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Composition and Seasonal Variation of Macro-benthic Invertebrate Species Caught by Bottom Trawling in Yumurtalık Bight (Iskenderun Bay-Türkiye)

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A R T I C L E I N F O

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A B S T R A C T

This study aims to determine the distribution and species diversity of macro-benthic invertebrates captured by bottom trawling at different depth layers in Yumurtalık Bight, a critical breeding and feeding ground for numerous species. Sampling was conducted monthly between September 2017 and August 2018 at depths of 0–10 m, 10–20 m, and 20–50 m. The lowest water temperature (15.9°C) was recorded at 0–10 m depth in January and the highest (30.13°C) at the same depth in July. Salinity ranged from 36.6 PSU in March to 39.4 PSU in October at 10–20 m depth. A total of 28 macro-benthic invertebrate taxa were identified, 20 at the species level and 8 at the phylum or class level. The majority of identified species belonged to the orders Decapoda (11 species), Stomatopoda (3 species), and Littorinimorpha (2 species). These species were classified into seven different phyla: Arthropoda, Mollusca, Echinodermata, Cnidaria, and Porifera. A significant proportion of the identified species were exotic, primarily of Indo-Pacific origin. The Shannon-Wiener Diversity Index (H') varied by month and depth, peaking at 1.90 in March (20–50 m) and 1.82 in September (0–10 m). The Simpson Dominance Index (D) ranged from 0.19 to 1.0, while the Pielou Index (J') ranged between 0.5 and 0.9 from July to November, dropped sharply in December and January, and increased again from April to June. According to the Soyer Dominance Index, the most abundant species were *Charybdis (Archias) longicollis* (13.13%), *Sepia officinalis* (12.12%), *Erugosquilla massavensis* (11.62%), *Loligo vulgaris* (11.11%), and *Penaeus semisulcatus* (11.11%). The Shannon-Wiener Diversity Index (H'), Simpson Dominance Index (D), and Pielou's Evenness Index (J') showed no statistically significant differences across depths and months, indicating a generally homogeneous ecological structure in the Yumurtalık Bight.

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Introduction

Benthic invertebrates in marine ecosystems represent the third link in the marine food chain, following phytoplanktonic and zooplanktonic organisms. Similar to phytoplankton and zooplankton, benthic invertebrates play a crucial role in the transformation of organic matter in the marine environment and constitute an essential component of the diet of various fish species (Özel, 1998). The species composition, biomass values, and seasonal variations of benthic invertebrates, as well as certain key species, are considered important ecological indicators that reflect the trophic structure, water quality, and pollution levels in marine environments. Following the opening of the Suez Canal, a migration of species from the Red Sea to the Mediterranean Sea started, leading to the introduction of numerous Indo-Pacific species into the Mediterranean (Mater et al., 1995). Biological invasions of alien species are currently a major environmental problem in the Mediterranean. The main routes for the introduction of alien organisms are via the Suez Canal, aquaculture and hull fouling and/or ballast water from ships. Maritime traffic along the Turkish coast and in the Mediterranean Sea has increased in recent years (Galil et al., 2008; Özcan et al., 2010). The total numbers of confirmed alien species in the Mediterranean ecosystem approaches 1000, of which 751 are established taxa, 242 are accidental taxa, and 23 species are considered unsuccessful introductions (Zenetos et al. 2022). This phenomenon has induced significant ecological changes, prompting numerous studies on its impacts. In recent years, the introduction of non-native species into the Mediterranean ecosystem has accelerated, leading to substantial ecological and economic consequences. In general, decapod and stomatopod crustaceans are one of the most valuable resources of the world trawl fishery. Commercially important crustaceans are generally caught off the Levantine coast of Turkey, particularly in the Iskenderun Bay (Özcan et al., 2016). Yumurtalık Bight, located on the northwestern coast of Iskenderun Bay, is believed to be highly influenced by the influx of Indo-Pacific species. However, comprehensive studies on the macro-benthic fauna of Yumurtalık Bight scarce. Additionally, the region supports a commercial fishery for invertebrate species such as shrimp, crabs, and squid. This study aims to identify the macro-benthic invertebrate fauna collected by bottom trawling at various depth layers in Yumurtalık Bight, a critical breeding and feeding ground for numerous marine species, especially fish. In addition, it seeks to examine species distribution, analyze the diversity of macro-benthic organisms, and evaluate the ecological quality of the benthic community in the region. The high species diversity observed in the Mediterranean is thought to be attributed to the region's complex geological history and fluctuating environmental conditions, which have driven a high rate of speciation. The endemism rate in the Mediterranean is estimated to constitute approximately 25% of the entire Mediterranean biota (Bianchi and Morri, 2000). Considering the increasing introductions of non-native species in recent years and their ecological and economic impacts, research aimed at monitoring and understanding these changes has been expanding and gaining increasing importance. Yumurtalık Bight, located in the northeastern Mediterranean within the Gulf of Iskenderun, harbors a rich diversity of fish and invertebrate species. Other than the study conducted by Başusta et al. (2002), no previous research has been identified in this region. By offering essential baseline data, this study is expected to inform and support future ecological monitoring initiatives.

