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Spatial Variation of Soft Bottom Arthropoda and Echinodermata Fauna in the Aegean Sea

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Abstract

A study was conducted on the community of the arthropod and echinoderm fauna in the Aegean Sea of Turkish coast between August 12th and 19th, 2014. Sampling was obtained utilizing a van Veen grab at 16 stations between Edirne-Enez and Marmaris by the R/V TUBITAK Marmara at depths ranging from 11.5 to 69 m. In the study area, an average of 79 individuals m^{-2} of 68 arthropod species with an average weight of 1.3 g m^{-2}; a total density of 18 individuals m^{-2} of 13 echinoderm species with a weight of 22 g m^{-2} were obtained. Amphipod *Gammaropsis sophiae* and ophiuroid *Amphiura cherbonnieri* are new record species for the Aegean coast of Turkiye. The frequency index indicates that tanaid *Apseudopsis latreillii* and Ophiroid *Amphipholis squamata* are the most common taxa. The quantitative dominance results for all study areas demonstrate that tanaid *Chondrochelia savignyi* and ophiroid *Amphiura chiajei* were the most dominant species. The highest number of species (33 species), abundance (373 ind m^{-2}) and biomass (247 g m^{-2}) were found in the station Çeşme while no species could be obtained at station outer Izmir Bay. In the implementation of ecosystem-based management strategies, the presentation of qualitative and quantitative information regarding fauna is of great importance

Introduction

The Aegean Sea is one of the five basins of the Eastern Mediterranean, separated from the Levantine Sea in the south by Crete, Kasos, Karpatos, Rhodes Islands and the Dalaman River (Hopkins, 1978). Due to its topography and complex oceanography, the Aegean Sea contains six different water bodies of different densities and volumes: Black Sea Water (BSW), Eastern Mediterranean Water (LSW), Aegean Sea Intermediate Water (AgIW), Crete Deep Water (CDW), North Aegean Deep Water (NAgDW) and Central Aegean Deep Water (CAgDW)) (Gertman et al., 2006). Due to the different water bodies, the Aegean Sea contains large variation according to its depths and latitudes. These differences have led to a rich biodiversity. Many gulfs and bays along the coast of the Aegean Sea are habitats to marine organisms of different trophic levels. However, these coasts, which are valuable and important for biodiversity, are also a major tourist attraction and therefore subject to antropogenic impact. Insufficient performance of wastewater treatment plants due to the increased loads from summer populations is only one of the factors threatening the quality of sea water of the Aegean Sea. The water quality is also negatively affected by diffuse pollution factors for the Northern Aegean, and by the increasing human population and industrial establishments from the central Aegean Sea coasts (Polat Beken et al., 2017). Besides the changing water quality, the main factors affecting the biological richness of the Aegean Sea are non-indigenous species (Çınar et al., 2021; Aslan & Polito, 2021), mucilage (Aslan et al., 2021), habitat degradation (Ateş et al., 2007; Aslan & İşmen 2019; Akçalı et al., 2020; Taşkın et al., 2024), and overfishing (Dereli et al., 2022).

Due to the increasing anthropogenic pressures on the marine environment in European Water bodies including the Aegean Sea (Mee et al. 2008), the European Union established the Water Framework Directive (WFD) (European Communities 2000) and the Marine Strategy Framework Directive (MSFD) (European Communities 2008) to achieve/maintain Good Environmental Status (GES). Turkish (T.C.) Ministry of Environment, Urbanization and Climate Change, General Directorate General of Environmental Impact Assessment, Permit and Inspection (EIA) conducts "Integrated Marine Pollution Monitoring Projects" for Turkish seas to achieve/maintain GES. GES monitoring is based on eleven quality descriptors, and macroinvertebrate benthic fauna is closely related to three of these descriptors: biological diversity, non-indigenous species, and seafloor integrity (Van Hoey et al., 2010). Macrozoobenthic communities serve as exemplary bioindicators for the assessment of marine ecosystem quality, given their role in maintaining productivity, energy flow, and nutrient recycling processes (Elliott et al., 2018; Crespo & Pardal, 2020; Tekeli & Aslan, 2023).

The aim of this study is to examine the structure of the Arthropoda and Echinodermata communities, which represent two of the most significant phyla of the macrobenthic fauna. Species were obtained within the scope of "Integrated Pollution Monitoring Project" in the Aegean Sea during 2014. According to the Arthropoda check-list made by Bakır et al., (2014), a total of 685 benthic Arthropoda species were reported from the Turkish coasts of the Aegean Sea, and a total of 76 Echinoderm species were reported by Öztoprak et al. (2014). The distribution of these species according to taxa is as follows: 24 species of Pycnogonida, 11 species of Maxillopoda, 3 species of Nebaliacea, 7 species of Stomatopoda, 26 species of Mysidacea, 289 species of Amphipoda, 68 species of Isopoda, 11 species of Tanaidacea, 27 species of Cumacea, 219 species of Decapoda; 2 species of Crinoidea, 22 species of Asterioida, 16 species of Ophiuroidea, 18 species of Echinoidea, 18 species of Holothuroidea from Echinoderms. In accordance with the aforementioned checklists, several researchers have continued to investigate the crustacean and echinoderm fauna of the Aegean Sea, including Larsen, 2014; Kocak & Moreira, 2015; Bakır et al., 2015; Doğan et al., 2015a, 2015b, 2016; Ates, et al., 2016; Bakır & Aydın, 2016; Karachle et al., 2016; Gönülal & Güreşen, 2017; Aslan et al., 2018; Çınar et al., 2019; Aslan & İşmen, 2019; Ozgen et al., 2019; Soykan et al., 2019; Özaydınlı & Bizsel, 2020; Bilecenoglu & Cınar, 2021; Aslan & Polito, 2021; Aslan et al., 2021; Aslan, 2022, Daglı et al., 2024. Thus, the number of Echinordem species known from the Aegean Sea increased to 78 and the number of benthic arthropod species increased to 733 (Bakır et al., 2024).

