



The meiofauna of the Eratosthenes Seamount (eastern Mediterranean Sea)—first insights into taxa composition, distribution, and diversity

Kai Horst George¹

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Abstract

During the research cruise MSM 14/1 of RV M.S. MERIAN to the eastern Mediterranean Eratosthenes Seamount in 2009/2010, samples were taken with a multiple corer to get first insights into the composition, abundance, and diversity of the meiofauna. Along two transects, a north–south and a west–east ones, 14 sites were sampled on the seamount. Additionally, a distant deep-sea site provided meiobenthic material for comparison with that of the seamount. Altogether, 15 meiobenthic major taxa were found. Nematoda and Copepoda Harpacticoida strongly dominated all sites, followed by Annelida and Tardigrada at most sites. Although direct comparison pointed towards a northern seamount community, this could not be confirmed by a detailed community analysis regarding taxa composition, abundance expressed by density (ind./10 cm²), and taxa diversity. It revealed neither a homogeneous seamount community nor any faunistic relation with bathymetric or geographic gradients, with exception of the taxa diversity that apparently followed a latitudinal gradient. Generally, Eratosthenes Seamount presents a quite heterogeneous meiobenthic assemblage that may be linked to small-scale biotic and abiotic variables. Moreover, also the distant reference site did not differ significantly from the seamount sites. A brief comparison with other Atlantic and Mediterranean seamounts and islands indicates that Eratosthenes Seamount is not characterized by an impoverished meiobenthic fauna.

Keywords Community analyses · Deep sea · Distribution · Faunistics · Meiobenthos

Introduction

Eratosthenes Seamount (EraS), a non-volcanic isolated continental fragment (e.g. Kokinou and Panagiotakis 2018 and references therein) located south of Cyprus (Fig. 1) and rising from approximately 2,500 m (base) to 800 m (summit) water depth, has been object of intensive geological and oceanographic investigation during the past decades, mainly embedded in geological studies of the eastern Mediterranean (e.g. Ben-Avraham et al. 1976; Ben-Avraham and Nur 1986;

Kempler 1998; Mart and Robertson 1998; Galindo-Zaldívar et al. 2001; Kokinou and Panagiotakis 2018). Also, studies on plankton and primary production in or including the eastern Mediterranean Sea have been undertaken (e.g. Dugdale and Wilkerson 1988; Koppelman et al. 2004; Siokou-Frangou et al. 2010 and references therein). In contrast, benthic studies from EraS are scarce (cf. Morato et al. 2013). For benthic mega- and macrofauna, only one scientific report has been published (Galil and Zibrowius 1998). Meiobenthic data from EraS were included in a study of Sevastou et al. (2013), aiming to compare meiobenthic, nematode, and microbial assemblages along five geographic areas of the central-eastern Mediterranean Basin. Furthermore, with *Echinoderes multiporus* Yamasaki, Neuhaus & George, 2018 (Cyclorhagida), Yamasaki et al. (2018) described the first Kinorhyncha species from EraS, whilst Yamasaki et al. (2019) addressed EraS whilst discussing the chorology of seamount Kinorhyncha. Like the studies of Sevastou et al. (2013) and Yamasaki et al. (2018, 2019), the contribution at hand bases on data obtained during research cruise MSM 14/1 of German RV MARIA S. MERIAN to Eratosthenes Seamount

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✉ Kai Horst George
Kai.George@senckenberg.de

¹ Senckenberg am Meer, Abt. DZMB, Südstrand 44,
26382 Wilhelmshaven, Germany

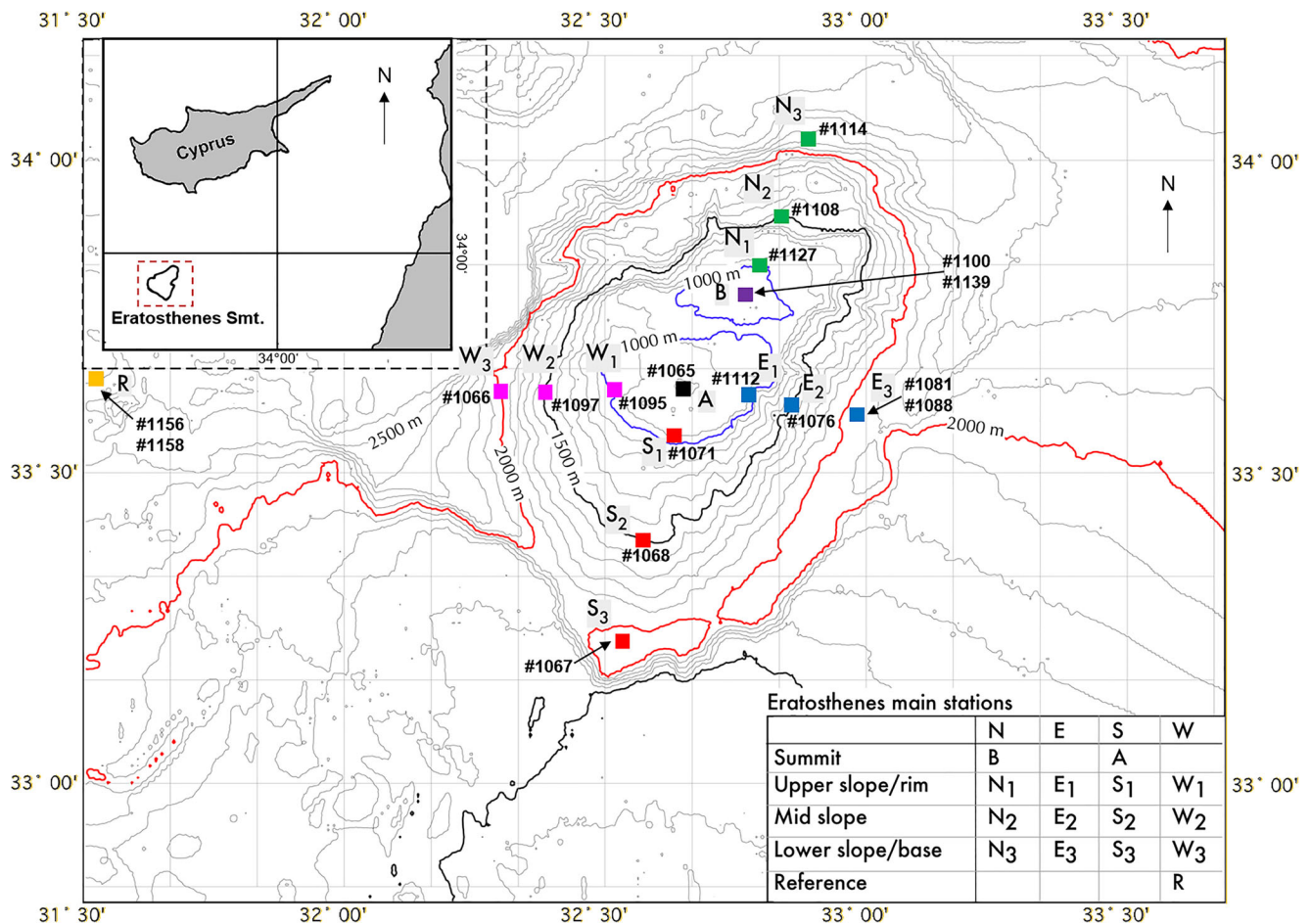


Fig. 1 Map showing the geographic position of the Eratosthenes Seamount (small cut-out on the upper left) and the main stations sampled with the MUC during research cruise MSM 14-1 of RV M.S. Merian in 2009/2010. Source: B. Christiansen, Hamburg

(Christiansen et al. 2012) from December 17th, 2009, to January 14th, 2010. It presents first information with respect to the composition, diversity, and distribution of the meiobenthic major taxa of Eratosthenes Seamount.