Materials and Methods

Between September 2017 and August 2018, monthly trawl surveys were carried out randomly in stratified layers in Yumurtalık Bight with a 5.83 m long, 32HP research vessel named "Observation" belonging to Çukurova University Fisheries Faculty registered at Yumurtalık Fishermen's Harbor. Samples were collected from 0-10, 10-20, 20-50m depths with a total of 3 tows of 30 minutes each and the towing speed of the boat was fixed at 2.1 knots (Figure 1). Trawling operations were carried out with the permission of the Ministry of Agriculture and Forestry. During the operation, physico-chemical parameters of seawater, such as temperature, salinity, dissolved oxygen (O_2), and pH, were measured using a Conductivity, Temperature, Depth (CTD) profiler. The total catch values obtained in each of the operations were recorded by weighing the total catch values of the invertebrate groups. If the number of samples was small, the whole sample was taken; if the number was large, a sub-sample was taken as described by Holden and Raitt (1974). The samples were anesthetized on ice and brought to the laboratory. Information about the weight and number of sub-samples, duration of the operation, vessel records (engine power, etc.), and net used and fishing area were recorded. In the laboratory, the sub-samples were separated according to species; individuals were counted in numbers and their weights were taken and noted. According to Avşar (2005), the data obtained from the sub-sample will be reflected to the total by simple proportion. Alvarez (1968), Falciai and Minervini (1996), Fischer et al. (1987a; 1987b), Tachet et al. (2003) and DecaNet (World List of Decapoda), WORM (World Register of Marine Species) websites were also utilized for invertebrate identification. The Shannon Index proposed by Magurran (2004) and Pielou (1975) regularity values were used.

Bay's species diversity index Shannon-Wiener (H') =Σ Pi* log Pi

Pi = Ni/N, Ni is the number of individuals of the i "th species;

N, total number of individuals was determined with the formula

The dominance index formula of Simpson (1949) was used to determine the dominance level. $D=\sum(ni\ (ni\text{-}1)/N(\text{N-}1))$ (ni : number of individuals of species i, N: total number of individuals). The frequency index of Soyer (1970) was used to determine the frequency of the species obtained from the stations. F=m/M x 100 (m: number of samples containing a single species, M: total number of samples), FI > 20% Very Common (Dominant), FI 10-20% Common (Subdominant), FI 5-10% Moderate Common, FI < 5% Rare (Ben-Tuvia, 1966; Gray, 2000). The Pielou's Evenness Index (J′) proposed by Pielou (1975) was calculated using the formula:

J′= H' /ln(S).

Where J′ is Pielou's Evenness Index, H′ is the Shannon-Wiener Diversity Index, S is the Total number of species, and ln(S) is the Natural logarithm of the total number of species

The Shannon-Wiener diversity index (H'), Simpson's Dominance index (D) and Pielou index (J') calculations were calculated using the PAST3 statistical software package (Hammer et al. 2001). All other statistical analyses were conducted using the SPSS software package.

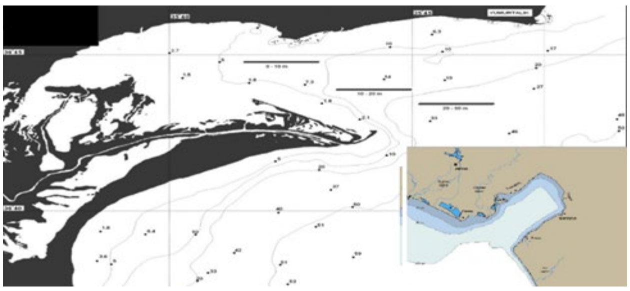

Figure 1. Study area (Yumurtalık, Bight Iskenderun Bay)

Results

Some physico-chemical measurements of seawater were taken from the sampling sites every month and shown in Table 1. The water temperature fluctuated during the year, the lowest temperature was measured at 0-10 m depth (15.9 °C) in January and the highest value was measured in July (30.13 °C) at the same depths.