Coastal soft-bottom macrozoobenthos is exposed to different disturbance sources and are considered good indicators of water and sediment quality. Furthermore, it is important to know the diversity of zoobenthos to implement ecosystem-based management plans for the seas. The objective of this study is to provide a spatial evaluation in a short term of the diversity of the Arthropoda and Echinodermata communities that inhabit the soft substrates of the Aegean Sea.

Materials & Methods

Collection and Identification of the Species

Sampling was obtained by means of a 0.1 m^2 van Veen grab at 16 stations on the Turkish coast of the Aegean Sea between the 12^{th} to 19^{th} of August 2014 from the R/V TUBITAK Marmara. This study was conducted within the scope of the "Integrated Marine Pollution Monitoring 2014 –2016 Program" coordinated by TUBITAK – Marmara Research Center of the Environment and Cleaner Production Institute.

Soft bottom sampling was carried out as three replicates in every station at depths ranging from 11.5 to 69 m between Edirne-Enez and Marmaris (Figure. 1, Table 1). All benthic materials were sieved through a 0.5 mm mesh size sieve and the retained fauna were fixed with a 4% formaldehyde-seawater solution on board. In the laboratory, the arthropods and echinoderms were separated under a stereomicroscope and preserved in 70% ethanol. Specimens were identified and counted, and the total wet weight of each species was estimated by using a balance with 0.0001 sensitivity. Specimens were defined at the species level The taxonomy used is that of WoRMS (2024).

Statistical Analyses

Species number (S) and individuals of every species (N) were counted and biomass of species were measured for each station. We estimated the frequency index (F≥50% continuous, 25%≤F<50% common, and F<25% rare) (Soyer, 1970) and quantitative dominance, Margalef richness index (Margalef, 1958) (d), the Pielou evenness index (Pielou, 1975) (J'), and the Shannon–Wiener Diversity index (Shannon and Weaver, 1949) (H') (based on $\log_2$). The Bray–Curtis similarity index was applied for a biogeographical summary of assemblages, data were log transformed (abundance + 1). The Bray–Curtis method was chosen for similarity indices. The grouping technique (cluster) and n-MDS (nonmetric multi-dimensional scaling) methods were used for the evaluation of communities and groups formed between stations. PRIMER package version 7.0 statistical package program (Clarke and Gorley, 2015) was used.

Figure 1. Map of the sampling stations in the Aegean Sea.

Table 1. Some properties of the sampling stations

Station code	Station name	Date	Depth (m)	Latitude	Longitude
EG1	Edirne-Enez	12.08.2014	17	40.706167	26.024167
EG2	Saroz Bay	12.08.2014	43	40.604917	26.800450
EG3	Bozcaada	13.08.2014	47	39.915667	26.017500
EG4	Çanakkale Strait	12.08.2014	18	39.953867	26.150817
EG5	Edremit Bay	13.08.2014	21	39.392433	26.441750
EG6	Aliağa Bay	14.08.2014	20	38.823333	26.952233
EG7	Inner Izmir Bay	14.08.2014	11.5	38.435100	27.124500
EG8	Outer Izmir Bay	15.08.2014	22	38.386667	26.774550
EG9	Ildır Bay	15.08.2014	68	38.418083	26.431200
EG10	Çeşme	16.08.2014	23	38.307700	26.252817
EG11	K. Menderes Estuary	16.08.2014	43	37.942350	27.255700
EG12	Didim Bay	17.08.2014	34	37.419200	27.204600
EG13	Akbük Bay	17.08.2014	24.5	37.365833	27.368200
EG14	Güllük Bay	17.08.2014	47.6	37.120817	27.505583
EG15	Gökova Bay	18.08.2014	69	37.002567	28.153367
EG16	Marmaris	19.08.2014	21	36.843750	28.270967

Results

In the study area, the average density of Arthropoda was estimated at 79 individuals m^{-2} of 68 species with an average wet weight of 1.3 g m^{-2}, and the average density of Echinodermata was 18 individuals m^{-2} of 13 species with a weight of weighing 22 g m^{-2}. The amphipod *Gammaropsis sophiae* from station EG3 and the ophiuroid *Amphiura cherbonnieri* from station EG9 record new species for the Aegean coast of Turkiye (Table 2). According to the frequency index results, while no continuous species were found, 9 species (tanaid *Apseudopsis latreillii* and ophiroid *Amphipholis squamata* (43.75%), *Amphiura filiformis*, *Amphiura chiajei* (37.5%) amphipod *Ampelisca tenuicornis, Ampelisca typica*, tanaid *Chondrochelia savignyi* (31.25%), amphipod *Ampelisca sarsi* and *Harpinia antennaria* (25%)) were common and the other 72 species were rare species (frequency<25%). As a result of the quantitative dominance, tanaid *Chondrochelia savignyi* (14.29%), *Apseudopsis latreillii* (5.76%) and ophiuroid *Amphiura chiajei* (6.61%) were the most dominant species for the whole study area. Furthermore, the brachyuran *Macrophthalmus (Macrophthalmus) indicus* from station EG16, and amphipod *Elasmopus pectenicrus* from station EG11 were recorded as non-indigenous species (Table 2).