Often, seamounts whose summits extend into the photic zone (<200m) have a taxa community that is richer in species and individuals than those of the slope and base, and which has a comparatively high proportion of shallow-water species (e.g. George and Schminke 2002; Plum and George 2009; Büntzow 2011; Yamasaki et al. 2019, but see also Koller and George 2011; Zeppilli et al. 2013). For the eastern Mediterranean Anaximenes seamount, whose summit does not rise above the bathyal, George et al. (2018) detected exclusively deep-sea species and thus no bathymetrically clearly distinguishable communities of benthic Copepoda; confirmed distinct communities overlapped the bathymetric ranges. Because the summit from EraS also does not extend beyond the bathyal (Fig. 1), like for the Anaximenes Seamount (cf. George et al. 2018), no significant differences in the meiobenthic composition and diversity on the seamount's summit, slope, and base were expected. The following particular questions should be addressed:

1. Are the summit, slope, and base of Eratosthenes Seamount characterized each by a distinct meiobenthic assemblage with respect to taxa composition, individual abundance, and taxa diversity?
2. Do the northern, southern, eastern, and western transect parts differ from each other with respect to taxa composition, individual abundance, and taxa diversity?

In addition, a faunistic comparison of the seamount sites with a distant deep-sea site located westerly of EraS was done in order to detect possible differences between a supposed seamount community and that of the surrounding deep sea. Moreover, a brief comparison with other Atlantic and Mediterranean seamounts and islands was realized.

Material and methods

Sampling is described in detail by Sevastou et al. (2012). Sampled stations were located along two transects that crossed the seamount in a north–south and a west–east direction (Fig. 1), enabling a faunistic comparison along a latitudinal and a

longitudinal gradient. Moreover, the seamount can be split into three vertical sub-areas: (i) a shallow sub-area (808–990m depth) enclosing two summit sites (Fig. 1, southern summit site A, northern summit site B) together with four shallow slope sites (Fig. 1, W1, S1, E1, N1); (ii) an intermediate slope sub-area (1,465–1,528m depth), including the sites W2, S2, E2, and N2 (Fig. 1); (iii) a deep base area (1,964–2,240m depth), enclosing the sites W3, S3, E3, and N3 (Fig. 1), and allowing the faunistic comparison along a bathymetrical gradient. To further compare the seamount fauna with that of the surrounding deep sea, two stations were sampled at a distant oceanic reference site (Fig. 1, R.) (Christiansen et al. 2012). It is located at ~39 nautical miles westerly from EraS and was selected to compare the deep oceanic meiobenthic assemblage with those of the seamount areas without the risk of being influenced by faunistic and ecological interactions—an approach that has been well-established in recent faunistic seamount research to investigate how a seamount might affect e.g. the taxonomic composition, abundance, diversity, geographical and bathymetrical distribution, and other (ecological) parameters of studied communities (e.g. Büntzow 2011; Denda and Christiansen 2011; Zeppilli et al. 2013; George et al. 2018).

At each site, the multiple corer (MUC) was deployed 2–4 times in order to obtain undisturbed replicative sediment samples (Sevastou et al. 2012). The meiobenthic samples kept for the German Centre of Marine Biodiversity Research (DZMB, Senckenberg am Meer, Wilhelmshaven, Germany) were fixed in 4–5% buffered formalin. For taxonomic and faunistic analyses, the upper 5 cm of sediment and the filtered overlaying water were centrifuged three times at 4,000 rpm using Levasil® (density: 1.17) as floating medium in order to separate the organisms from the sediment. For the here presented analyses, two cores of two replicated MUC hauls (e.g. hauls 4 and 5 at station #1065, cf. Tab. 1) were selected randomly (Table 1). At sites B, E3, and R, however, sampling was done intermittently, resulting in different station numbers and sampling dates (Fig. 1, Table 1).

Meiobenthic taxa were sorted by hand using a Leica MZ 12-5 stereo microscope and identified to major taxon levels using the keys of Higgins and Thiel (1988) and Schmidt-Rhaesa (2020).

Due to the low number of replicates ($n = 2/\text{site}$), statistics was restricted to descriptive/explorative approaches, so no parametric tests (ANOVA, PERMANOVA, etc.) were executed. For the estimation of taxa diversity, Shannon's H' and Pielou's Evenness J were calculated (Shannon and Weaver 1963; Pielou 1966). For similarity analyses, the Bray–Curtis Index (Bray and Curtis 1957) was applied, without data transformation. The decision to choose that index based on the observation of a generally wide but heterogeneous distribution of the taxa in the study area, so the abundance values—that are stronger weighted by the Bray–Curtis Index than by others (e.g. the Cosine Similarity; cf. Pfeifer et al. 1998; George

et al. 2014)—were considered of higher relevance than the simple presence/absence of a taxon. A non-parametric one-way analysis of similarity (ANOSIM; cf. Clarke 1993) was performed to test if observed dissimilarities between sites are significant. Faunistic comparison comprising diversity and similarity analyses was undertaken with the use of the statistical software package PAST 4.03 (Hammer et al. 2001).

Abbreviations used in the text are as follows: A, southern summit site; AnaS, Anaximenes Seamount; B, northern summit site; ConS, Condor Seamount; E1–E3, study sites of the eastern transect; EraS, Eratosthenes Seamount; *HT*, major taxa richness (= absolute number of meiobenthic major taxa); *N*, number of individuals; N1–N3, study sites of the northern transect; nm, nautical miles; R, distant reference deep-sea site; S1–S3, study sites of the southern transect; W1–W3, study sites of the western transect.

Results

Altogether, 22,646 individuals assigned to 15 meiobenthic major taxa were found in the study area (Table 2). Further 128 individuals/fragments could not be allocated to any meiobenthic major group (Table 2, “undetermined”); these were not considered in the evaluation. The sites in Table 2 are arranged with respect to the two sampled transects crossing the seamount. As site A forms the central point of both transects, it is mentioned twice in Table 2 (grey columns); however, the faunistic data reported from that site are listed in the left side of the table only, i.e. in the west–east transect.

Meiofauna of Eratosthenes Seamount

Taxa composition

Nematoda (rel. abundance 71.97–89.15%) and Harpacticoida (rel. abundance 8.43–21.80%) clearly dominated the meiobenthic assemblages at all study sites. Both taxa combined reached relative abundance values between 91.22 and 97.58% (Table 2, Fig. 2).

Annelida and Tardigrada were also present at all sites (Table 2, Figs. 2 and 3), whilst the remaining 11 taxa were heterogeneously distributed over the seamount. Annelids formed the third-most dominant taxon, being replaced by the Rotifera only at the western deep site W3 (Table 2, Fig. 3). Tardigrada provided highest relative abundance values after Annelida. In an area that encloses sites S1–S3, E2, and W3, they were, however, clearly outnumbered by bivalves (Table 2, Fig. 3). These conditions point towards a faunistic shift across EraS along an east–west running borderline (cf. Fig. 6b), with Annelida/Tardigrada sub-dominating its northern, and Annelida/Bivalvia sub-dominating its southern half.

