed that significant differences in meiofauna communities abundances were found among the three Italian MPAs, and in particular between Capo Caccia and Porto Cesareo (3840 ± 422 SE individuals·10 cm^{-2} at Miramare, 5716 ± 857 SE ind.·10 cm^{-2} in Porto Cesareo, and 1063 ± 289 SE ind.·10 cm^{-2} in Capo Caccia). These differences were mainly due to a clear change in nematodes and copepods abundances in the two MPAs. Meiofauna diversity was not significantly different among the three MPAs. The analysis on nematode communities showed a dominance of deposit feeders in Porto Cesareo (*Anoplostoma*, *Daptonema* and *Theristus*), while in the marine reserves of Miramare and Capo Caccia epigrowth feeding nematodes, and predators/omnivores were dominant (*Mesacanthion*, *Marylynnia*). The results reported here represent a new contribution to the knowledge of the Mediterranean meiofauna and nematode assemblages structure and composition.

Keywords: *Meiofauna, free-living marine nematodes, shallow subtidal, Italian Marine Protected Areas*

Introduction

Shallow subtidal sandy systems might be considered as examples of "simple" ecosystems, principally driven by the physical forces of waves, tides and sediment movements (Short 1999). The simplicity is mainly related to the biodiversity of the system rather than to the adaptation of the organisms, which may be very specialized and therefore very fragile, because of the highly dynamic environment (Brown & McLachlan 1990). These sandy systems support diverse populations of benthic invertebrates, bacteria, diatoms and algae, often with very high abundances. These species play important and different roles in the ecological functioning of the beach, as primary producers (diatoms and algae), as decomposers (bacteria), as first-level (heterotrophic bacteria and meiobenthos) and second-level consumers (macrobenthos) (Knox 2001).

As a rule, the major stresses on the coastal environment have been linked with overexploitation of natural resources, pollution, industrialization and erosion (Dronkers & de Vries 1999). In many coastal and nearshore marine areas, human activities introduce distinctive pollutants that may produce severe alterations in the different trophic levels of the ecosystems. This has led many countries, including Italy, to implement a series of measures to conserve stocks and habitats with the creation of Marine Protected Areas (MPAs). Although the knowledge of the effects of protection measures on marine assemblages is still far from exhaustive (Planes et al. 2000), the MPAs are important for conservation as they can provide unique protection for critical areas and spatial escape for overexploited species.

An increasing number of investigations focussed on the search for organisms that serve as a means of biomonitoring the impact of anthropogenic changes in coastal areas and MPAs. Since the historical study

by Pearson and Rosenberg (1978), many investigations have been carried out on pollution effects mainly on macrobenthos (e.g. Warwick & Clarke 1993; Sardà et al. 2000; Blanchard & Feder 2003). Studies dealing with the potential impacts on strandline meiofauna are very scarce. In fact, previous research on meiofauna was mainly focused at the higher taxon level (e.g. Martens et al. 1985; Jouk et al. 1988; Rodriguez et al. 2001; Menn 2002) or at factors influencing the interstitial habitats (Blome et al. 1999). Research at species or even at genus level is rather scarce and limited to a few environments (Gheskiere et al. 2004, 2005a, 2006; Urban-Malinga et al. 2006).

The state and composition of meiofauna assemblages may reflect the general health of the marine benthos (Kennedy & Jacobi 1999). Therefore, the meiofauna is generally considered as an excellent tool to be used as ecological indicators for benthic habitats and for studying the impacts of different kinds of natural and anthropogenic disturbances in the marine environment (Schratzberger et al. 2000; Gheskiere et al. 2005b). In particular, we investigate nematodes since they are well suited (overall high abundances, wide tolerance spectra, no pelagic life stages, ubiquitous distribution, rapid generation and fast metabolic rates, relatively short life spans) for marine environment health assessment (Heip et al. 1985; Schratzberger et al. 2000).

The present study is concerned with the meiofauna and nematode communities from different Italian sandy shallow subtidal areas, and aims at describing the meiobenthic and nematode assemblages of three Italian MPAs, Miramare (Trieste, Friuli-Venezia Giulia), Porto Cesareo (Lecce, Apulia) and Capo Caccia (Sassari, Sardinia), adding further information on their characteristics along the Italian coasts (Gheskiere et al. 2005a; De Leonardis et al. 2008). These considerations might be particularly useful when planning conservation strategies programmes in MPAs (Badalamenti et al. 2000).