Amphipods were the dominant order both in terms of species number (47 species) and abundance (720 specimens). The second highest species number

Table 2. Average abundance ind m^{-2} and standard deviation results (±) of species in the stations and frequency and dominancy values of every species

Species/Stations	EG1	EG2	EG3	EG4	EG5	EG6	EG7	EG8	EG9	EG10	EG11	EG12	EG13	EG14	EG15	EG16	F	D
Phylum: **ARTHROPODA**																		
Subphylum: **CRUSTACEA**																		
Order: AMPHIPODA																		
AMPELISCIDAE																		
Ampelisca brevicornis (A. Costa, 1853)	3±1																6.25	0.21
Ampelisca diadema (A. Costa, 1853)													3±1		3±1		12.5	0.43
Ampelisca pseudosarsi Bellan-Santini & Kaim-Malka, 1977												13±2					6.25	0.85
Ampelisca sarsi Chevreux, 1888					7±1	3±1						13±2		50±6			25	4.69
Ampelisca tenuicornis Liljeborg, 1856							3±1		7±1	3±1		10±1				3±1	31.25	1.71
Ampelisca truncata Bellan-Santini & Kaim-Malka, 1977									7±1	7±1					7±1		18.75	1.28
Ampelisca typica (Spence Bate, 1857)					50±5		10±2					3±1	7±1	3±1			31.25	4.69
Ampelisca sp.					7±1												6.25	0.43
AORIDAE																		
Autonoe spiniventris Della Valle, 1893																53±9	6.25	3.41
Microdeutopus anomalus (Rathke, 1843)										7±1							6.25	0.43
Microdeutopus obtusatus Myers, 1973														3±1			6.25	0.21
Microdeutopus sp.			3±1							47±8						3±1	18.75	3.41
CALLIOPIIDAE																		
Apherusa chiereghinii Giordani- Soika, 1949										13±2							6.25	0.85
Apherusa ruffoi Krapp-Schickel, 1969												3±1					6.25	0.21
Apherusa vexatrix Krapp-Schickel, 1979										3±1							6.25	0.21
COROPHIIDAE																		
Leptocheirus pilosus Zaddach, 1844									7±1			13±1		3±1			18.75	1.49
Leptocheirus pectinatus (Norman, 1869)															3±1		6.25	0.21
Apocorophium acutum (Chevreux, 1908)															3±1		6.25	0.21
ISCHYROCERIDAE																		
Ericthonius punctatus (Spence Bate, 1857)												3±1					6.25	0.21
DEXAMINIDAE																		
Dexamine spinosa (Montagu, 1813)										3±1		7±1					12.5	0.64
PHOTIDAE																		
**Gammaropsis sophiae* (Boeck, 1861)			3±1														6.25	0.21
MAERIDAE																		
Maera schieckei Karaman & Ruffo, 1971										13±2							6.25	0.85
Maera pachytelson Karaman & Ruffo, 1971										3±1							6.25	0.21
Elasmopus rapax A. Costa, 1853										3±1							6.25	0.21
Elasmopus pectenicrus (Spence Bate, 1862)											3±1						6.25	0.21
Elasmopus sp.										3±1							6.25	0.21
LEUCOTHOIDAE																		
Leucothoe incisa Robertson, 1892													3±1	10±1			12.5	0.85
Leucothoe oboa Karaman, 1971						3±1					3±1						12.5	0.43
Leucothoe lilljeborgi Boeck, 1861							3±1		7±1					10±1			18.75	1.28
Leucothoe serraticarpa Della Valle, 1893							3±1									3±1	12.5	0.43
Leucothoe sp.										3±1							6.25	0.21
LILJEBORGIIDAE																		
Liljeborgia psaltrica Krapp-Schickel, 1975											10±2						6.25	0.64
Liljeborgia sp.														3±1			6.25	0.21
LYSIANASSIDAE																		
Lysianassa costae H. Milne Edwards, 1830										7±1							6.25	0.43
Lysianassa plumosa Boeck, 1871										3±1							6.25	0.21
Lysianassa sp.										3±1							6.25	0.21
OEDICEROTIDAE																		
Deflexilodes acutipes (Ledoyer, 1983)										3±1		3±1		3±1			18.75	0.64
Deflexilodes subnudus (Norman, 1889)														3±1			6.25	0.21
Westwoodilla rectirostris (Della Valle, 1893)																7±1	6.25	0.43
PHOXOCEPHALIDAE																		
Harpinia ala Karaman, 1987					10±2												6.25	0.64
Harpinia antennaria Meinert, 1890										7±1	7±1			37±3	3±1		25	3.41
Harpinia pectinata Sars, 1891		3±1		3±1													12.5	0.43
Harpinia truncata Sars, 1891															10±2		6.25	0.64
Metaphoxus simplex (Spence Bate, 1857)										57±5		3±1		10±1			18.75	4.48
Metaphoxus gruneri Karaman, 1986														3±1	3±1		12.5	0.43
CAPRELLIDAE																		
Caprella acanthifera Leach, 1814				7±1						20±3							12.5	1.71
Caprella rapax Mayer, 1890										7±1							6.25	0.43
Order: CUMACEA																		
BODOTRIIDAE																		
Iphinoe douniae Ledoyer, 1965			3±1														6.25	0.21
Vaunthompsonia cristata Bate, 1858													7±1				6.25	0.43
NANNASTACIDAE																		
Cumella (Cumella) limicola Sars, 1879										7±1							6.25	0.43
Order: MYSIDA																		
MYSIDAE																		
Paramysis sp.										3±1		3±1		3±1			18.75	0.64
Order: ISOPODA																		
GNATHIIDAE																		