Table 1 List of the sampled study sites showing the transects, stations, hauls, sampling dates, geographic positions, water depths, and number of analysed MUC cores

	Area	Station-haul	Date	Latitude	Longitude	Depth (m)	No. cores	
W-E transect	W3	#1066-9	12/18/2009	33° 37.79' N	32° 18.01' E	1964.6	2	
		#1066-11	12/18/2009	33° 37.79' N	32° 18.00' E	1964.7	2	
	W2	#1097-1	12/27/2009	33° 37.70' N	32° 23.10' E	1528.7	2	
		#1097-2	12/27/2009	33° 37.69' N	32° 23.10' E	1529.0	2	
	W1	#1095-5	12/26/2009	33° 38.10' N	32° 32.62' E	942.6	2	
		#1095-6	12/26/2009	33° 38.11' N	32° 32.62' E	942.5	2	
	A	#1065-4	12/17/2009	33° 37.29' N	32° 38.60' E	808.4	2	
		#1065-5	12/17/2009	33° 37.29' N	32° 38.60' E	808.4	2	
	E1	#1112-6	12/29/2009	33° 37.48' N	32° 46.53' E	874.7	2	
		#1112-7	12/29/2009	33° 37.48' N	32° 46.53' E	874.8	2	
	E2	#1076-1	12/21/2009	33° 36.58' N	32° 51.51' E	1465.1	2	
		#1076-3	12/21/2009	33° 36.58' N	32° 51.51' E	1465.1	2	
	E3	#1081-8	12/23/2009	33° 35.59' N	32° 59.00' E	2043.2	2	
		#1088-1	12/25/2009	33° 35.60' N	32° 59.00' E	2042.5	2	
	N-S transect	N3	#1114-1	12/30/2009	34° 01.99' N	32° 53.40' E	2240.1	2
			#1114-2	12/30/2009	34° 01.99' N	32° 53.40' E	2239.9	2
		N2	#1108-1	12/28/2009	33° 54.64' N	32° 50.31' E	1482.4	2
			#1108-3	12/28/2009	33° 54.63' N	32° 50.30' E	1482.3	2
N1		#1127-1	1/1/2010	33° 49.83' N	32° 47.82' E	990.5	2	
		#1127-2	1/1/2010	33° 49.83' N	32° 47.82' E	990.5	2	
B		#1100-1	12/27/2009	33° 47.13' N	32° 46.11' E	906.0	2	
		#1139-4	1/4/2010	33° 47.10' N	32° 46.10' E	904.9	2	
S1		#1071-5	12/21/2009	33° 33.62' N	32° 38.05' E	886.6	2	
		#1071-7	12/21/2009	33° 33.62' N	32° 38.05' E	886.6	2	
S2		#1068-1	12/20/2009	33° 23.50' N	32° 34.40' E	1499.5	2	
		#1068-3	12/20/2009	33° 23.50' N	32° 34.40' E	1499.3	2	
S3		#1067-8	12/19/2009	33° 13.56' N	32° 32.23' E	2017.4	2	
		#1067-9	12/19/2009	33° 13.56' N	32° 32.23' E	2017.6	2	
R		#1156-1	1/6/2010	33° 39.02' N	31° 31.58' E	2419.5	2	
		#1158-13	1/7/2010	33° 39.03' N	31° 31.58' E	2419.4	2	

Meiobenthic abundance

Only the western section of the W–E transect (sites W3–W1) showed an increased abundance, expressed as the taxa density (individuals per 10 cm²), with decreasing water depth (Table 2, Fig. 4). Nonetheless, a correlation between bathymetry and meiobenthic abundance could not be confirmed (Fig. 5). The calculated determination coefficient $r = -0.2520$ suggests almost no correlation between the two variables, which is clearly confirmed by the quite low stability index $r^2 = 0.0635$ (Fig. 5). Instead, like for the taxa composition, also for the abundance a division of EraS into a northern and southern half was corroborated (Fig. 6a, b). The sites of the northern half (N1–N3, B, W1, W2, E1, E3) form a cluster (Fig. 6a, CI) that is characterized by comparatively high densities (mean = 132.65 ind./10cm²). In contrast, the southern half of EraS (S1–S3, E2, W3) differs from the remaining study sites by

remarkably low density values that do not reach 70 ind./10cm² (Fig. 4). These are pooled in cluster CII (Fig. 6a; (mean density = 41.50 ind./10cm²), in which also the southern summit site A is included. Figure 6a suggests a strong correlation ($r = 0.8769$; $r^2 = 0.7691$) between the geographic location of a site—i.e. if situated on the northern or southern half of EraS—and the respective density.

Meiobenthic diversity

As documented above, only four taxa were collected at all study sites, whilst the remaining 11 were distributed heterogeneously over the different sites (Table 2, Figs. 2 and 3). The absolute numbers of the major taxa (= higher taxa richness *HT*) reported from the different sites (= α -diversity) are given in Table 3 and Figure 7. The shallow sites W1 and S1 present highest numbers of major taxa ($HT = 12$), followed by the

Table 2 List of the collected meiobenthic major taxa at the different study sites, with absolute abundance values, number of discarded individuals, and number of areas per taxon

No.	Taxon/area	Σ/N	W-E transect							N-S transect							Σ areas/ taxon	R	
			W3	W2	W1	A	E1	E2	E3	N3	N2	N1	B	(A)	S1	S2			S3
1	Nematoda	18435	502	1566	2103	826	1853	408	1749	1766	1451	1858	1586		704	416	575	14	1072
2	Harpacticoida	3021	73	240	404	101	309	119	236	167	197	294	261		158	126	99	14	237
3	Annelida	560	8	31	85	35	50	16	47	20	27	61	70		46	21	19	14	24
4	Tardigrada	346	5	27	59	15	28	4	28	21	19	52	56		4	1	3	14	24
United to "others":																			
5	Bivalvia	92	9		7	1	2	11	1			2	24		12	8	14	11	1
6	Ostracoda	56		9	5	4	11		2	2	6	13	3			1		10	
7	Gastrotricha	36	3		3		3		2	2	1	5	2		7	3		10	5
8	Rotifera	23	14							1						1	1	4	6
9	Loricifera	19				7				1		6	2		1			5	2
10	Kinorhyncha	17	2	1	5	2						1	4		1		1	8	
11	Tantulocarida	14		1	1	2			4		1		3		1			7	1
12	Halacarida	11			2	1		1			1				5	1		6	
13	Isopoda	7			1					1	2				3			4	
14	Tanaidacea	6			1		1		1		1		2					5	
15	Priapulida	3													3			1	
Σ studied N		22646	616	1875	2676	994	2257	559	2070	1981	1706	2292	2013		945	578	712		1372
Undetermined		128	6	1		2	2	25	5	1	2	1	12		23	20	21		7
Σ total N		22774	622	1876	2676	996	2259	584	2075	1982	1708	2293	2025		968	598	733		1379

summit sites B ($HT = 11$) and A ($HT = 10$), and the northern intermediate site N2 ($HT = 10$). Instead, the eastern intermediate site E2 provides the lowest HT (6). Calculation of H' , which relates HT with individual numbers N , reveals a remarkable up-and-down for those sites located along the W–E transect (Fig. 8a), confirming almost no correlation between diversity and longitude ($r = -0.1091$; $r^2 = 0.0119$). It is

noteworthy that just the intermediate site E2, which presented the lowest HT , provides the third-highest H' of all seamount sites (Table 3, Fig. 8a). In contrast, along the N–S transect the calculated biodiversity patterns apparently follow a latitudinal as well as a bathymetrical gradient. H' increases from the deepest northern site, reaching the highest value at the shallow site S1 and decreasing again towards the deeper southern sites

Fig. 2 Relative abundance (%) of the meiobenthic major taxa at the different study sites. Values of Nematoda and Harpacticoida are given. The composition of the group “others” is given in Table 2