Table 1. Physico-Chemical Parameters of Seawater

Month	Stations	Temperature (ºC)	Salinite (Psu)	pH	DO mg/L
	1	30.13	38.95	7.49	6.17
July	2	27.00	38.46	6.99	6.49
	3	24.63	38.00	7.77	5.73
	1	29.15	38.69	8.54	5.99
August	2	28.21	38.10	8.46	6.00
	3	28.29	38.10	8.46	6.00
	1	27.27	38.27	8.24	6.17
September	2	28.38	38.68	8.27	6.36
	3	28.75	38.50	8.25	6.18
	1	24.87	37.96	7.93	6.51
October	2	26.30	39.49	8.19	6.22
	3	24.46	38.40	7.97	6.28
	1	21.66	38.55	8.26	6.93
November	2	22.41	38.40	8.56	6.79
	3	22.33	38.68	8.18	6.68
	1	16.44	38.80	6.75	7.77
December	2	19.17	38.34	6.56	7.29
	3	19.25	38.01	6.24	7.13
	1	15.93	38.15	5.63	7.75
January	2	17.97	38.07	5.10	7.72
	3	17.91	37.92	5.13	7.37
	1	16.53	37.85	6.99	8.64
March	2	16.40	36.65	6.86	8.66
	3	16.88	37.72	6.69	4.10
	1	16.63	38.09	8.10	9.08
April	2	17.36	37.85	8,06	8.03
	3	17.45	37.38	7,98	7.29
	1	23.97	37.54	9,86	5.74
May	2	22.83	37.83	10.01	7.59
	3	19.14	37.41	10.11	8.50
	1	25.20	38.01	9.26	7.11
June	2	25.11	37.68	9.36	11.80
	3	25.74	37.64	9.07	6.58

When the annual average salinity values according to the depth levels are analyzed, the lowest value (36.6 Psu) was measured in March and the highest value (39.4 Psu) was measured in October at 10-20 m depth DO mg/L.

As given in Table 2, 20 of the 28 macroinvertebrates caught by trawling during the study period were identified at the species level and 8 of them were identified at the branch or class level. The majority of the species belong to the orders Decapoda (11), Stomatopoda (3) and Littorinimorpha (2). It was determined that the species were members of 7 orders, namely Arthropoda (Arthropods), Mollusca (Molluscs), Echinodermata (Echinoderms), Cnidaria (Cnidarians), Porifera (Sponges). The detected individuals belong to Bivalvia, Gastropoda, Scyphozoa, Malacostraca, Cephalopoda classes. *Carcinus aestuarii* belonging to the order Decapoda is a native species of the Mediterranean and the other 10 species are exotic species. The exotic species are Indo-pacific species except two Atlantic species. The other two species are exotic, except *Rissoides desmaresti*, which belongs to the order Stomatopoda. The 3 species of Mollusca are Atlantic, 2 species are Indo-pacific and *Octopus vulgaris* is global.

As seen in Table 3, *P. segnis*, *C. longicollis*, *C. sapidus*, *P. semisulcatus*, *M. monoceros*, *P. kerathurus*, *E. massvensis*, *C. albolitura*, *S. officinalis*, *L. vulgaris* species and individuals belonging to Bivalvia, Cnidaria and Echinodermata were obtained from all stations. *I. monodi*, *C. aestuarii*, *M. stebbingi*, *T. galea*, *C. persicus* species and individuals belonging to Nudibranchia, Gastropoda, Porifera were caught from only one station.

During the study period, the highest number of individuals (2772) was obtained from 20-50 m depth, followed by 0-10 m shallow zone with 1665 individuals (Table 3).

The Crustacea class of the Arthropoda branch has the highest number of individuals from all depth zones, followed by Cephalopoda, Bivalvia, Gastropoda classes of the Mollusca branch. Specimens of Echinodermata and Porifera were not caught at 0-10 m, followed by 4% and 0.04% after 20 m depths, respectively. Cnidaria specimens were obtained from all depth zones, with the highest occurrence at 10-20m (Figure 2).

The values of Shannon-Wiener diversity index (H'), Simpson dominance index (D) and Pielou index (J') calculated according to months and depths during the study period are given in figures 3, 4, 5.

The Shannon-Wiener Diversity Index (H') fluctuates during the year depending on the months and depths. In January, the (H') index decreased almost to zero in the 10-20m zone. The highest index was calculated in March in the 20-50m zone (1.90) and then in September in the 0-10m zone (1.82). The differences between months (Kruskal-Wallis Chi-Square = 14.602, df = 10, p = 0.147) and depths (Kruskal-Wallis Chi-Square = 1.845, df = 2, p = 0.397) were not significant.