Table 2. ***Continued***

Gnathia oxyuraea (Lilljeborg, 1855)										3±1							6.25	0.21
Gnathia vorax (Lucas, 1849)															3±1		6.25	0.21
Paragnathia formica (Hesse, 1864)									3±1					3±1			12.5	0.43
ANTHURIDAE																		
Apanthura corsica Amar, 1953										3±1							6.25	0.21
CIROLANIDAE																		
Eurydice pulchra Leach, 1816						7±1						13±1		10±1			18.75	1.92
SPHAEROMATIDAE																		
Dynamene edwardsi (Lucas, 1849)									3±1								6.25	0.21
Order: TANAIDACEA																		
APSEUDIDAE																		
Apseudopsis latreillii (Milne Edwards, 1828)					20±2	17±3	33±6			7±1		7±1		3±1	3±1		43.75	5.76
LEPTOCHELIIDAE																		
Chondrochelia savignyi (Kroyer, 1842)										103±16		27±3		7±1	20±2	67±7	31.25	14.29
Order: STOMATOPODA																		
SQUILLIDAE																		
Squilla mantis (Linnaeus, 1758)														3±1			6.25	0.21
Order: DECAPODA																		
CALLIANASSIDAE																		
Callianassa subterranea (Montagu, 1808)		10±1													7±1	3±1	18.75	1.28
UPOGEBIIDAE																		
Upogebia deltaura (Leach, 1816)					3±1												6.25	0.21
Upogebia pusilla (Petagna, 1792)						3±1									3±1		12.5	0.43
POLYBIIDAE																		
Liocarcinus navigator (Herbst, 1794)												13±1					6.25	0.85
Liocarcinus pusillus (Leach, 1816)												3±1					6.25	0.21
GONEPLACIDAE																		
Goneplax rhomboides (Linnaeus, 1758)	7±1								3±1					3±1			18.75	0.85
MAJIDAE																		
Eurynome aspera (Pennant, 1777)															3±1		6.25	0.21
MACROPHTHALMIDAE																		
Macrophthalmus (Macrophthalmus) indicus Davie, 2012																10±1	6.25	0.64
GALATHEIDAE																		
Galathea intermedia Lilljeborg, 1851												3±1			7±1	3±1	18.75	0.85
MUNIDIDAE																		
Munida sp.										3±1							6.25	0.21
PAGURIDAE																		
Anapagurus breviaculeatus Fenizia, 1937											3±1					7±1	12.5	0.64
Anapagurus pusillus Henderson, 1888												3±1					6.25	0.21
ALPHEIDAE																		
Alpheus glaber (Olivi, 1792)			3±1								7±1						12.5	0.64
Athanas nitescens (Leach, 1814)											7±1	3±1				10±1	18.75	1.28
HIPPOLYTIDAE																		
Hippolyte sp.										3±1							6.25	0.21
PROCESSIDAE																		
Processa canaliculata Leach, 1815						3±1								3±1			12.5	0.43
Processa edulis (Risso, 1816)							7±1										6.25	0.43
CRANGONIDAE																		
Philocheras sp.											3±1	3±1					12.5	0.43
Phylum: ECHINODERMATA																		
Class: ASTEROIDEA																		
ASTERINIDAE																		
Asterina pancerii (Gasco, 1876)				7±1													6.25	0.43
ASTROPECTINIDAE																		
Astropecten bispinosus (Otto, 1823)					3±1												6.25	0.21
Class: OPHIUROIDEA																		
AMPHIURIDAE																		
Amphipholis squamata (Delle Chiaje, 1828)					3±1	3±1	23±3		3±1	7±1		13±2		3±1			43.75	3.62
Amphiura filiformis (O.F. Müller, 1776)	7±1				10±1				40±3		3±1				7±1	7±1	37.5	4.69
Amphiura chiajei Forbes, 1843	27±4				7±1				10±2			40±5			17±3	3±1	37.5	6.61
**Amphiura cherbonnieri* Guille, 1972									3±1								6.25	0.21
OPHIODERMATIDAE																		
Ophioderma longicaudum (Bruzelius, 1805)										3±1							6.25	0.21
Class: HOLOTHUROIDEA																		
Holothuria (Holothuria) tubulosa Gmelin, 1791										3±1							6.25	0.21
Class: ECHİNOİDEA																		
TRIGONOCIDARIDAE																		
Genocidaris maculata A. Agassiz, 1869										3±1							6.25	0.21
FIBULARIIDAE																		
Echinocyamus pusillus (O.F. Müller, 1776)				3±1								3±1					12.5	0.43
LOVENIIDAE																		
Echinocardium cordatum (Pennant, 1777)							3±1							3±1			12.5	0.43
SCHIZASTERIDAE																		
Ova canalifera (Lamarck, 1816)										7±1		10±1					12.5	1.07
BRISSIDAE																		
Brissopsis atlantica Mortensen, 1907															7±1		6.25	0.43

belonged to Decapoda (18 species), followed by Isopoda (6 species), Echinoidea and Ophiuroidea classes of Echinodermata (5 species each). The second-highest abundance (313 individuals) were found in only 2 species of tanaids followed by ophiroids (240 specimens) in Echinodermata. The first three highest biomass belonged to the species of the phylum of Echinodermata (Table 2). The taxa with the highest biomass (205.14 g) were echinoids, with 40 individuals belonging to only 5 species. The second highest biomass belonged to Holothuroidea with 88.89 g for only 1 species and 3 specimens by followed ophiuroid with 3.18 g. Decapods, constituting 96% of the biomass of all arthropods, were the 4th taxa with a total weight of 19.22 g. Figures 2 and 3 aim to provide an overview of the distribution of species by taxonomic categories within each phylum, based on data on species number, abundance and biomass. The decapod crustaceans constituted 96% of the total biomass of arthropods obtained from the stations, ranking third in terms of abundance with a rate of 12% after the amphipods and tanaids. The Cumacea, representing less than 1% of the arthropods in terms of biomass and abundance, and were found to constitute the third most numerous order of species (Figure 2). In the Echinodermata phylum, Echinoidea and Ophiroid classes were dominant in biomass and abundance, respectively, while both classes exhibited a similar species number, with five species each (Figure 3).