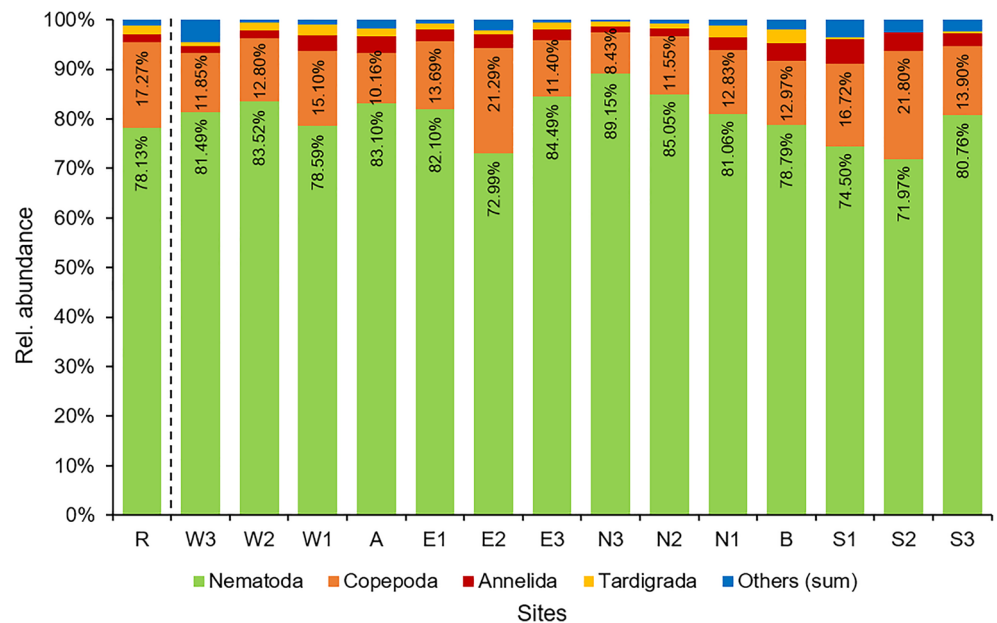
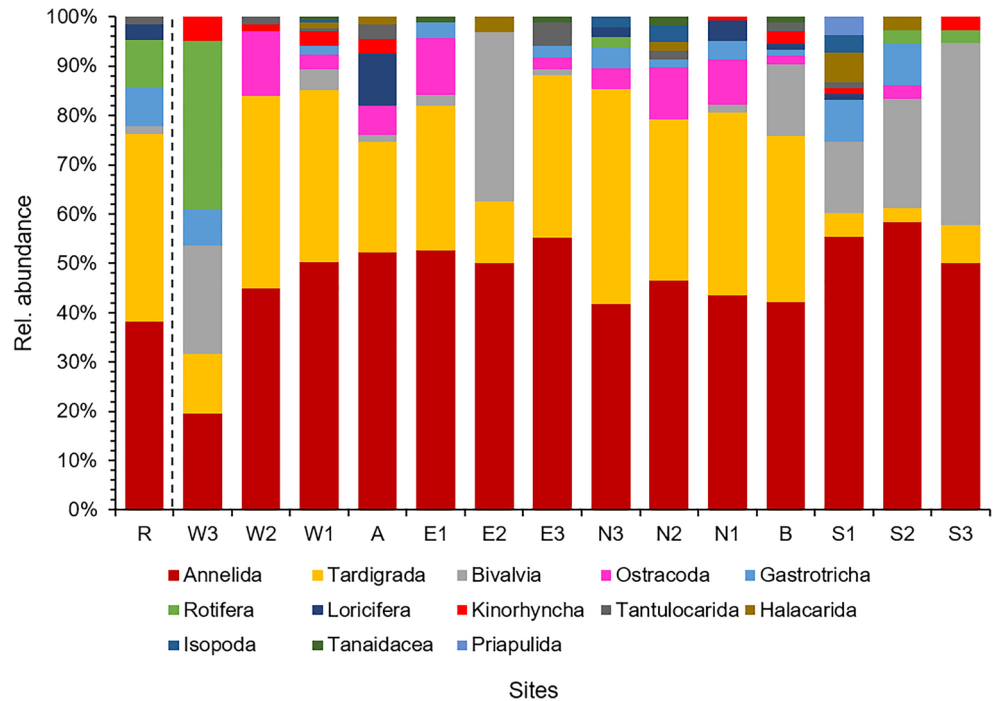


Fig. 3 Relative abundance (%) of the meiobenthic major taxa except Nematoda and Harpacticoida at the different study sites



(Fig. 8b). Here, a clear positive correlation can be confirmed ($r = 0.6964$; $r^2 = 0.485$).

To test whether the correlation refers rather to bathymetry or to latitude, the diversity values were graphically arranged along a bathymetric gradient (Fig. 8c). A correlation analysis ($r = 0.4999$; $r^2 = 0.2499$) revealed, however, that the bathymetry shows less influence on the meiobenthic diversity than the latitude.

The low Evenness J at all sites (Fig. 8) that furthermore generally follows the H' -curve, underlines the continuous dominance of few taxa (primarily Nematoda and Harpacticoida) on EraS.

Similarity analysis

A similarity analysis enclosing HT , abundance, and taxa composition underlines the potential division of EraS into a

Fig. 4 Density values (ind./10cm²) of the meiofauna at the different study sites. The different colours mark the respective transect sections (W, A, E, N, B, S) as well as site R.

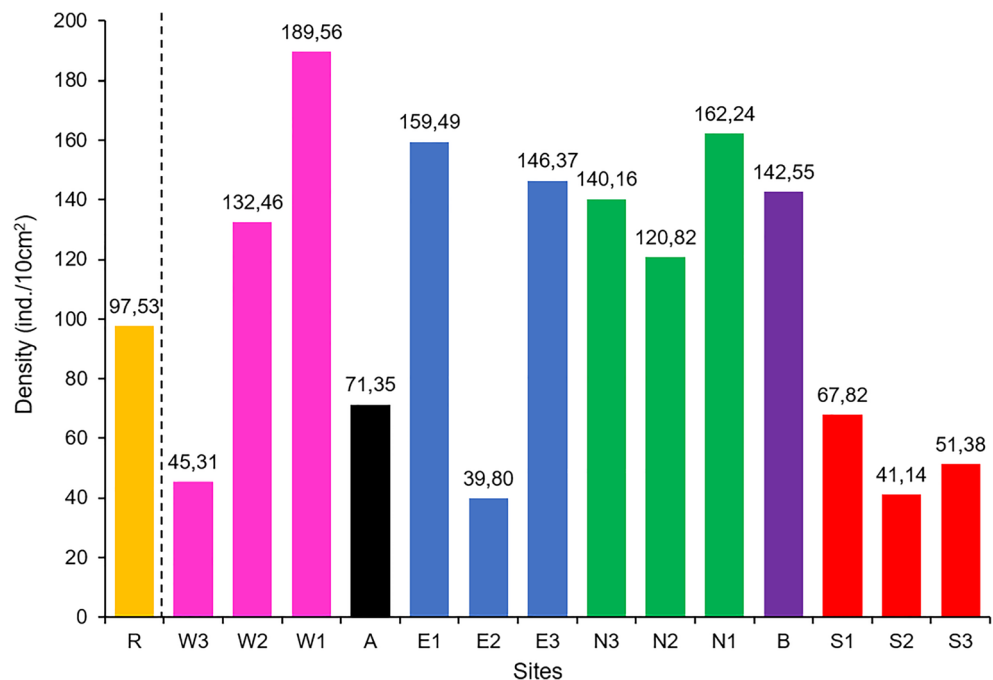
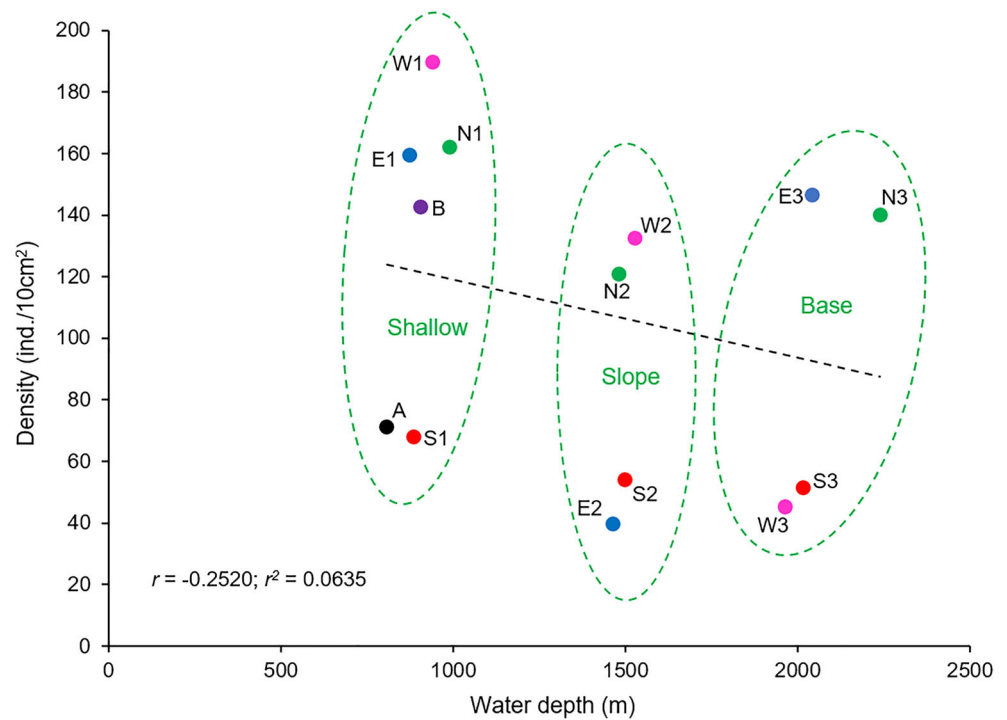