Materials and methods

Study area

In Italy there are currently 20 MPAs formally established (and 18 forthcoming), and they safeguard in total approximately 184,000 ha of sea and 580,000 km of coast. Italian MPAs include one or more no-take/no-access zones (hereafter called "total reserves" and formally defined as "A zones" according to Italian law), surrounded by buffer zones (defined as "B and C zones", where restrictions to human uses, including fishing, become progressively more lax).

Figure 1. Geographical position of the three Italian Marine Protected Areas.

Three Italian MPAs, Miramare (Trieste, Friuli-Venezia Giulia), Porto Cesareo (Lecce, Apulia) and Capo Caccia (Sassari, Sardinia), were investigated (Figure 1).

The MPA of Miramare (45°42′ N - 13°43′ E) is located in the Northern Adriatic Sea and it extends for 1700 m along the coastline and for 120 ha at sea.

The Porto Cesareo MPA (40°15′ N–18°53′ E) is located along the Ionian Sea coast, just in front of the village of Porto Cesareo. It extends for 18,000 m along the Porto Cesareo coastline and 6000 m along the Nardò coastline, occupying 17,156 ha at sea.

The Marine Reserve of Capo Caccia–Isola Piana (40°34′ N–8°13′ E) extends from Punta delle Gessiere to Capo Galera (Sassari-Sardinia), for 36,144 m along the coastline and for 2631 ha at sea.

Sampling strategy and treatment of samples

Sampling was carried out in the shallow subtidal (1–4 m depth) of the three MPAs during summer 2005. In each MPA, four sites (Miramare, MI1–M4; Porto Cesareo, PC1–PC4; Capo Caccia, CC1–CC4) were sampled for meiofauna and sediment analysis. Triplicate sediment samples were collected by direct hand coring to a depth of 10 cm, using a perspex corer (6.2 cm^2). All samples (except those for sedimentological analysis) were fixed in 5% neutral formaldehyde seawater solution. The

meiofauna samples were treated in the laboratory: the organisms were extracted from the sediment by manual centrifugation and retained on a 42 μm mesh sieve. Meiofauna was stained with Rose Bengal, counted and sorted into the major taxa under a stereomicroscope.

Sediment particle size distribution was determined and the sediment fractions were defined according to the Wentworth scale (Buchanan 1984). The sand was sifted for 20 min using a series of sieves (from 841 μm to 74 μm), and the different sediment fractions (coarse, medium, fine and very fine) were weighed using an analytical balance. The values in grams were converted in percentages.

From one of the three replicates of each site, all nematodes (or 100, if more than 100) were randomly picked out, transferred to glycerol through two series of ethanol–glycerol solutions and mounted in glycerin slides (Vincx 1996). All nematodes were identified to the genus level using the pictorial keys of Platt and Warwick (1983, 1988), Warwick et al. (1998), and the NeMys online identification key (Steyaert et al. 2005). All nematode genera were assigned to a feeding type according to Wieser (1953): (1A) buccal cavity absent or fine and tubular – selective deposit feeders; (1B) large but unarmed buccal cavity – non-selective deposit feeders; (2A) buccal cavity with scraping tooth or teeth – epistrate (diatom) feeders; (2B) buccal cavity with large jaws – predators/omnivores.

Data analysis

Multivariate analyses were performed both on sediment texture data and on biological data. Principal Component Analysis (PCA) was applied to show spatial differences in the grain size variables of the sampling sites.

The meiofauna community structure was analysed after square-root transformation and ordination by non-metric Multi-Dimensional Scaling (MDS), using the Bray–Curtis similarity measure. A measurement of goodness-of-fit test of the MDS ordination was given by the stress value: a low stress value (<0.2) indicated a good ordination with no real prospect of a misleading interpretation (Clarke 1993). One-way analysis of similarities (ANOSIM; Clarke 1993) was used to test for significant differences among the three MPAs (Miramare, Porto Cesareo and Capo Caccia). The similarity percentages programme (SIMPER; Clarke & Warwick 1994) was applied to determine the contribution of higher meiofauna taxa to the dissimilarity between the areas. Meiofauna taxon abundance data (ind.10 cm^{-2}) were used to calculate the Shannon–Wiener diversity index (H', log e based) and the Pielou's evenness (J). After testing for the assumptions of ANOVA, differences in meiofauna diversity (H') and in evenness (J) among the three MPAs were analysed using one-way ANOVA.

All multivariate analyses and calculations of diversity indices were done using PRIMER 6 (Clarke & Gorley 2006). The univariate analyses were performed using the STATISTICA 6 software package (StatSoft 1995).