Table 2. Species and Distribution

Species	Pyhlum	Clasis	Order	Distribution
Portunus segnis (Forskål, 1775)	Arthropoda	Malacostraca	Decapoda	Indo-Pacific, Mediterranean
Charybdis (Archias) longicollis Leene, 1938	Arthropoda	Malacostraca	Decapoda	Indo-Pacific, Mediterranean
Callinectes sapidus Rathbun, 1896	Arthropoda	Malacostraca	Decapoda	Atlantic, Mediterranean
Ixa monodi Holthuis & Gottlieb, 1956	Arthropoda	Malacostraca	Decapoda	Indo-Pacific, Mediterranean
Myra subgranula Kossmann, 1877	Arthropoda	Malacostraca	Decapoda	Indo-Pacific, Mediterranean
Carcinus aestuarii Nardo, 1847	Arthropoda	Malacostraca	Decapoda	Mediterranean, East Atlantic
Penaeus semisulcatus De Haan, 1844	Arthropoda	Malacostraca	Decapoda	Indo-Pacific, Mediterranean
Metapenaeus monoceros (Fabricius, 1798)	Arthropoda	Malacostraca	Decapoda	Indo- west Pacific, South Atlantic
Metapenaeus stebbingi Nobili, 1904	Arthropoda	Malacostraca	Decapoda	Indo-Pacific
Metapaneus kerathurus (Forskål, 1775)	Arthropoda	Malacostraca	Decapoda	Atlantic, Mediterranean
Metapenaeopsis aegyptia Galil & Golani, 1990	Arthropoda	Malacostraca	Decapoda	Indo West Pacific
Erugosquilla massavensis (Kossmann, 1880)	Arthropoda	Malacostraca	Stomatopoda	Indo-Pacific
Clorida albolitura Ahyong & Naiyanetr, 2000	Arthropoda	Malacostraca	Stomatopoda	Indo-west Pacific
Rissoides desmaresti (Risso, 1816)	Arthropoda	Malacostraca	Stomatopoda	North Atlantic Mediterranean
Sepia officinalis Linnaeus, 1758	Mollusca	Cephalapoda	Sepiida	East Atlantic, Mediterranean
Loligo vulgaris Lamarck, 1798	Mollusca	Cephalapoda	Myopsida	East Atlantic, Mediterranean
Octopus vulgaris Cuvier, 1797	Mollusca	Cephalapoda	Octopoda	Global
Tonna galea (Linnaeus, 1758)	Mollusca	Gastropoda	Littorinimorpha	Indo Pacific, Atlantic Ocean, East Atlantic, Mediterranean
Hexaplex turunculus (Linnaeus, 1758)	Mollusca	Gastropoda	Neogastropoda	East Atlantic, East Atlantic, Mediterranean
Conomurex persicus (Swainson, 1821)	Mollusca	Gastropoda	Littorinimorpha	West Indian Ocean
Other	Mollusca	Gastropoda	Nudıbranchia	
	Cnidaria	Scyphozoa		
	Porifera			
	Echinodermata			

Table 3. Number of Individuals Obtained from Sampling Depths

Species	0-10m	10-20m	20-50m
Portunus segnis (Forskål, 1775)	298	51	6
Charybdis (Archias) longicollis Leene, 1938	17	71	1085
Callinectes sapidus Rathbun, 1896	294	15	26
Ixa monodi, Holthuis & Gottlieb, 1956	10	-	16
Myra subgranula Kossmann, 1877	-	-	4
Carcinus aestuarii Nardo, 1847	-	1	-
Penaeus semisulcatus De Haan, 1844	121	37	418
Metapenaeus monoceros (Fabricius, 1798)	52	8	136
Metapenaeus stebbingi Nobili, 1904	393	-	-
Metapaneus kerathurus (Forskål, 1775)	2	1	3
Metapenaeopsis aegyptia Galil & Golani, 1990	-	-	8
Erugosquilla massavensis (Kossmann, 1880)	164	287	207
Clorida albolitura Ahyong & Naiyanetr, 2000	2	3	7
Rissoides desmaresti (Risso, 1816)	6	2	-
Others	14	6	6
Sepia officinalis Linnaeus, 1758	34	75	57
Loligo vulgaris Lamarck, 1798	241	169	636
Octopus vulgaris Cuvier, 1797	-	-	5
Tonna galea (Linnaeus, 1758)	-	1	-
Hexaplex turunculus (Linnaeus, 1758)	-	1	1
Conomurex persicus (Swainson, 1821)	2	-	-
Other (Gastropoda)	-	-	24
Bivalvia	10	1	11
Nudibranchia (Gastropoda)	-	-	3
Cnidaria	1	6	7
Porifera	-	-	1
Echinodermata	4	30	105
Total	1665	765	2772