Fig. 5 Density values (ind./10cm²) of the meiofauna at the different study sites, ordered along water depth



faunistic northern and a southern half. A two-dimensional nMDS (Fig. 9, Bray–Curtis, stress 0.013) shows a cluster (dotted circle) of eight sites that suggests the existence of a meiobenthic assemblage corresponding to cluster CI of Fig. 6a, b, though those sites pooled to cluster CII in Fig. 6a, b are widely separated (Fig. 9), qualifying the existence of a uniform southern community. Although sharing low densities

and Bivalvia as one of the sub-dominant taxa, sites S1, S3, and W3 differ remarkably from each other. Site A is positioned even more isolated, presumably due to a relatively high amount of Loricifera (Fig. 3, Table 2). Just sites E2 and S2 are located closely together, due to the similar presence of Halacarida (Fig. 3) and the almost identical density values (Fig. 4).

Fig. 6 a Seamount sampling sites ordered with respect to their density values (ind./10cm²), showing an assumed faunistic northern (cluster CI) and southern assemblage (cluster CII). b Schematic illustration of Eratosthenes Seamount including the sampling sites. The dotted line marks the border between the assumed faunistic northern and southern clusters CI and CII.

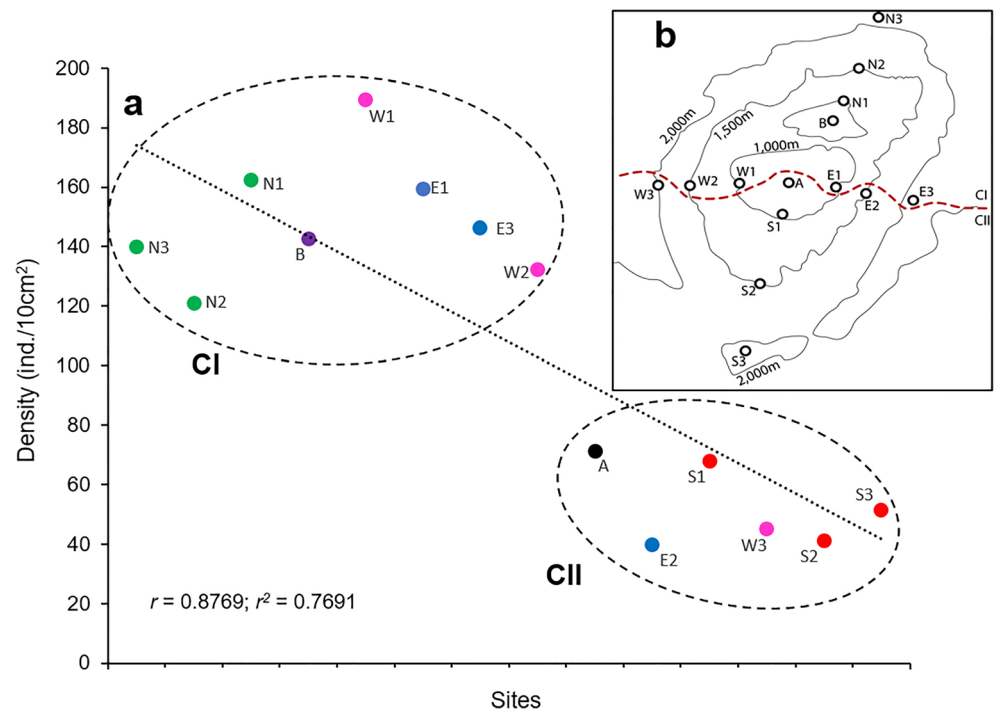


Table 3 Diversity values documented and estimated for the different study sites. *HT*, higher taxa richness; *N*, individual number; *H'*, Shannon Index; *J*, Pielou's Evenness

Site	W-E transect							N-S transect							
	W3	W2	W1	A	E1	E2	E3	N3	N2	N1	B	S1	S2	S3	R
<i>HT</i>	8	7	12	10	8	6	9	9	10	9	11	12	9	7	9
<i>N</i>	616	1875	2676	994	2257	559	2070	1981	1706	2292	2013	945	578	712	1372
<i>H'</i>	0.7073	0.5761	0.7293	0.6633	0.6174	0.7848	0.567	0.4309	0.5479	0.6838	0.7743	0.8664	0.8198	0.6624	0.7019
<i>J</i>	0.3401	0.2961	0.2935	0.2881	0.2969	0.438	0.258	0.1961	0.238	0.3112	0.3229	0.3487	0.3731	0.3404	0.3195

It is noticeable from Fig. 9 that the single sites group together neither with respect to a refined bathymetrical nor to a latitudinal or longitudinal aspect. This circumstance points towards a rather assorted distribution of most of the meiobenthic major taxa over the seamount, which is confirmed by a one-way ANOSIM (Fig. 10) (Clarke 1993). The test statistic $R = 0.434$ ($p = 0.0001$) reveals that the dissimilarities between the sites are on average similar to those within the sites. Thus, even the above described apparent division of EraS into a northern and a southern meiobenthic community is not significant.

Eratosthenes Seamount versus the deep reference site R

The reference site R, located approximately 39 nm away from EraS, resembles the seamount sites in some aspects. Like the latter it is strongly dominated by Nematoda and Harpacticoida, followed by Annelida and Tardigrada (Table 2, Fig. 2). A certain vicinity to the western deep site W3 is indicated by the comparatively high abundance of Rotifera and Gastrotricha (Table 2,

Fig. 3), which play an only minor role in the remaining seamount stations.

Regarding the taxa density, R (Fig. 4: 97.53 ind./cm²) ranks higher than the seamount sites clustered as CII in Figure 6a. Likewise, with $HT = 9$ (Fig. 7), R inhabits more meiobenthic taxa than the seamount sites W3, W2, E1, E2, S2, and S3, and also with $H' = 0.7019$ ($J = 0.3195$) R occupies a rather elevated position; only six seamount sites provide a higher H' , whilst eight sites lay below the value of R (Table 3). So, although the reference site R lacks the meiobenthic Halacarida, Isopoda, Kinorhyncha, Ostracoda, Priapulida, and Tanaidacea, appearing to inhabit an impoverished meiofaunal assemblage if compared with the whole EraS, the comparison with the single seamount sites blurs these apparent differences.

Discussion

The eastern Mediterranean Sea is considered a quite oligotrophic marine region (e.g. Kröncke et al. 2003; Tselepidis et al.