Results

Abiotic variables

The fine (250–125 μm) and very fine (125–62 μm) sand fractions were the main sediment components at all sites, with exception of three sites (MI3, PC4 and CC3), where coarse (1000–500 μm) and medium (500–250 μm) sand was dominant (Figure 2). Sediment textures were compared using PCA (Figure 3);
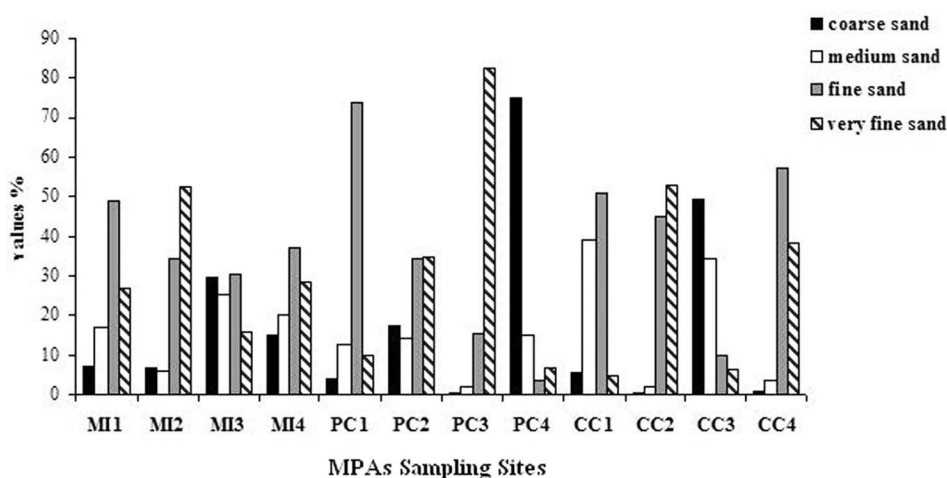

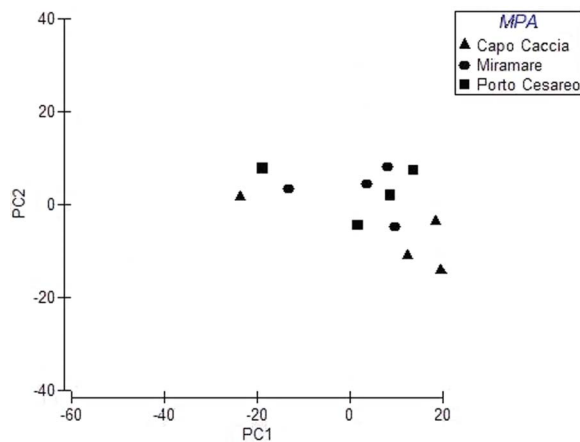Figure 2. Grain size of MPAs sampling sites.

Figure 3. PCA ordination plot of average values of grain size variables. The comparison is per MPA. See text for further explanations.

ordination revealed that the sampling sites were rather aggregated within the three MPAs, with the exception of the three coarse–medium sand sites. The first two principal components (54.7% and 31%) explained 85.7% of the total variance, suggesting that the two-dimensional ordination gave an appropriate representation of the similarity between the sampling sites.

Composition of the meiofauna

Within the meiobenthos, 15 taxa (Nematoda, Copepoda, Annelida, Ostracoda, Kinorhyncha, Turbellaria, Tardigrada, Gastrotricha, Cumacea, Amphipoda, Isopoda, Tanaidacea, Cnidaria, Ciliophora, and Acarina) and copepod naupliar stages were recognized on the investigated sites, ranging from six taxa at sites MI1 and CC1 to 11 taxa at sites PC4 and CC3 (Table I).

Total meiobenthic densities ranged from 291 ± 65 SE ind.$\cdot 10$ cm^{-2} at site CC1 to 7558 ± 194 SE ind.$\cdot 10$ cm^{-2} at site PC3 (Table I). The average meiofauna abundance recorded were 3840 ± 422 SE ind.$\cdot 10$ cm^{-2} at Miramare, 5716 ± 857 SE ind.$\cdot 10$ cm^{-2} in Porto Cesareo, and 1063 ± 289 SE ind.$\cdot 10$ cm^{-2} in Capo Caccia (Table I; Figure 4).