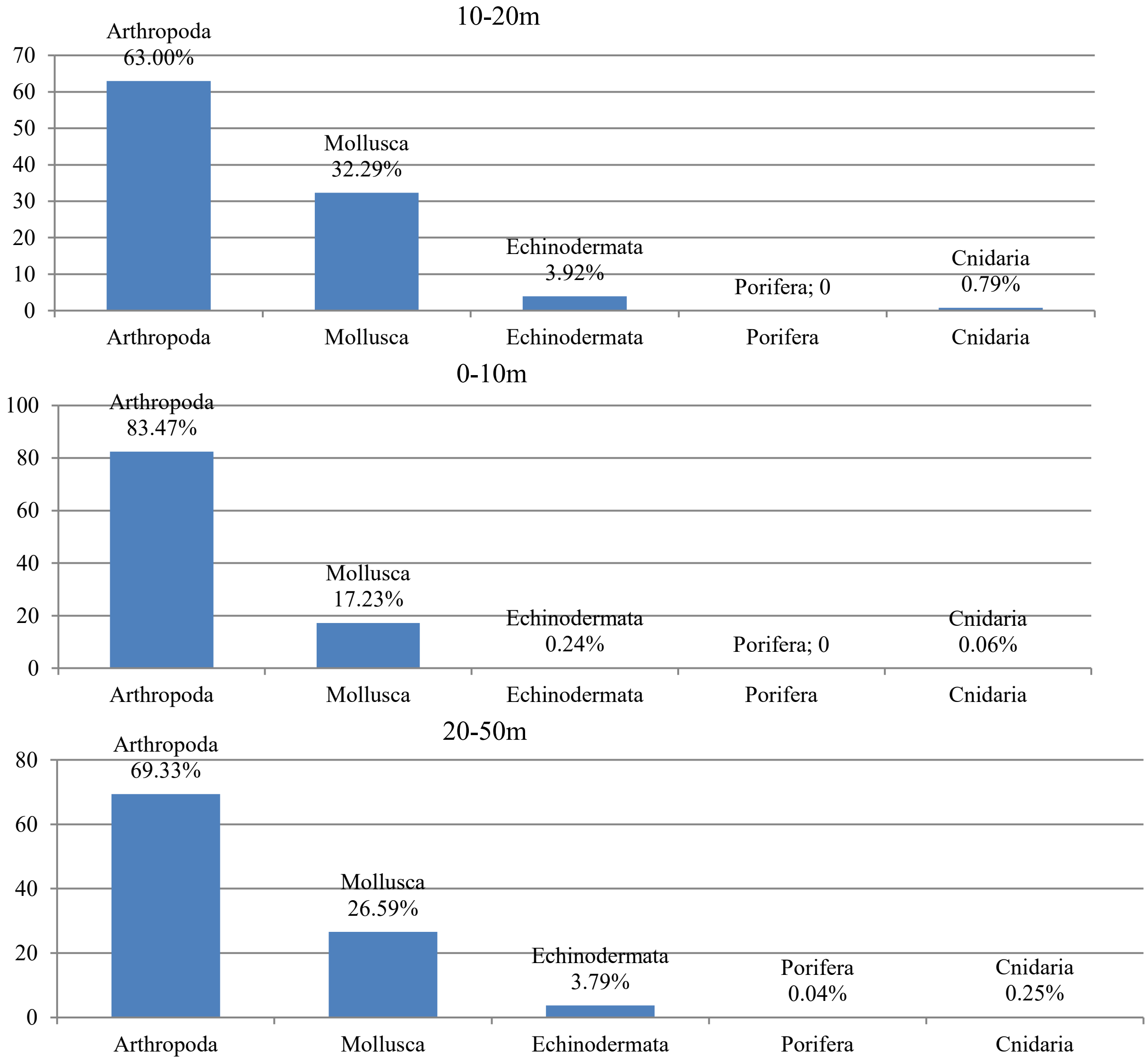

Figure 2. Distribution of Phylum by Obtained from Sampling Depths

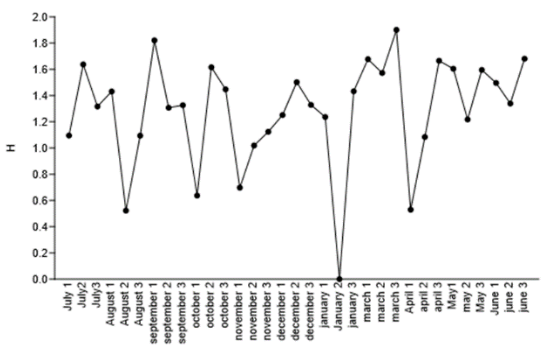

Figure 3. Shannon-Wiener Diversity Index (H') Calculated by Months and Depths

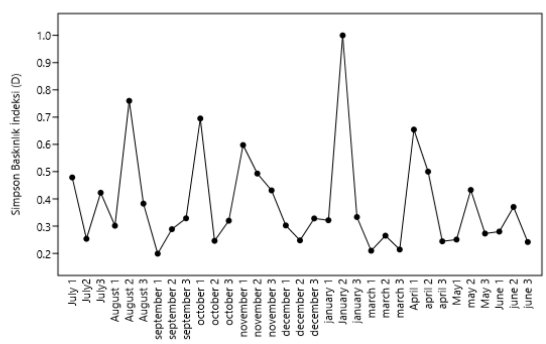

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Figure 4. Simpson Dominance Index (D) Calculated by Months and Depths