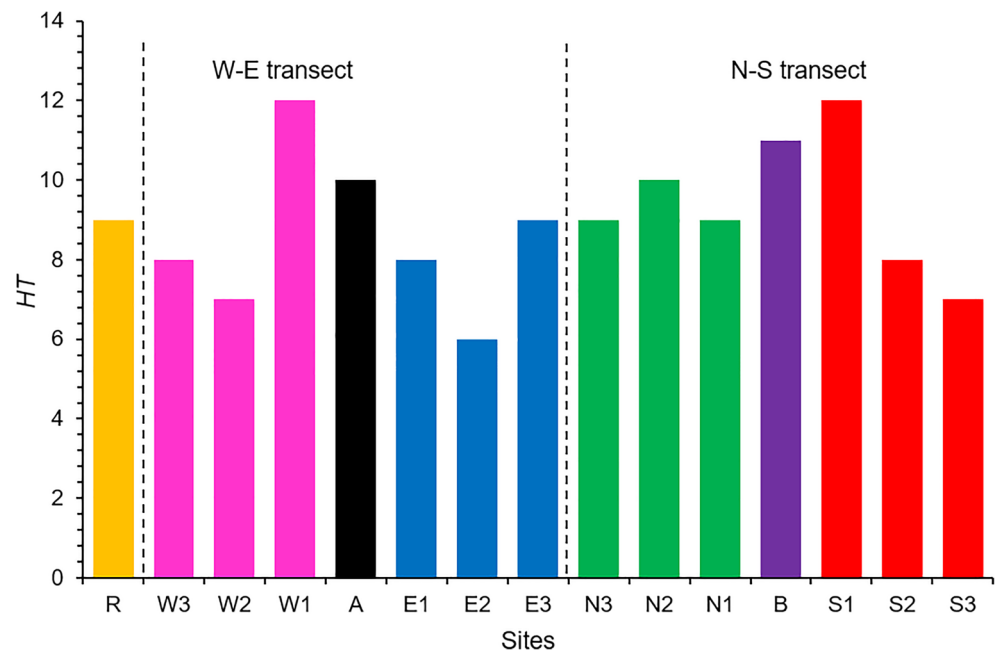
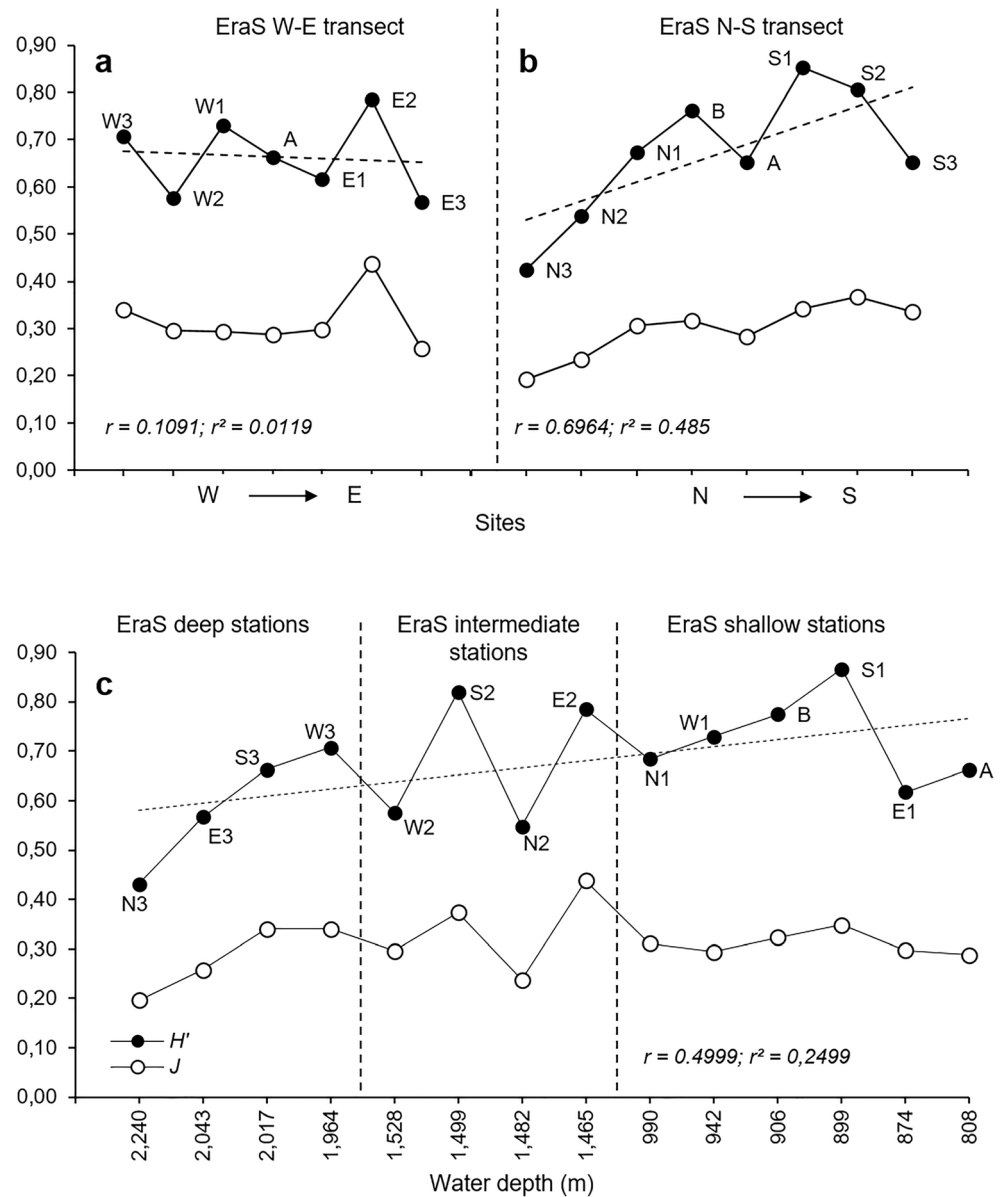
Fig. 7 Meiobenthic major taxa richness *HT* at the different study sites

Fig. 8 Shannon Index H' and Evenness J sampled at Eratosthenes Seamount and ordered along **a** the W–E transect, **b** the N–S transect, **c** a bathymetrical gradient. Because sampling site A builds the crossing point of the transects, it appears in both a and b