Nematoda and Copepoda were the most important taxa of meiofauna communities. Nematodes were dominant at all sampling sites, with the exception of the sites 3 and 4 of Miramare, and the site 3 of Capo Caccia, where Copepoda and nauplii had higher values of abundance (Table I). Generally, Nematoda showed high percentage values in all three MPAs (54–61% of total meiofauna), followed by Copepoda including nauplii (18–25%). The remaining taxa, Annelida (3–8%), Turbellaria (2–8%) and Ciliophora (5–18%), were well represented, while Ostracoda, Tardigrada, Gastrotricha and Isopoda were found less frequently (less than 2%; Figure 5).

The meiofauna: diversity and community analysis

In all sampling sites, the meiofauna showed high values of diversity (H') and evenness (J), ranging from 1.42 (MI2) to 2.13 (CC3), and from 0.65 (MI2) to 0.93 (CC1), respectively (Table I). The average diversity indices per MPA are shown in Figure 4: H' = 1.64 ± 0.11 SE and J = 0.77 ± 0.05 SE at Miramare, H' = 1.79 ± 0.13 SE and J = 0.78 ± 0.03 SE in Porto Cesareo, and H' = 1.80 ± 0.12 SE and J = 0.80 ± 0.06 SE in Capo Caccia. The one-way ANOVA test revealed that meiofauna Shannon-Wiener diversity (H') and in Pielou's evenness (J) indices based on taxa abundance were not significantly different among the three MPAs ($p > 0.05$).

Differences in meiofauna community composition per MPA were analysed using MDS and ANOSIM. In the MDS ordination there were three significantly distinct groups, corresponding to the different MPAs (Figure 6). The ANOSIM test (Table II) revealed that significant differences in meiofauna communities were found among the three Italian MPAs ($R = 0.33$, $p < 0.05$). In particular, the pairwise comparison indicated high and significant differences in the meiofauna assemblages between Capo Caccia and Porto Cesareo ($R = 0.73$; $p = 0.03$), while no other pairwise significant differences were found ($p > 0.05$) (Table II).

SIMPER analysis per MPA groups revealed a clear difference in meiofauna taxa abundance between Capo Caccia and Porto Cesareo (Table III). The average dissimilarity among these two MPAs (49.34) was mainly due to nematodes (31.2%) and copepods (19.11%). In particular, in Porto Cesareo, the Nematoda and Copepoda taxa were present with high average abundance (58.96 ind.$\cdot 10$ cm^{-2} and 29.37 ind.$\cdot 10$ cm^{-2}, respectively), while lower values were recorded in the marine reserve of Capo Caccia (23.7 ind.$\cdot 10$ cm^{-2} and 9.47 ind.$\cdot 10$ cm^{-2}, respectively) (Table III).

Nematode communities composition

About 1200 nematode specimens were identified and allocated to a total of 54 genera, 22 families and 3 orders (Table IV). At Miramare MPA, 8 families and 18 genera were identified, and the most common genera were *Mesacanthion* (24%), *Daptonema* (15%) and *Marylynnia* (11%). Of a total of 18 families and 32 genera recorded in Porto Cesareo, the most important genera were *Anoplostoma* (23%),

Table I. Average density (ind. 10 cm^{-2} ± SE) and diversity (H' and J) of meiofaunal taxa in the three MPAs.