Species number (S), abundance (N), biomass, species richness (d), evenness (J), and diversity (H') for each station are shown in Figure 4. The highest number

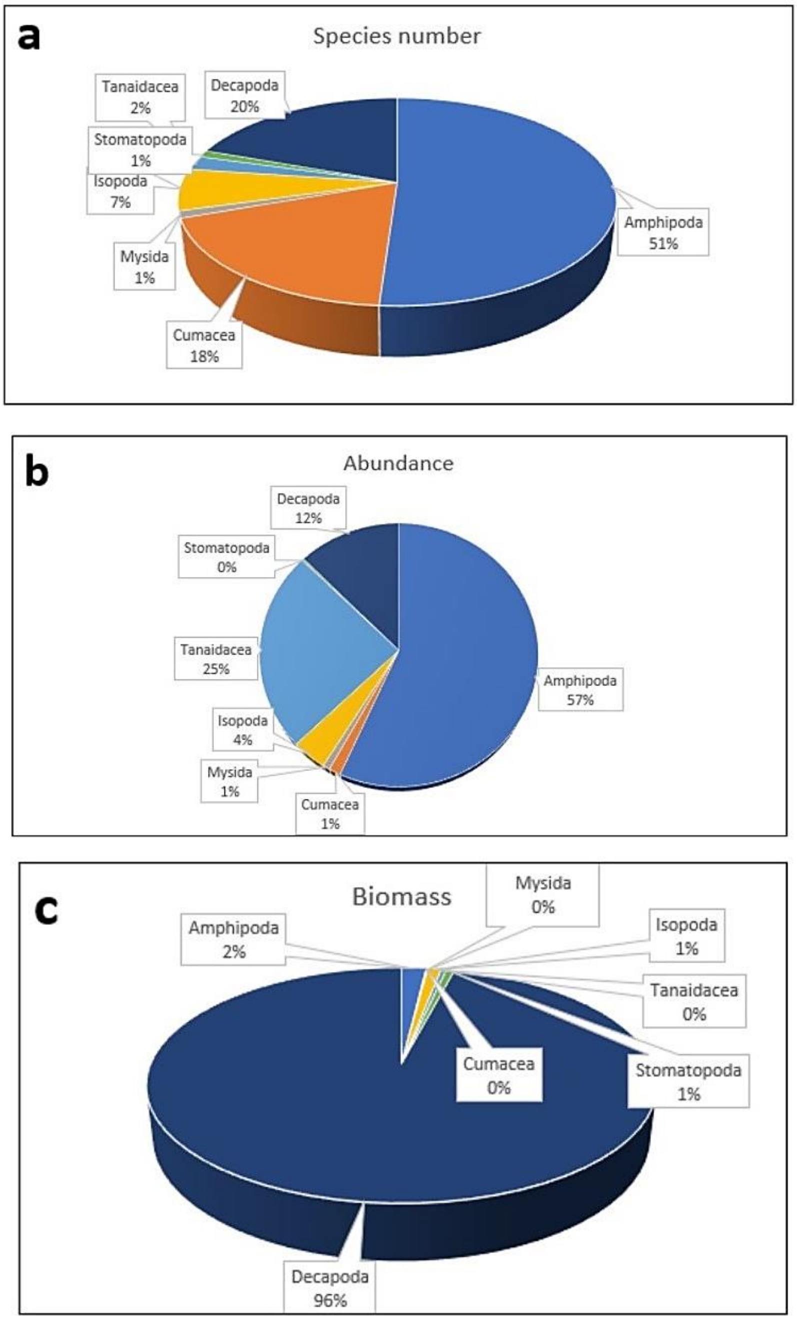

Figure 2. Percent values of **a)** species number, **b)** abundance and **c)** biomass according to the Arthropoda orders.

of species, abundance, and biomass were found in station EG10 with 33 species, 373 ind m^{-2} and 246.76 g m^{-2} followed by stations EG12 and EG14 with 24 species, 220 ind m^{-2}, 48.47 g m^{-2} and 22 species, 183 ind m^{-2} and 18.27 g m^{-2}, respectively. While no species could be collected at station EG8, the lowest number of species was found at station EG2 (2 species), and the lowest number of individuals was found at stations EG2 and EG3, with 13 individuals. The highest richness was found at stations EG10 followed by stations EG12 and EG14 proportionally to the number of species and specimens. However, the highest evenness was found at station EG3, and the highest diversity was found at station EG12. After station EG8, the lowest diversity was EG2 (0.81), EG1 (1.55), and EG4 and EG13 stations with values of 1.92.