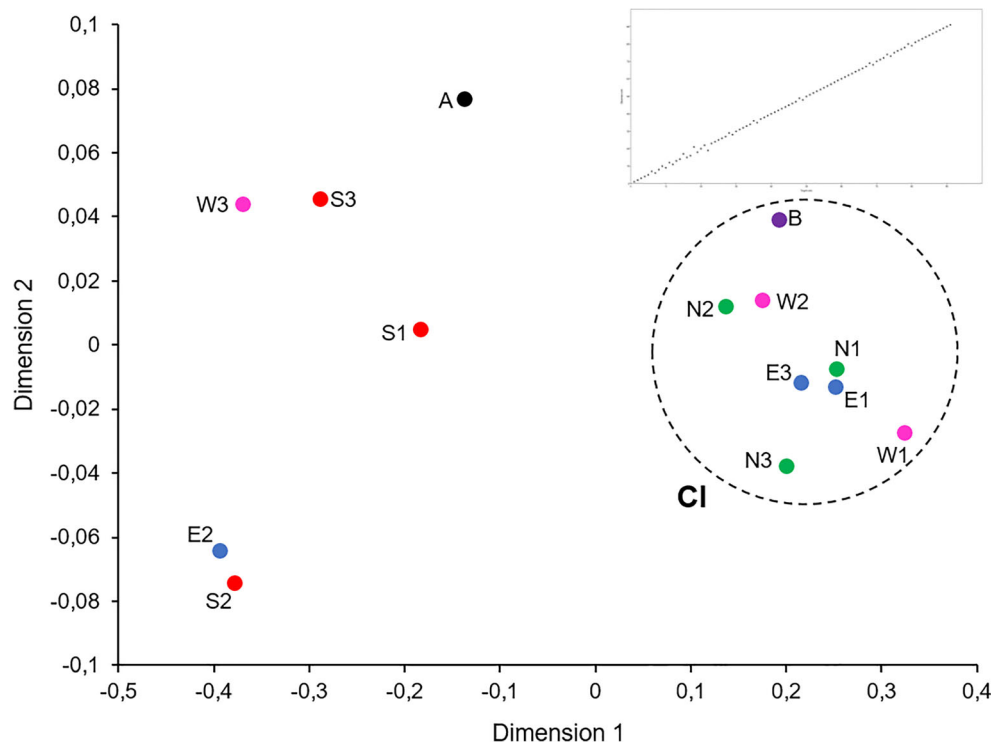


2004; Lampadariou et al. 2009; Lubinevsky et al. 2017; George et al. 2018). Consequently, the region is characterized by a low productivity (Sevastou et al. 2013) and an impoverished marine fauna (Galil and Goren 1994; Danovaro et al. 2000; Kröncke et al. 2003; Galil 2004; Sardà et al. 2004; Lampadariou et al. 2009). Being situated in the eastern Mediterranean Sea, south of Cyprus (Fig. 1; cf. Christiansen 2012), the Eratosthenes Seamount should therefore match these oligotrophic, impoverished conditions. Biological studies on EraS are scarce (Morato et al. 2013), but with respect to the macrobenthos Galil and Zibrowius (1998: 111) confirmed a “relatively rich and diverse fauna”. Sevastou et al. (2013) included 13 samples taken from EraS of the here treated RV M.S. MERIAN cruise MSM 14/1 in their extensive comparison of eastern Mediterranean meiobenthic

deep-sea communities. Nonetheless, these authors did not compare the single seamount samples but pooled them together with material from other research cruises as “Eastern Levantine” samples for further comparison with other Mediterranean deep-sea regions (Sevastou et al. 2013: 4863, tab. 1). Thus, the contribution on hand is the first quantitative study focusing explicitly on 15 meiobenthic major taxa reported from EraS (Table 2). In addition to the 14 seamount study sites, one distant reference site was sampled.

As mentioned initially, with its base at approximately 2,400 m and the summit at approximately 800 m, EraS represents a completely bathyal elevation. Thus, it was assumed that the meiofauna on the seamount might constitute a uniform, homogeneous community. The comparative analyses revealed, however, a complex situation.

Fig. 9 Ordination plot of a non-metrical MDS, showing the mutual (dis)similarity of the seamount sites with respect to *HT*, their composition and the abundance (ind./10cm²). Dotted circle marking cluster of sites corresponding to cluster CI shown in Fig. 6. Bray–Curtis Index, stress: 0.13. Upper right: Shepard diagram

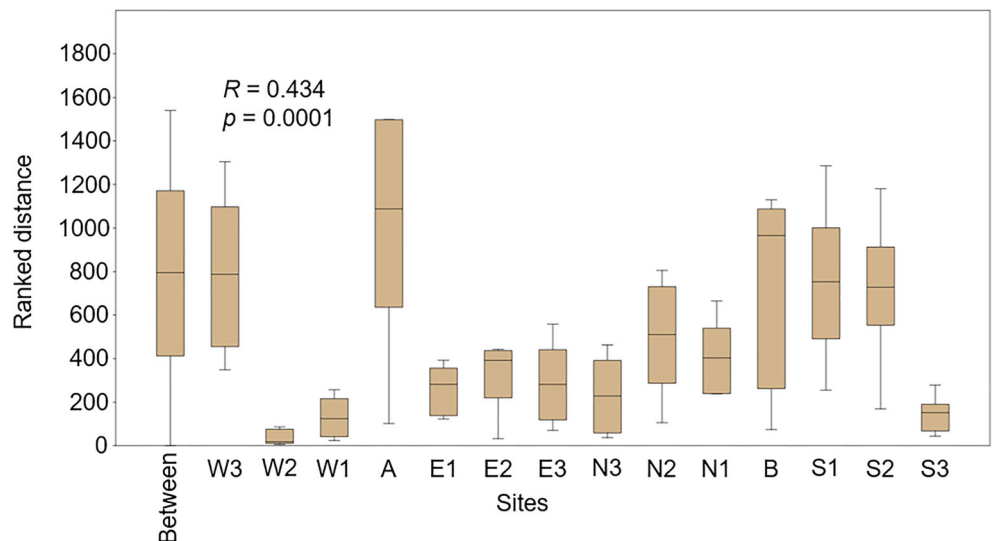


Meiofauna on Eratosthenes Seamount

Like for the observation made by Sevastou et al. (2013) at different Mediterranean study areas, also at EraS the meiofaunal abundance followed that of Nematoda and Harpacticoida. Both taxa strongly dominate the meiobenthic samples (>91%), insinuating a homogeneous meiobenthic seamount community that might support the initial assumption. Nevertheless, as demonstrated above, the single study sites differ remarkably from each other by means of taxa composition, abundance, and diversity, particularly if the

superimposing Nematoda and Harpacticoida are excluded. Such comparison revealed that the differences found at the different sites are not linked to any longitudinal, latitudinal, or bathymetrical gradient, perhaps with the exception of the α -diversity, i.e. the comparison of the single sites calculated with *H'*, which points towards a latitudinal, and in a lower dimension also a bathymetrical gradient along the N–S transect. Apart from that hint, however, and as confirmed by a one-way ANOSIM, the meiobenthic assemblage on EraS shows a remarkable heterogeneity in taxa composition, abundance, and diversity, inhibiting the characterization of a uniform,

Fig. 10 Box–Whisker plot showing the results of a one-way ANOSIM basing on the similarity analysis



homogeneous meiobenthic seamount community. Even an apparent northern assemblage could not be confirmed statistically by ANOSIM, and no clear relationships between bathymetrical and/or geographical conditions could be detected. This disagrees with results of Sevastou et al. (2013), who documented a general difference of the meiobenthic composition along depth gradients in their study areas. Nevertheless, these authors also noted highly variable environmental conditions at all study sites, providing higher differences within than between different habitats. This is confirmed by the results of the here presented study, leading to the conclusion that the heterogeneous meiofauna assemblage of EraS reflects similar assorted environmental conditions at a small scale. That means that although no significant differences were confirmed, this is not because of the existence of a uniform and homogeneous meiobenthic community. Instead, it must be concluded that Eratosthenes Seamount hosts a quite heterogeneous meiofaunal assemblage, whose structure (composition, abundance, diversity) is linked to small-scale biotic and abiotic conditions on the seamount. Similar results were obtained from other seamounts, e.g. Anaximenes Seamount south off Turkey (Harpacticoida at (sub)family level; George et al. 2018), Condor Seamount (meiobenthic major taxa; Zeppilli et al. 2013) and the Great Meteor Seamount in the subtropical northern Atlantic, (Cylindropsyllidae; Richter 2019). Although differences were observed in the abovementioned studies—e.g. in Zeppilli et al. (2013) a higher alpha diversity on the summit of Condor Lake Mountain than on its flanks and base, which in turn showed higher abundances—the differences were not significant, so that a clear delimitation of the bathymetric regions was not possible.

Eratosthenes Seamount versus the deep reference site R

The distant reference site R was located at a depth similar to the seamount's base (water depth 2,419m). Thus, it was presumed that there might be no differences between the meiobenthic assemblages of R and EraS. In a first sight, the reference site R resembles EraS, particularly its northern half. Like for the latter, also R is strongly dominated by Nematoda and Harpacticoida, followed by Annelida and Tardigrada (Figs. 2 and 3). Also, the taxa density (Fig. 4, Table 2) and major taxa richness HT (γ -diversity) (Fig. 8, Table 3) of R and EraS present similar values. This indicates that the general structure of the meiobenthic assemblage in R resembles that of the seamount.