| MPA	Miramare				Porto Cesareo				Capo Caccia			
Site	MI1	MI2	MI3	MI4	PC1	PC2	PC3	PC4	CC1	CC2	CC3	CC4
Depth	1 m	2 m	3 m	4 m	1 m	2 m	3 m	4 m	1 m	2 m	3 m	4 m
TAXA												
Nematoda	2458 ± 296	3410 ± 727	1125 ± 176	463 ± 95	1991 ± 189	3987 ± 1936	5683 ± 262	2777 ± 941	113 ± 24	972 ± 209	515 ± 146	919 ± 151
Copepoda	163 ± 23	105 ± 23	420 ± 131	699 ± 156	1305 ± 125	695 ± 540	513 ± 34	1047 ± 527	65 ± 17	45 ± 18	373 ± 242	15 ± 1
Nauplii	104 ± 52	138 ± 80	1272 ± 343	514 ± 252	79 ± 14	18 ± 10	816 ± 119	618 ± 279	25 ± 10	20 ± 8	194 ± 100	13 ± 5
Annelida	71 ± 53	37 ± 10	129 ± 14	96 ± 28	89 ± 22	212 ± 163	198 ± 32	173 ± 109	28 ± 5	43 ± 19	157 ± 55	4 ± 2
Ostracoda	0 ± 0	0 ± 0	1 ± 1	2 ± 1	1 ± 1	5 ± 4	1 ± 1	495 ± 283	9 ± 4	3 ± 1	0 ± 0	0 ± 0
Kinorhyncha	0 ± 0	1 ± 1	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	11 ± 7	0 ± 0	0 ± 0	0 ± 0	1 ± 1
Turbellaria	113 ± 58	38 ± 26	89 ± 9	95 ± 14	15 ± 5	76 ± 20	34 ± 10	58 ± 22	49 ± 11	36 ± 6	108 ± 15	5 ± 1
Tardigrada	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	179 ± 104	0 ± 0	1 ± 1	0 ± 0	3 ± 2
Gastrotricha	0 ± 0	0 ± 0	0 ± 0	32 ± 14	0 ± 0	239 ± 109	17 ± 7	23 ± 11	0 ± 0	0 ± 0	223 ± 24	1 ± 1
Cumacea	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1 ± 1	1 ± 1	0 ± 0
Amphipoda	0 ± 0	1 ± 1	0 ± 0	1 ± 1	0 ± 0	8 ± 4	1 ± 1	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1 ± 1
Isopoda	6 ± 6	18 ± 9	122 ± 39	0 ± 0	5 ± 5	0 ± 0	161 ± 32	0 ± 0	0 ± 0	0 ± 0	3 ± 1	0 ± 0
Tanaidacea	0 ± 0	0 ± 0	0 ± 0	1 ± 1	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1 ± 1	0 ± 0
Cnidaria	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1 ± 1	0 ± 0	0 ± 0	0 ± 0	1 ± 1
Acarina	4 ± 2	0 ± 0	0 ± 0	0 ± 0	5 ± 4	51 ± 49	0 ± 0	3 ± 2	0 ± 0	0 ± 0	1 ± 1	0 ± 0
Ciliophora	0 ± 0	2 ± 2	570 ± 46	3063 ± 1341	0 ± 0	1055 ± 445	135 ± 42	88 ± 45	3 ± 3	35 ± 20	94 ± 21	152 ± 41
Total taxa	6	8	7	9	7	9	9	11	6	8	11	10
Total density	2919 ± 344	3749 ± 838	3728 ± 533	4966 ± 1345	3489 ± 280	6345 ± 2301	7558 ± 194	5473 ± 1564	291 ± 65	1156 ± 220	1692 ± 548	1114 ± 158
Average density	3848 ± 422				5716 ± 857				1063 ± 289			
H' (loge)	1.48	1.42	1.86	1.79	1.46	1.87	1.74	2.08	1.82	1.66	2.13	1.59
J	0.76	0.65	0.89	0.78	0.70	0.81	0.75	0.84	0.93	0.76	0.86	0.66
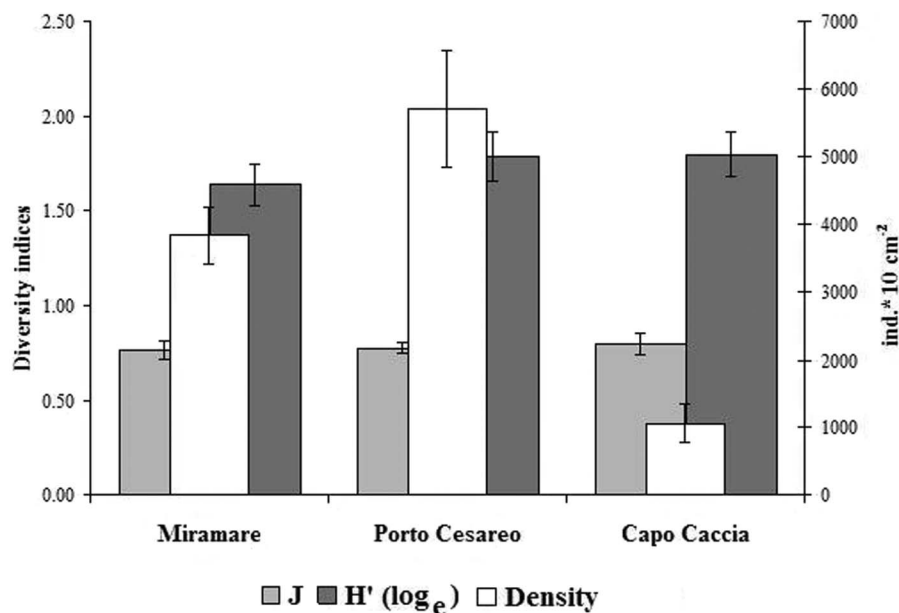
Figure 4. Average Meiofauna density (ind.·10 cm^{-2} ± SE) and biodiversity (H' and J) of the three MPAs.
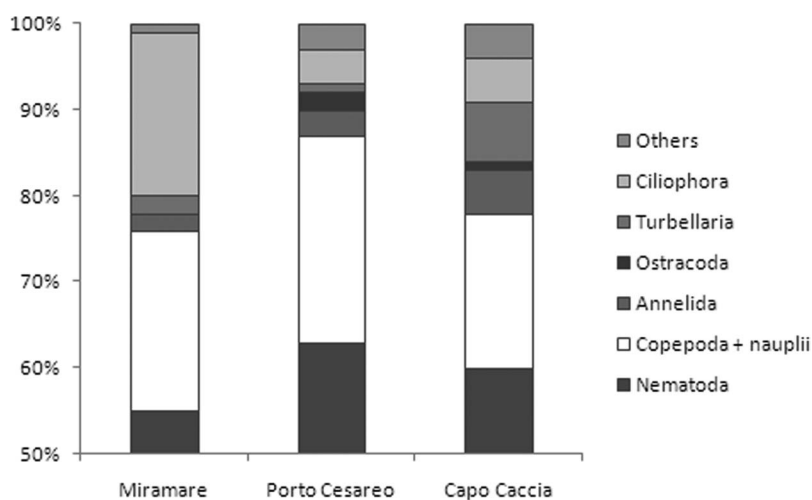