According to the cluster and n-MDS analyses applied to the total abundance of species, there were no groups with similarity values higher than 50%. Furthermore, station EG8, where no species were identified, and stations EG3 and EG13, which each have four species, exhibit no similarity with the other stations. The SIMPER analysis revealed that, there is only 27% similarity between stations EG2 and EG4, while the remaining eleven stations displayed only 17.20% similarity. The species responsible for this low level of

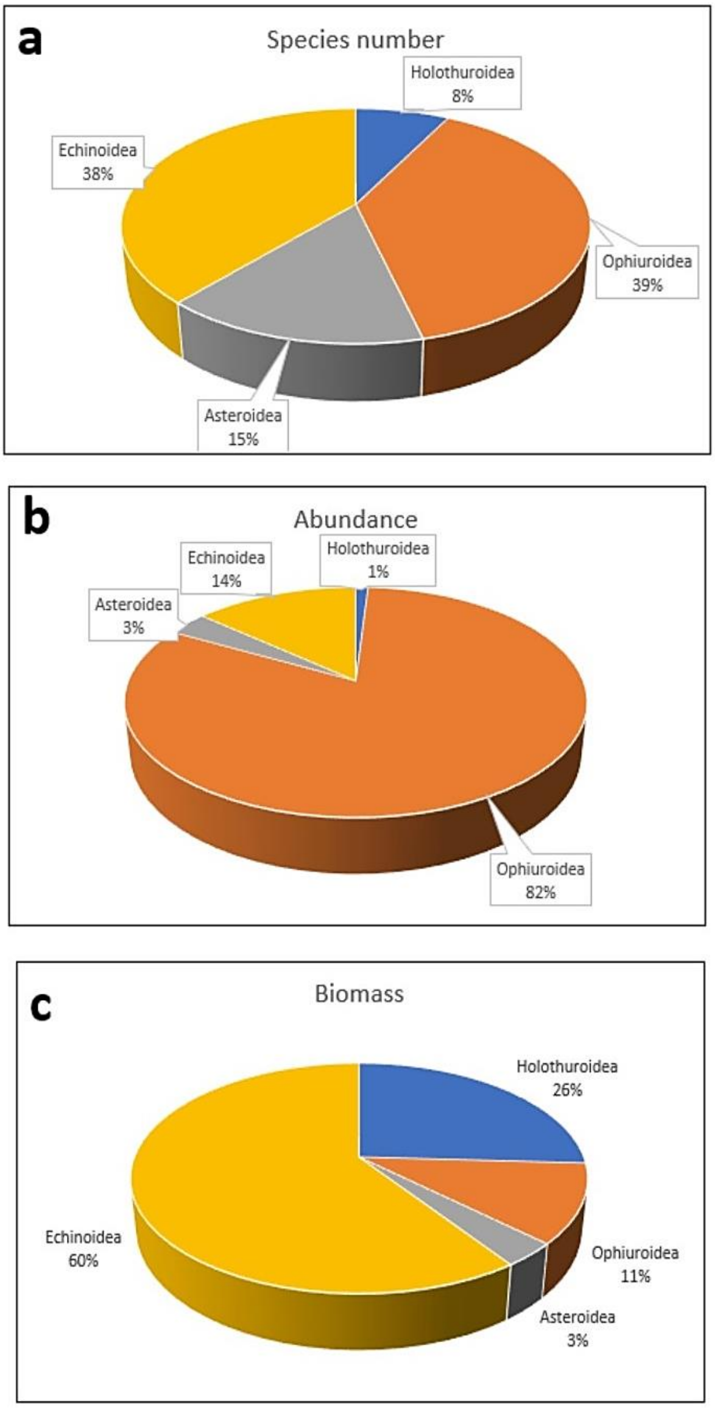

Figure 3. Percent values of **a)** species number, **b)** abundance and **c)** biomass according to the Echinodermata classis.

similarity were also identified as the species with the highest frequency and dominance (*Apseudopsis latreillii*, *Amphiura filiformis*, *Amphiura chiajei* and *Amphipholis squamata*) (Figure 5).

Discussion

Faunistic analyses of the arthropod and echinoderm community in the soft bottom of the Aegean Sea revealed the presence of 81 species, a total of 1563 specimens, and totally 363.75 gr. In this study, amphipods were the dominant group in terms of both number of species and abundance, with a total of 47 species and an average of 45 individuals per m^2. Due to their broad ecological and functional characteristics, amphipods are known as an important taxonomic category in determining the structure of coastal ecosystems (Bellan-Santini, 1998, Scipione et al., 2005, Aslan-Cihangir & Pancucci-Papadopoulou, 2011a, Aslan & İsmen, 2019). Decapods, which are the second group with the highest number of species (18 species), were found to have a biomass of 19 g, which is less than all the classes of the phylum Echinodermata except the class Asteroidea. Aslan-Cihangir & Pancucci-Papadopoulou, (2011b) reported that the decapod fauna of the Canakkale Strait has a large population of very small individuals during the summer months. In this study, species *C. savignyi* and *A. latreillii*, belonging to the order Tanaidacea (313 individuals), the most abundant order after Amphipoda, are the two quantitative dominance species of the entire study. These two species were reported as predominant in sediments with rich organic matter (Grall & Glemarec, 1997, Chintiroglou et al., 2004, Aslan-Cihangir & Pancucci-Papadopoulou, 2011a). *Amphiura chiajei*, an infaunal species that lives as a detritivorous suspension