Similar results were obtained by Zeppilli et al. (2013) for the Azorean Condor Seamount (ConS) compared with a far field site. These results suggest no clear differences between seamounts and distant deep-sea locations, which might qualify the seamounts' importance for enhancing diversity and productivity in the high seas. Nevertheless, site R is located

approximately 39 nm away from EraS, whilst Zeppilli's et al. (2013) far field site is situated even closer to ConS, being located only approximately 11 nm away from it. Consequently, the selection of both distant deep-sea locations as reference sites was perhaps not appropriate for the intended clear separation of the seamounts from the corresponding deep-sea locations, because the similarity of the deep-sea and seamount sites suggests—against any former expectation—faunistic and ecological interactions. That assumption is supported by the results of George et al. (2018), who documented a clear difference between the Mediterranean Anaximenes Seamount (AnaS) and the compared reference site F in the Rhodes Basin with respect to the studied assemblages of benthic Copepoda. Site F in George et al. (2018) was positioned approximately 74 nm away from the seamount, much farther away than R in the contribution at hand and the far field site in Zeppilli et al. (2013). So, to exclude any faunistic and ecological interactions between a seamount and the surrounding deep sea, an adequate distance between a studied seamount and the selected reference site may (among other variables) play a crucial role. It has to be taken into consideration, however, that (a) only two stations were sampled at R, which might be insufficient for an unambiguous characterization of that area, and (b) studies at higher taxonomic levels might blur actual differences, as each major taxon encloses different subordinated groups with their own, distinct ecological demands (in particular at species level). Therefore, ongoing investigation of the benthic Copepoda of both the Condor and the Eratosthenes Seamount shall elucidate if the results at the major taxon level on these seamounts reflect those obtained at the species level.

Comparison with other seamounts

In his review, George (2013) compiled 26 major meiobenthic taxa from eight seamounts worldwide. Basing on that list, an update of his list is presented in Table 4. It includes three further seamounts, i.e. ConS, the eastern Mediterranean AnaS, and the here treated EraS. Moreover, three Azorean Islands are listed. They were sampled during the BIODIAZ expedition of RV METEOR in August/September 2018 (George et al. 2021). The respective data refer to sublittoral samples taken around the islands at approximately 300-m water depth (George et al. in prep.). The Pacific seamounts and the Atlantic Josephine Bank included by George (2013) for completeness are excluded from Table 4 because of the biased sampling or taxa determination (cf. George 2013 for explanation). Data of meiobenthic major taxa of AnaS are added from George (unpublished). As some literature data pool Polychaeta and Oligochaeta as Annelida, this was adopted here, too, resulting in a number of 25 reported meiobenthic taxa provided by George (2013). Nevertheless, with the Priapulida collected from both EraS (present contribution), AnaS (George unpubl.), and from the Azorean islands Flores

Table 4 Meiobenthic major taxa reported from six Atlantic and Mediterranean seamounts and the sublittoral (~300m depth) of the Azorean islands Flores, Terceira, and Santa Maria, which were sampled during the BIODIAZ campaign in 2018 (George et al. 2020). *AnaS*, Anaximenes Seamount; *ConS*, Condor Seamount; *EraS*, Eratosthenes

Seamount; *GMS*, Great Meteor Seamount; *SedS*, Sedlo Seamount; *SeiS*, Seine Seamount. Data from George and Schminke (2002) (*GMS*), Büntzow (2011) (*SedS*, *SeiS*), Zeppilli et al. (2013) (*ConS*), George et al. (in prep.) (Flores, Terceira, and Sta. Maria Islands), George (unpubl) (*AnaS*), present contribution (*EraS*)

No.	Major taxon	Northern subtropical Atlantic							Mediterranean	
		<i>GMS</i>	<i>SedS</i>	<i>SeiS</i>	<i>ConS</i>	Terceira	Sta. Maria	Flores	<i>AnaS</i>	<i>EraS</i>
1	Kinorhyncha	+	+	+	+	+	+	+	+	+
2	Loricifera	+	+	+	+	+	+	+	+	+
3	Nematoda	+	+	+	+	+	+	+	+	+
4	Ostracoda	+	+	+	+	+	+	+	+	+
5	Tardigrada	+	+	+	+	+	+	+	+	+
6	Halacarida	+	+	+	+	+	+	+	+	+
7	Harpacticoida	+	+	+	+	+	+	+	+	+
8	Isopoda	+	+	+	+	+	+	+	+	+
9	Tanaidacea	+	+	+	+	+	+	+	+	+
10	Bivalvia	+	+	+	+	+	+	+	+	+
11	Amphipoda	+	+	+	+				+	
12	Gastrotricha	+	+	+		+		+	+	+
13	Pantopoda	+	+							
14	Annelida	+			+	+	+	+	+	+
15	Rotifera	+		+				+	+	+
16	Cnidaria	+		+						
17	Tantulocarida	+		+		+			+	+
18	Turbellaria	+								
19	Cumacea	+			+					
20	Gastropoda	+			+					
21	Sipuncula	+						+	+	
22	Bryozoa	+								
23	Entoprocta	+								
24	Leptostraca	+								
25	Solenogastres		+							
26	Echiura				+					
27	Priapulida					+		+	+	+
	No. taxa	24	14	15	15	14	10	13	17	15

and Terceira (George unpubl.), plus the Echiura documented from *ConS* (Zeppilli et al. 2013), the list increased up to 27. Of these, eight major taxa (29.6%) have been documented so far from all seamounts and islands listed in Table 4. Still, the Great Meteor Seamount provides the highest number of major taxa, whereas from the Azorean island Santa Maria just 10 taxa were reported. Sorting of the Mediterranean samples was done meticulous, so the lack of ten respectively 12 taxa from *AnaS* and *EraS* (Table 4) may point to their factual absence on these seamounts. The same may apply to Amphipoda and Sipuncula, which were found on the subtropical Atlantic seamounts and *AnaS* but neither on the Azorean islands nor on *EraS*. However, the report of 17 and 15 major taxa on *AnaS* and *EraS*, respectively, does in fact not confirm impoverished

meiofaunal associations in the eastern Mediterranean Sea at higher taxonomic level. Basing on the available data, the results from *EraS* support those presented by George et al. (2018) for benthic copepod species from Anaximenes Seamount and also Galil's and Zibrowius' (1998) statement of a rich and diverse fauna on Eratosthenes Seamount.

Conclusion

The faunistic analysis of 60 replicates from 30 stations taken at 15 study sites—14 at Eratosthenes seamount, 1 distant deep-sea reference site—provided the following results:

1. In all study sites Nematoda and Copepoda Harpacticoida dominate clearly the meiobenthic associations, providing 91.22–97.58% of relative abundance on EraS, and 95.40% at R. They are followed by Annelida that constitute the third-highest taxon at all sites except at the western seamount site W3, where it is outnumbered by the Rotifera and Bivalvia.
2. A detection of an apparent northern faunistic area at Eratosthenes Seamount, whose community might be characterized by Nematoda, Harpacticoida, Annelida, and Tardigrada as dominant taxa, as well as by comparatively high abundance values (mean density = 132.65 ind./10cm²) and a similar taxa composition, was not confirmed by a one-way ANOSIM, as no significant difference was detected between dissimilarities between the sites compared with those within the sites.
3. The obtained data indicate that Eratosthenes Seamount hosts a heterogeneous meiobenthic community, whose structure (composition, abundance, diversity) is linked to small-scale biotic and abiotic conditions on the seamount.
4. Comparison with the distant reference site R yielded no clear-cut differences between the seamount and the deep-sea assemblages. However, this might be due to the low number of samples taken at R, combined with the distance between the two regions that might be too short to exclude any ecological and faunistic interactions between them.
5. A comparison of the meiobenthic major taxa inventory of EraS with other Mediterranean and Atlantic seamounts and islands does not confirm a general faunistic impoverishment of seamounts in the eastern Mediterranean.

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Declarations

Conflict of interest The author declares no competing interests.

Ethical approval No animal testing was performed during this study.

Sampling and field studies All necessary permits for sampling and observational field studies had been obtained by the expedition leader from the competent authorities. The study is compliant with CBD and Nagoya protocols.

Data availability All data generated or analysed during this study are included in this published article.

Author contribution This study has been realized solely by KHG

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