Simpson dominance ratio (D) varied between 0.19 and 1.0. The lowest was found in the 0-10m depth zone in September and the highest was 20-50m in January (Figure 4). A more balanced distribution (D ≈ 0.3-0.5) is observed in the months other than August 10-20m, October, November and April 0-10m depth zones. In summer (July, August), the dominance is moderate (D ≈ 0.3-0.6), while in autumn (September, October, November) the dominance increases. In winter (December, January, February) (D ≈ 1), sudden increases in dominance are observed at some times. Dominance decreases in spring (March-April-May). Shapiro-Wilk test was applied for normality test. According to the results, the data for the variable D for January are not normally distributed (Shapiro-Wilk = 0.76, p = 0.003).

Table 4. Soyer Frequency Index Values of Species according to Stations

Species	0-10m	10-20m	20-50m	Total	FI(%)
C.longicollis	6	9	11	26	13.13
S.officinalis	7	9	8	24	12.12
E.massavensis	7	9	7	23	11.62
L.vulgaris	4	9	9	22	11.11
P. semisulcatus	6	5	11	22	11.11
P. segnis	11	5	3	19	9.60
C.sapidus	6	3	4	13	6.57
P.monocerus	2	2	6	10	5.05
P. kerathurus	1	1	5	7	3.54
C. albolitura	1	2	3	6	3.03
I. monodi	1	0	5	6	3.03
M. aegyptia	1	0	5	6	3.03
R.desmaresti	2	1	0	3	1.52
O.vulgaris	0	0	3	3	1.52
M. granulata	0	0	2	2	1.01
H. turunculus	0	1	1	2	1.01
M.stebbingi	1	0	0	1	0.51
T.galea	0	1	0	1	0.51
C. aestuarii	0	1	0	1	0.51
C. percicus	1	0	0	1	0.51

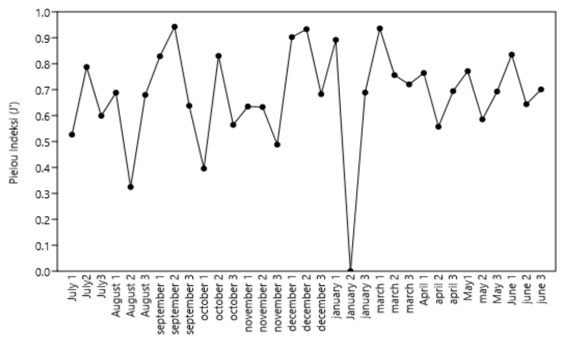

Figure 5. Pielou Index (J') Calculated by Months and Depths

According to the depths, 0-10 and 10-20m values are not normally distributed since they are less than 0.05 (Shapiro-Wilk = 0.85; 0.80, p = 0.04; 0.01). According to the Kruskal-Wallis test results, no significant difference was found in the distribution of the D variable between months (Chi-Square = 13,098, df = 10, p = 0,218). Therefore, it is accepted that the variable does not differ between months. This finding indicates that the effect of months on the D variable is not significant. The difference between depths was also not significant (H=1.035, df=2, p=0.596).

Figure 5 shows that the Pielou Index (J') generally varies between 0.5 - 0.9 in July - November and there are sudden decreases in December - January (J' ≈ 0). Although there are decreases again in February - March, it is observed that the value (J') increases in April - June. Shapiro-Wilk test was applied for normality test. According to the results, the variable J is not normally distributed in August (Shapiro-Wilk = 0.768, p = 0.03) and November (Shapiro-Wilk = 0.760, p = 0.02). According to the depths, 20-50 m values are not normally distributed because they are less than 0.05 ((Shapiro-Wilk = 0.825, p = 0.02, 0.01). The variation of Pielou regularity values according to months and depths in the study area was not statistically significant (Kruskal Wallis Test, Chi-Square = 12.42, df = 10, p = 0.258) (Kruskal Wallis Test, Chi-Square = 2.610, df = 2, p = 0.271).

According to the Soyer Frequency Index, *C. longicollis* (13.13%), *S. officinalis* (12.12%), *E. massavensis* (11.62%), *L. vulgaris* (11.11%) and *P. semisulcatus* (11.11%) are the most common species. This was followed by *P. segnis* (9.60%), *C. sapidus* (6.57%), *P. monocerus* (5.05%) as medium common species (relatively frequent). *M. stebbingi*, *T. galea*, *C. aestuarii*, *C. percicus* with FI 0.50%, *M. granulata* with 1.01%, *O. vulgaris* with *H. turunculus* (1.01%), *R. desmaresti* (1.51%) are considered rare species (table 4).