Figure 5. Meiofauna percentage composition. "Others" indicates all taxa with percentage <2%.

Daptonema (12%) and *Theristus* (10%). Finally, in Capo Caccia, 17 families and 33 genera were found; the dominant genera were *Daptonema* (15%), *Promonhystera* (14%) and *Mesacanthion* (11%) (Table IV).

Analysis of the feeding types according to Wieser (1953) showed a dominance of deposit feeders (1A+1B) in Porto Cesareo MPA (60%), while in the marine reserve of Miramare and in Capo Caccia epi-growth feeding nematodes (2A) and predators and omnivores (2B) were dominant (76% and 66%, respectively) (Figure 7).

Discussion and conclusion

Most of the Mediterranean shallow sandy habitats, including those ones studied in this paper, are influenced by a narrow tidal range (<2 m), a limited height wave, and relatively coarse sediments at the base of the swash zone and fine grained at shallow subtidal zone (Wright & Short 1984). Most studies on meiofauna of such habitats have been carried out in environments where the tides play an important role (e.g. McLachlan et al. 1977; Rodriguez et al. 2001, 2003; Menn 2002; Gheskiere et al.
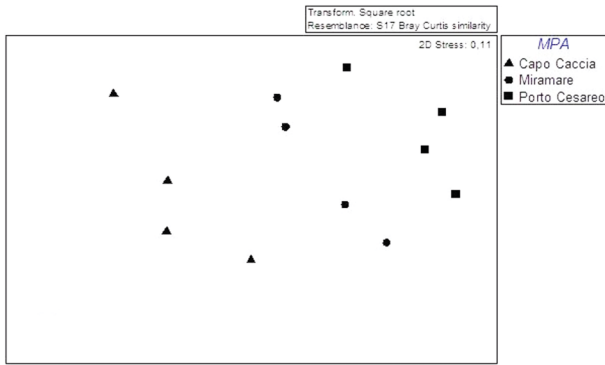
Figure 6. Result of the MDS analyses on average meiofauna taxa abundances per MPA group.

Table II. Results of the one-way ANOSIM and pairwise test for difference among the three MPAs on the meiofauna assemblage structure.

	R	*P*
Test for differences between MPA groups		
Global test	0.33	0.02
Pairwise test		
Capo Caccia – Miramare	0.25	0.14
Capo Caccia – Porto Cesareo	0.73	0.03
Porto Cesareo – Miramare	0.10	0.29

Table III. SIMPER list showing the contribution of each taxon to the mean Bray–Curtis dissimilarity between Capo Caccia and Porto Cesareo.