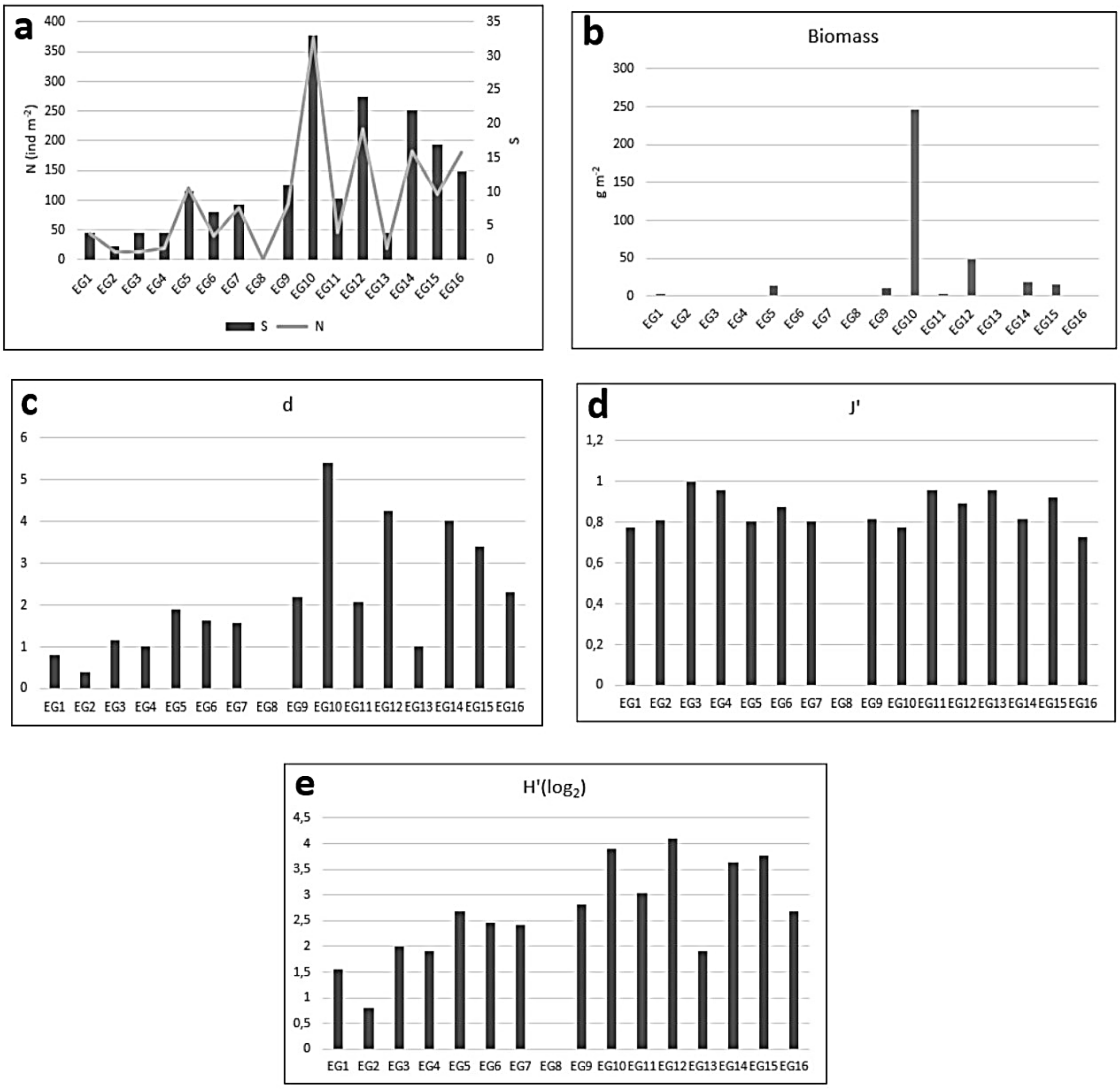

Figure 4. a) Species number (S), Abundance (N); **b)** Biomass; **c)** Margalef Richness (d), **d)** Pielou Evenness (J'); and **e)** Shannon-Wiener Diversity (H') index values obtained in stations.

feeder in mud and muddy sands where organic matter enrichment is recorded, was one of the species with the highest frequency and dominance in this study (Munday & Keegan, 1992; Sköld & Gunnarson, 1996; Aslan-Cihangir & Pancucci-Papadopoulou, 2012). This species, recorded at a total of six stations in this study, was not observed in Güllük Bay, which is known to be exposed to an elevated organic matter load due to aquaculture and tourism activities. However, Bengil et al., (2013) reported a density of 3-70 individuals m^{-2} in Güllük Bay, which was sampled during 2009. Furthermore, Aslan-Cihangir & Pancucci-Papadopoulou (2012) reported that the abundance of *A. chiajei* per sample ranged between 3 and 20 individuals m^{-2} from the Canakkale Strait. The monitoring of bioindicator species such as *A. chiajei* on coasts subject to anthropogenic pressure is of significant importance, as they provide immediate and expedient insight into organic matter enrichment. On the other hand, cumaceans may also be used to determine high eutrophication levels, because their abundance increases with higher organic matter content (Corbera & Cardell, 1995; Aslan-Cihangir & Pancucci-Papadopoulou, 2011a). As it is the third crustacean order with the highest number of species in this study. The Mysid order, which includes epibenthic species, was represented only by one species for the whole study since it could not be sampled by grab (Lourido et al., 2008; Aslan-Cihangir & Pancucci-Papadopoulou, 2011a).

The decapod crustaceans, which constituted only 12% of the total arthropod abundance obtained from all stations, represented 96% of the biomass. Similarly, the echinoids, which constituted only 14% of all echinoderms, represented 60% of the biomass. The presence of large-sized species in the field can facilitate the acquisition of preliminary fundamental data regarding the organic matter load (Pearson & Rosenberg, 1978).

