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Macrobenthic assemblage structure and distribution at the Boojagh Marine National Park, Southern Caspian Sea, Iran.

Bahrebar S.[1]; Negarestan H.[2]*; Maghsoudlo A.[3]; Danehkar A.[4]

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Abstract

Although macrobenthic assemblages are considered as major players in many ecosystems around the world, the ecology of Caspian Sea macrobenthos is currently understudied. This study describes the species composition and quantitative distribution of macrobenthos in the southern Caspian Sea and relates the distribution to seasonal changes at three depths (1, 5 and 10 meters) on the Boojagh Marine National Park (BMNP) coast in the southern Caspian Sea between the summers of 2015 and 2016. To investigate the distribution of macrobenthos in BMNP, the data of 450 samples were analyzed. In this study sixteen species were identified: *Cerastoderma glaucum*, *Mytilaster lineatus*, *Pyrgula grimmi*, *Anisus kolesnikovi*, *Stenogammarus carausui*, *Paraniphargoides motasi*, *Onisimus caspius*, *Pterocuma pectinatum*, *Pterocuma sowinskyi*, *Pseudocuma (Stenocuma) gracile*, *Nais* sp., *Hypania invalida*, *Manayunkia caspica*, *Streblospio gynobranchiata*, *Hediste diversicolor*, *Amphibalanus improvisus.*
Among them, the non-indigenous *C. glaucum* was the dominant species, accounting for 27% of the total abundance and in descending order *P. grimmi* with 14.4%, *A. improvisus* with 8.7%, *M. lineatus* with 7.9%, *Nais* sp. with 7.5%, *N. carausui* with 5.2%, *P. motasi* with 5%, *S. gynobranchiata* with 4.5%, *H. invalida* with 5%, *M. Caspica* with 3.1%, *P. sowinskyi* with 2.5%, *O. caspius* with 2.4%, *A. kolesnikovi* and *H. diversicolor* with 1.8%, *S. gracilis* with 1.6% and *P. pectinatum* with 1.5% were in the next rank. Significant differences in abundance across the sixteen species were observed among depths and seasons. This study highlights the potential consequences of established non-indigenous species in the southern Caspian Sea.

Keywords: Macrobenthos, Assemblage structure, Boojagh Marine National Park, Caspian Sea.

1-Department of Marine Biology, Science and Research Branch, Islamic Azad University, Tehran, Iran.

2-Department of Fisheries, Tehran North Branch, Islamic Azad University, Tehran, Iran.

3-Department of Marine Science, Iranian National Institute for Oceanography and Atmospheric Science, Tehran, Iran.

4-Department of Natural Resources, College of Agriculture and Natural Resources, University of Tehran, Tehran, Iran.

*Corresponding author's Email: hosseinnegarestan@yahoo.com

Introduction

The Caspian Sea, the largest enclosed body of water on Earth, containing approximately 40% of the global continental water mass, is primarily brackish in composition (Dumont, 1998). The fauna of the Caspian Sea are vulnerable to adverse effects of introductions and invasions of non-native species (Dumont, 2000). Inevitably, the enormous size and diversity of habitats make the Caspian Sea exceptionally suitable for the acclimation and establishment of invasive species and consequently, the displacement of native species (Zenkevitch, 1963).

In a general classification, the Caspian Sea can be divided into three parts: north, middle and south Caspian Sea (Glemarec, 1998; Alizadeh, 2012). The southern part of Caspian Sea has the highest volume of water, approximately 64% of the total volume, and 35% of the total area of the Caspian Sea (Eleftheriou, 2007; Konstantinos and Luczak, 2012). Factors affecting the distribution and abundance of benthic invertebrates are largely continuous and linked together (Clifford, 2005). Because of the importance of the ecological functions of macrobenthos within the marine ecosystem, knowledge on the macrobenthic diversity patterns is indispensable to identify priority areas for conservation and for the adjustment of human activities in the marine zone (Buhr, 1996).

Boojagh Marine National Park (BMNP) with an area of 3260 hectares is a protected area in Astaneh Ashrafieh city, Gilan Province, Iran, and is the first "coastal and terrestrial national park" established in Iran. BMNP covers approximately 1,600 hectares of coastal area, 160 hectares of wetland meadows, and 1500 hectares of terrestrial areas (Safari, 1976; Vosoughi *et al*., 2000). At BMNP due to the variable and diverse environmental conditions a wide range of macrobenthic assemblages might be expected. Due to the importance of its biodiversity a number of researchers focused on the fauna and flora of this National Park (Khara *et al*., 2006; Ashuri *et al*., 2008; Yousefi *et al*., 2013; Coad, 2016). The coastal waters of BMNP are to some extent affected by human activities such as pollutants of the Sefidrood, port of Kiashahr and fishing activities so a benthic study can be an efficient tool to evaluate these impacts (Yousefi *et al*., 2013).

The Caspian Sea ecosystem constitutes a great number of benthic invertebrate species (Curras and Mora, 2004; Bachelet, 2006); according to Gauch and Whittaker (2008) benthos of the Caspian Sea contains 724 species and subspecies. However, the southern Caspian Sea has smaller numbers of benthic species, for example 16 species were identified in the present study.