Examines MPAs groups				
Groups Capo Caccia and Porto Cesareo				
Average dissimilarity = 49.34				
Taxon	Capo Caccia Av.Abund.	Porto Cesareo Av.Abund.	Contrib.%	Cum.%
Nematoda	23.7	58.96	31.2	31.2
Copepoda	9.47	29.37	19.11	50.31
Nauplii	6.79	16.65	10.16	60.47
Ciliophora	7.4	13.37	9.11	69.57
Annelida	6.61	12.79	6	75.57
Gastrotricha	3.92	6.07	5.69	81.26
Ostracoda	2.36	6.51	5.26	86.52
Isopoda	0.41	3.72	3.27	89.78
Tardigrada	0.71	3.35	3.05	92.83

2004), while few works have considered the meiofauna of the shallow subtidal Mediterranean sands (e.g. Gheskiere et al. 2005a,b; Moreno et al. 2005). Sandy sediments are common in shallow sublittoral environments (Emery 1968). They are

characterized by highly diverse meiofauna communities (Heip et al. 1985; Coull 1988; Giere 1993), with nematodes usually representing the dominant taxonomic group. This is supported by the results of the present study, where the meiofaunal assemblages in the three MPAs are very rich, and the dominant taxa are generally nematodes and copepods, followed by several other groups of variable importance.

Our study shows that the density and relative abundance of meiofauna does not differ considerably from that previously shown in other Mediterranean studies (Rodriguez et al. 2003; Gheskiere et al. 2004, 2005a,b; Covazzi-Harriague et al. 2006; Moreno et al. 2006; Papageorgiou et al. 2007). On the other hand, the meiofaunal densities reported here were not comparable to those found in similar habitats of Ligurian Sea (Fabiano et al. 2002, 2004; Moreno et al. 2005), where the low abundance of meiofauna was related to the low concentrations of organic matter and bacterial density representing the primary food sources.

Based on sedimentological characteristics, marked habitat differences among the three MPAs are not detectable. However, these biological systems are quite different when we consider their community structures. In fact, meiofauna density was clearly higher in Porto Cesareo followed by Miramare, and the lowest densities were recorded in Capo Caccia MPA. The higher meiofauna density of Porto Cesareo was mainly due to higher abundance of nematodes and copepods, and might be related to a higher organic content of urban origin (Porto Cesareo). The higher fraction of medium–fine sands in respect to fine sediment in Capo Caccia could be due to a higher hydrodynamic regime that, consequently, induced a lower meiofauna density. However, the marine reserve of Capo Caccia showed slightly higher meiofaunal diversities than Miramare, also due to consistent findings of minor taxa such as Ostracoda. In particular, the MPA of Capo Caccia showed a higher percentage of Annelida (6%) than the other two Italian MPAs (2% at Miramare and 3% in Porto Cesareo). Meiofaunal studies usually record Annelida only in very small numbers (Higgins & Thiel 1988).

Dominance of nematodes within the meiofauna of shallow subtidal sandy sediments (Brown & McLachlan 1990) is also evident for Miramare, Porto Cesareo and Capo Caccia sites. Total nematode densities are fairly similar to those reported from studies at higher meiofaunal taxon levels on similar European sandy environments (Gray & Rieger 1971; Harris 1972; McIntyre & Murison 1973; Olafsson 1991; Rodriguez et al. 2003; Gheskiere et al. 2004, 2005a). The high nematode diversity in these

Table IV. Nematode communities structure in the three MPAs. Numbers represent the average percentage contribution per area. F.t. = Feeding types (1A: selective deposit feeders; 1B: non-selective deposit feeders; 2A: epistrate feeders; 2B: predators/omnivores).