Discussion

During the study period, significant fluctuations were observed in water temperature and salinity values. Temperature showed the lowest value with 15.9°C in January and the highest value with 30.13°C in July. Salinity was lowest in March (36.6%) and highest in October (39.4%). Kumlu et al. (1999) investigated some biological characteristics of *Penaeus semisulcatus* and *Metapenaeus stebbingi* by trawling at depths of 5-30 m in Yumurtalık Bight. They reported that the salinity was slightly higher in summer (38.8-39.6 ppt) than in winter (36.5-38.2 ppt) and the temperatures ranged between 25.3 and 28.2°C in summer, between 24 and 27°C in fall and between 15.2 and 17.5°C in winter. Similar values were also reported by Başusta et al. (2002). When compared with these values, it is seen that temperatures were 1-2 °C higher in all seasons during the study period. Salinity values were low for the summer period and high for the winter period. Kumlu et al. (1999) found that during the whole study period, only two penaeid shrimp species, *P. semisulcatus* and *M. stebbingi*, dominated the catch and in May 1995, *P. semisulcatus* accounted for more than 85% of the total shrimp catch. *M. stebbingi* was reportedly never caught during the winter months. Only a few individuals of *M. monoceros* were caught during the study period. As current results, they reported that only two commercially important Penaeid shrimp species, *P. semisulcatus* and *M. stebbingi*, live at depths of 5-30 m in Yumurtalık Bight and only a few specimens of *M. monoceros* were caught. While both species were abundant during the warmer months (May-September), *M. stebbingi* was not caught in the bay during October-January and probably migrated to deeper and warmer waters when the temperature dropped. Similar to this study, *P. semisulcatus* was found to be the common species and *M. stebbingi* was caught only in August and not in other months. However, contrary to this study, *M. monocerus* was observed in the catch except in winter. According to Soyer frequency index, it was determined as a medium common species. Başusta et al. (2002) conducted trawling in the same area between May 1996 and April 1997 for about 30 minutes at depths of 5-30 m. In the study, 29 bony and 4 cartilaginous fish species belonging to 25 families, 4 of which were lesepsian, and 7 invertebrate species were obtained by using bottom trawl. Invertebrates constituted 45.5% of the total biomass and *C. sapidus* was the highest with 39.74%. They stated that blue crabs are in a good feeding and breeding environment in the bay. *P. semisulcatus* was obtained during four seasons. Invertebrate species obtained in the study were *Loligo vulgaris*, *Octopus vulgaris*, *Sepia officinalis*, *Squilla mantis*, *Callinectes sapidus*, *Penaus semisulcatus*, *Metapenaus stebbingi*. According to the results reported above, quite a large number (n=20) of macro-invertebrate species were identified from the same region. However, the most striking point is that *S. mantis*, one of the endemic species, could not be sampled during the whole study. This species was replaced by 2 indo-pacific Stomatopoda species. Especially *E.massavensis* was determined as the common and dominant species. In addition, *C. sapidus* species lost its dominance and was replaced by indo-pacific decapoda species (Table 4). As a result of a project carried out between April 2005 and December 2017 to determine the seasonal availability of some aquatic invertebrates caught by bottom trawling in the coastal area of Yumurtalik in Iskenderun Bay (between Yumurtalık and Botaş), a total of 84 taxa were identified, of which 29 were molluscs, 24 were crustaceans and 17 were classified in other invertebrate groups (Manaşırlı et al., 2019). They reported that 44 of these species were indigenous (AM), 23 were leprosy (L), 12 were uncertain (NA) and 5 were (C) species. They were determined to be members of 7 phyla: Mollusca, Arthropoda, Echinodermata, Cnidaria, Chordata, Porifera, and Bryozoa. The percentage distribution of phylum was determined as 39% Mollusca and 33% Arthropoda. Quite a lot of species were reported from our study results. It can be thought that this is due to the fact that the sampling period covers a very long period of time as well as covering all invertebrates. In addition, unlike the above-mentioned researchers, the majority of the macroinvertebrate species identified in Yumurtalık Bight in this study were Arthropoda species.