G. sophiae, obtained in Bozacada as a new record for the Turkish coast of the Aegean Sea from the soft substrate at a depth of 47 m, as reported by Bakır et al.,

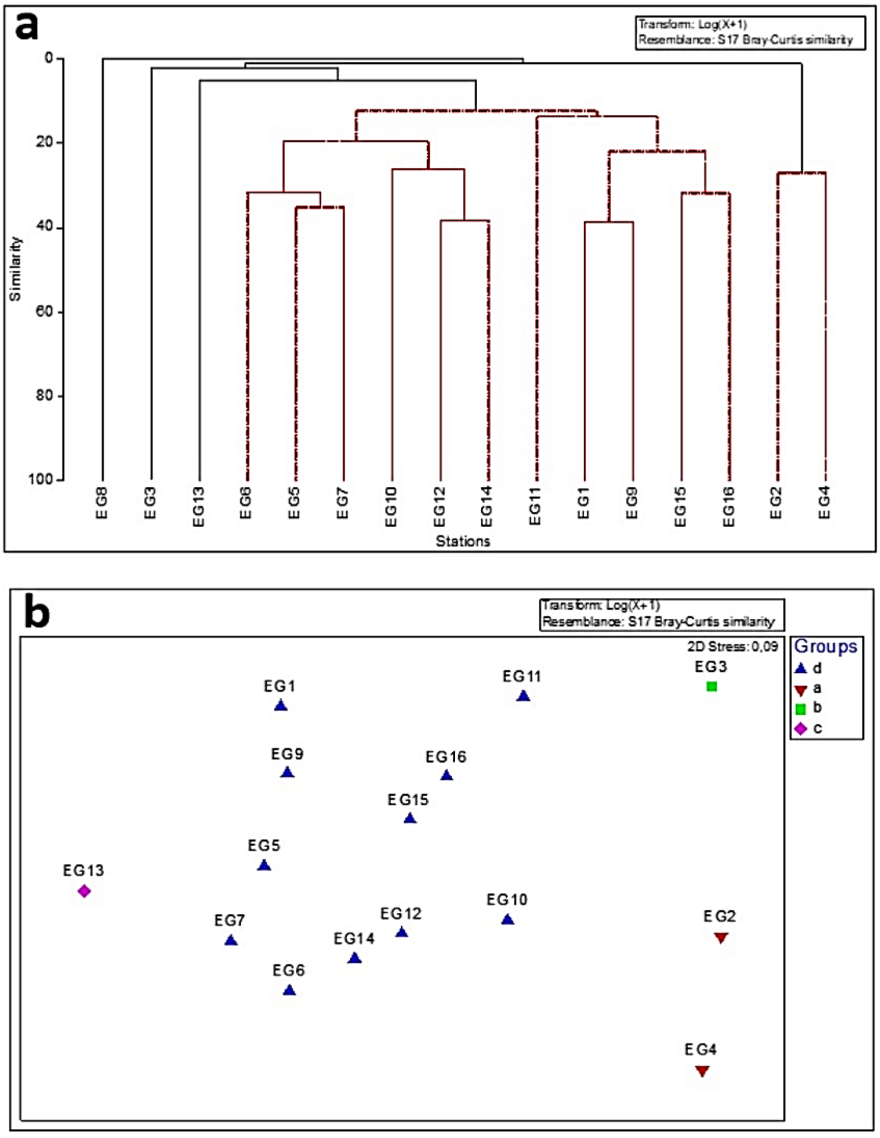

Figure 5. Benthic Arthropoda and Echinodermata community similarity based on the total species abundance of the stations a) Bray-Curtis similarity dendogram, b) n-MDS analyses, except station EG8.

(2014) from the Mediterranean coast of Türkiye from a hard substrate between 1-3 m depths and the same species was reported from the Marmara Sea by Mülayim (2021), between 33-60 m depths with mud and fine sand structures. *A. cherbonnieri*, an ophiroid species reported only from the Dardanelles in Türkiye (Aslan-Cihangir & Pancucci-Papadopoulou, 2012), was also reported from Ildır Bay in this study.

The results of the sampling carried out at a total of 16 stations revealed significant fluctuations in the number of species and species density. A total of 33 species and 373 individuals m^{-2} in the phyla Arthropoda and Echinodermata were identified at station EG10 (Çeşme), in contrast to the absence of species at station EG8 (Outer Izmir Bay). Aslan and Ovalis (2023) reported that 40,620 dead individuals m^{-2} of bivalve *Varicorbula gibba* (Olivi, 1792) were detected, based on the same sampling results as in this study. The poor ecological quality of the EG8 (Outer Izmir Bay) Station, exposed to excessive organic load due to agricultural and industrial wastes carried by the Gediz River (Çınar et al., 2012) has caused the excessive abundance of the *V. corbula* species, which is a pollution indicator (Aslan & Ovalis, 2023). The 2014 snapshot of station EG8 with these features demonstrates that it is unsuitable for the survival of any arthropod or echinoderm species. The results of this study indicate a similarity between the low species number (S), number of individuals (N), species richness (d) and species diversity (H) of arthropods and echinoderms obtained from stations in the North Aegean Sea and the community structure of mollusc species reported by Aslan & Ovalis (2023).

Conclusion

Regular monitoring of the zoobenthos community structure of the seas, especially those under the influence of different pollution sources, the assessment of whole benthic communities and their interpretation together with some essential abiotic parameter values are very important for the sustainable management of marine resources. In addition to these holistic studies, which require a great deal of time and expertise, it is also important to identify spatial changes in the qualitative and quantitative characteristics of some indicator taxa in order to understand immediate degradation and take urgent management action.

Ethical Statement

The author have read, understood, and have complied as applicable with the statement on "Ethical Responsibilities of Authors" as found in the Instructions for Authors.

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Author Contribution

All steps in the preparation of this article are entirely the work of the author.

Conflict of Interest

The author declare that they have no known competing financial or non-financial, professional, or personal conflicts that could have appeared to influence the work reported in this paper.

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