Order	Family	Genus	F.t.	Miramare	Porto Cesareo	Capo Caccia
Enoplida	Enoplidae	*Enoplus*	2B		2	
	Thoracostomopsidae	*Enoploides*	2B		6	5
		Epacanthion	2B		1	
		Mesacanthion	2B	24	1	11
	Anoplostomatidae	*Chaetonema*	1A			4
		Anoplostoma	1B		23	
	Anticomidae	*Anticoma*	1A			1
	Oxystominidae	*Halalaimus*	1A		3	1
	Oncholaimidae	*Viscosia*	2B	8	2	5
	Enchelidiidae	*Calyptronema*	2B			1
		Bathylaimus	2B		1	
	Dorylaimidae	*Mesodorylaimus*	2B		2	
Monhysterida	Xyalidae	*Theristus*	1B	5	10	
		Daptonema	1B	15	12	15
		Elzalia	1B		1	
		Cobbia	2A	2	6	1
		Xyala	1B			1
		Rynchonema	1A		1	
		Promonhystera	1B	1	1	14
	Linhomoeidae	*Eumorpholaimus*	1B	1		
		Terschellingia	1A	2		
	Diplopeltidae	*Araeolaimus*	1A			1
	Axonolaimidae	*Odontophora*	1B		6	3
Chromadorida	Chromadoridae	*Prochromadorella*	2A	6		1
		Chromadorella	2A			1
		Chromadorina	2A	7		
		Dichromadora	2A	4	1	2
		Chromadora	2A			1
		Spilophorella	2A	4		
		Neochromadora	2A		1	2
		Metachromadora	2B			1
		Chromadorita	2A	3	4	8
	Comesomatidae	*Sabatieria*	1B			1
		Paracomesoma	2A		2	
		Comesoma	1B		1	1
	Cyatholaimidae	*Nannolaimoides*	1A	1		3
		Paracanthoncus	2A		1	
		Pomponema	2B		1	2
		Marylynnia	2A	11	1	2
	Selachinematidae	*Latronema*	2B			1
		Sinonchiella	2B		1	1
	Desmodoridae	*Chromaspirina*	2B			2
		Spirinia	2A		2	
		Desmodora	2A	4		2
		Eubostricus	1A		1	
		Leptonemella	1A			2
	Epsilonematidae	*Epsilonema*	1A		1	
	Microlaimidae	*Calomicrolaimus*	2A		1	
		Microlaimus	2A		2	2
	Monoposthiidae	*Monoposthia*	2A		1	1
	Leptolaimidae	*Camacolaimus*	2A	1		
		Diodontolaimus	2A	1		
	Ceramonematidae	*Metadasynemoides*	1A			1
		Pselionema	1A		1	

habitats might be explained by the ability of this taxon to partition the food source in various ways (Platt & Warwick 1980; Heip et al. 1985). In fact, the relative proportion of each of the four Wieser feeding types in a community depends on the nature of the available food, which in turn is reflected to a great extent by the nature of the sediment (Platt & Warwick 1980). The non-selective deposit feeders
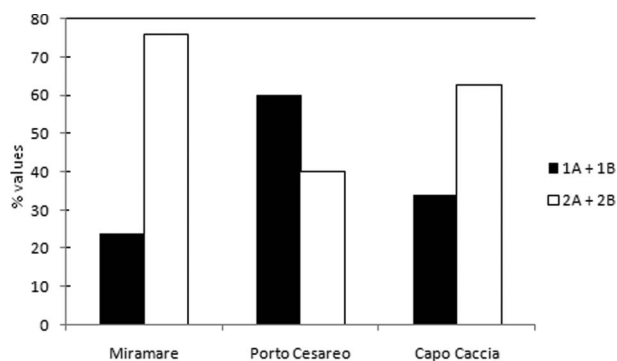
Figure 7. Percentage distribution of the different nematode feeding types in the three MPAs.

were the dominant trophic group in Porto Cesareo MPA. The high proportion and diversity of epistrate feeders in the marine reserve of Miramare and Capo Caccia might suggest a local importance of diatoms and other microalgae as a food source. The dominance of the family Xyalidae, mainly composed by non-selective feeders, in all studied sites was previously noticed by Gheskiere et al. (2004, 2005a,b) in Belgian, Italian and Polish areas. These species have larger buccal cavities and feed on organic particles, including diatoms and bacteria, confirming the importance of microphytobenthos in this type of habitat. The analysis of nematode genera showed a dominance of *Anoplostoma* and *Daptonema* in Porto Cesareo beaches, probably due to their ability to utilize different kinds of food. Finally, the increase in the percentage abundance of epigrowth feeders (such as *Marylynnia*) and predators (*Mesacanthion*) recorded at Miramare and Capo Caccia could indicate a more complex and structured nematode community with more abundant higher trophic levels than in Porto Cesareo. Therefore, we believe that at Miramare and Capo Caccia there might be a wider range of food source (POM, DOM, diatoms, bacteria), due to their more heterogeneous habitat types, that may justify the presence of a higher number of nematode genera with different trophic roles.

The results of the present study stress the importance of an accurate assessment of the ecological role and changes in meiofaunal community structure for the evaluation of the state of health in shallow subtidal benthic environments. It is known that nematodes, in particular, present several features favourable for their use as bioindicators of the sediment condition (Heip et al. 1985; Sandulli & de Nicola 1991; Schratzberger et al. 2000), being ecologically very heterogeneous and occupying different roles in benthic food webs (Schmid-Araya & Schmid 2000; Aarnio 2001); the same features could make

them even more useful in the assessment of the ecosystem functioning in sedimentary habitats.

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