The Shannon-Wiener Diversity Index (H') calculated during this study showed a fluctuating trend depending on the months and depths during the year. In January, the H' index decreased almost to zero in the 10-20m zone, suggesting a serious degradation in the ecosystem. However, the H' index then increased again (the highest index reached in March in the 20-50m zone (1.90)), suggesting that the ecosystem has the capacity to recover. The second peak was calculated in September in the 0-10m zone (1.82). The fact that the H' index becomes more balanced after March, which is relatively more balanced in spring and summer, may indicate that the ecosystem has adapted to seasonal changes and that species diversity has stabilized. It is thought that the fluctuation of the H' index over time may be due to factors such as seasonal changes in the ecosystem, migrations, temperature fluctuations or changes in the number of resources. Simpson's dominance ratio (D) varied between 0.19 and 1.0. The lowest was found in September at a depth of 0-10m and the highest was 20-50m in January (Figure 4). Especially in January, *C. longicollis* is the most common species as a single individual from the indicated depth station. In summer months (July, August) the dominance is moderate ($D \approx 0.3$-0.6). In autumn months (September, October, November) the dominance increases. In winter (December, January, February) ($D \approx 1$), there are sudden increases in dominance at some times. It is thought that this is again due to the fact that *C. longicollis* is the most common species. In spring (March-April-May), dominance decreases and species diversity increases in the region. In July - November, the Pielou Index (J') generally varies between 0.5 - 0.9 and there are sudden decreases in December - January ($J' \approx 0$). Although decreases are observed again in February - March, it is observed that the value increases in April - June (J'). Periods of High Equivalence ($J' \approx 0.7$-1.0) are in August - November and February - April. Especially before December - January, diversity seems to be balanced. The Periods of Low Equivalence ($J' \approx 0$-0.4) are in January and March, when $J' = 0$, i.e. dominance is increased. This is consistent with the periods when the dominance index (D) is highest. The Shannon-Wiener Diversity Index (H'), Simpson Dominance Index (D), and Pielou's Evenness Index (J') calculated for the study area were not found to show statistically significant differences in macroinvertebrate biodiversity and evenness across depth layers and months. These results suggest that the study area may exhibit a generally homogeneous ecological structure. As a result of the Soyer frequency index, *C. longicollis* (13.13%), *S. officinalis* (12.12%), *E. massavensis* (11.62%), *L. vulgaris* (11.11%) and *P. semisulcatus* (11.11%) were the most common species. The dominance of *C. longicollis* as a leading species suggests that it may possess a higher tolerance to environmental stress conditions. However, this finding was not observed in the study conducted by Kumlu et al. (1999) in the same region. In their study, which included both bony and cartilaginous fish species in the assessment, the reported Shannon-Wiener diversity index (H') was 3.41, a considerably higher value. This discrepancy may be attributed to methodological differences and variations in the taxonomic groups targeted in the respective studies. Similarly, Manaşırlı et al. (2019) found no statistically significant variation in the Shannon-Wiener and Pielou evenness indices at 10 m and 20 m depth zones in their study conducted in the Yumurtalık coastal area. These findings are consistent with the current study and suggest that depth-related biodiversity differences along the Yumurtalık coasts may be limited. Overall, although benthic macroinvertebrate diversity in the study area exhibited seasonal fluctuations throughout the year, these changes were not found to be statistically significant.

Conclusion

In this study, 28 macroinvertebrate species were identified from trawl surveys conducted in 3 different depth zones of Yumurtalık Bight. The majority of them belong to groups such as Decapoda (11 species), Stomatopoda (3 species) and Littorinimorpha (2 species). Most of the detected species are exotic and especially Indo-Pacific species are seen to be prominent. This result is in parallel with the warming of the Mediterranean Sea. In addition, temperatures were measured 2 °C higher on average compared to previous studies conducted in same region by Kumlu et al (1999) and Basusta et al (2002). Significant fluctuations in water temperature and salinity values were observed during this study. Species of the Crustacea class and the Mollusca order made up the majority of the samples. The Shannon-Wiener diversity index fluctuated throughout the year, dropping to very low levels in January and then rising again, reaching its highest value in March in the 20-50m zone (1.90). However, there was no significant change in macro-invertebrate biodiversity depending on the seasons, and their diversity was similar in the study area depending on depths and months. *C. longicollis* (13.13%), *S. officinalis* (12.12%), *E. massavensis* (11.62%), *L. vulgaris* (11.11%) and *P. semisulcatus* (11.11%) were the most common species in the bay. While one endemic species was detected, the endemic *S. mantis* reported in previous studies was not caught. However, our study has some limitations. Sample size, biomass and CPUE calculations could not be made. However, the results constitute a reference point for future studies and emphasize the need for larger scale research.

Declarations

Ethical Approval Certificate

The material used in this article is invertebrate species therefore ethics committee approval is not required for this study.

Author Contribution Statement

Dr.Canan Türeli: Data collection, investigation, formal analysis, and writing the original draft
Dr.İrem Yeşilyurt: Data collection and investigation
Dr.Erhan Akamca: Data collection and investigation
Dr.Hacer Yeldan: Data collection and investigation

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