Tajalipour (1979) in a ten-year study examined the distribution of benthic species along the Iranian coasts of the Caspian Sea in the 1960s. He sampled at depths of 5-200 meters in each station with 10 sampling sites and three replications in each site. In his report most species of mollusca in the south western Caspian coastline were found in depths of 3 to 5 meters. Members of the order Cardiida were distributed mostly in 5 to 7 meter depths; and the distribution of the family Nereididae was mostly limited to depths of 3 to 5 meters. Bagheri (2010) assessed the ecological quality of the macrobenthos of the coastal waters in the southern Caspian Sea. He sampled in 12 stations in autumn 2010 on the shores of the Sysangan area, Caspian Sea, using a Van Veen grab sampler. Generally, 6 families and 8 species of macrobenthos were identified in his study. Also, a study by Hashemiyan (1998) identified a total of 57 groups of macrobenthos including 5 species of gastropoda, 47 crustacea, 4 polychaeta and 1 hirudinea. According to Gasemof (2004) out of 724 species and subspecies of the Caspian Sea benthos, 16 entered the Caspian Sea from the Black and Azov Seas. Hosseini (2005) in a study on the hydrobiology of the Caspian Sea identified 57 species of macrobenthos including 5 species of bivalvia, 47 crustacea, 4 polychaeta and one hirudinea.

Laluey (2000) examined population structure and diversity of macrobenthos in the Caspian Sea and reported that the greatest diversity belonged to amphipoda. In this research, macrobenthos assemblages of Astara in the far western coast of the south Caspian up to Hasangholy in the far eastern south Caspian were analyzed and a total of 192 samples were collected from 16 stations. He identified 41 species of macrobenthos and found that crustaceans, with 14 species, had the highest species richness in this area. He reported that the greatest diversity belonged to amphipoda while Farabi (2009) identified 24 species of macrobenthos with the greatest diversity belonging to polychaeta. Nasrollahzadeh Saravi (2010) and Farabi (2009) also introduced polychaete as the most abundant macrobenthic group in the southern coasts of the Caspian Sea.

Macrobenthos and their associated habitats in the Caspian Sea are, at present, poorly understood. Furthermore, as Thomsen *et al*. (2009) stated, information from the benthic animals of the southern coasts of the Caspian Sea is limited. The aims of this paper are: to characterize structure of macrobenthic assemblages of the BMNP on the southern coasts of the Caspian Sea on the basis of their species composition, their habitat preferences and impact of human activities in the area; and to compare the macrobenthic assemblage structure with similar assemblages in other areas.

Materials and methods

Study area

The study area covers the Boojagh Marine National Park (BMNP) with 15.43 km coastline, located in the southern coasts of the Caspian Sea. Sampling transects were placed 3 kilometers apart and their geographical coordinates were marked on the map at the longitude of 50° 2' 17''E and latitude of 37°27' 50''N (Fig. 1). In each transect 3 stations at depths of 1, 5 and 10 meters were sampled. The number of sampling stations added up to 18 stations for the 6 transects. It should be

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noted that in order to make sure of sampling from the exact site position in each sampling time, land marks of the coastal area were also considered.

Figure 1: Study area and sites of sampling, Boojagh Marine National Park (6 transect; 18 sampling stations).

Sampling

Seasonal samplings were conducted from the summer of 2015 to the summer of 2016 with 5 replications, and all together 450 samples (18 sampling sites per each time) were collected in five seasons.

Method of sampling and analyses

Sediment samples were taken to study the macrobenthos using a Van veen grab with a sampling surface area of 0.22 m^2. Each replicate was placed in a separate container and tagged with transect and sampling station specifications. Then a 73 g L^{-1} solution of magnesium chloride was used to relax the species (Souza and Gianuca, 2005; Elliott, 2006; Holtmann, 2006; Dauvin, 2008; Creutzberg and Wapenaar, 2014).

In the laboratory of Science and Research Branch of Islamic Azad University, the samples were fixed in 10% formalin. In order to identify macrobenthic invertebrates, samples were washed though a 0.5 mm mesh sieve. Specimens of the macrobenthos were sorted and identified with a stereomicroscope and microscope. Identified taxa were kept in 80% ethanol for further reference. Species were identified to the lowest possible level of taxonomy using Birshtain *et al*. (1966) as identification main reference with up to date corrections from World Register of Marine Species (WRoMS) reference website. To evaluate the significant differences of means a one way ANOVA was performed using SPSS 16 software and a post hock test of LSD was used among sites. Also, Microsoft Excel was used for calculating location and dispersion parameters.

Results

Distribution of macrobenthos

Different soft sediment macrobenthic species were distinguished in Boojagh Marine National Park (NBMP) sediments of the Southern Caspian Sea. Overall, in the present study, 16 species, (belonging to 13 families, 12 orders and 5 classes) were identified (Table 1). Most specimens were gathered in the summer of 2015 (30.5%) and summer of 2016 (28.2%). In the summer of 2015, some species such as, *Cerastoderma glaucum*, *Hypania invalida* and *Stenogammarus carausui* were present almost in all depths of transects four, five and six. Some species, such as *Mytilaster lineatus*, *Pyrgula grimmi* and *Nais* sp. not present in transects one, two and three and showed a sparse presence in other sites.

Table 1: Identified species in the 5 seasons from summer 2015 until summer 2016.

Class	Order	Family	Species names
Bivalvia	Cardiida	Cardiidae	*Cerastoderma glaucum*
	Mytilida	Mytilidae	*Mytilaster lineatus*
Gastropoda	Littorinimorpha	Hydrobiidae	*Pyrgula grimmi*
	Hygrophila	Planorbidae	*Anisus kolesnikovi*
Malacostraca	Amphipoda	Pontogammaridae	*Stenogammarus carausui*
			Paraniphargoides motasi
		Uristidae	*Onisimus caspius*
	Cumacea	Pseudocumatidae	*Pterocuma pectinatum*
			Pterocuma sowinskyi
			Pseudocuma (Stenocuma) gracile
Hexanauplia	Sessilia	Balanidae	*Amphibalanus improvisus*
Polychaeta	Terebellida	Ampharetidae	*Hypania invalida*
	Sabellida	Fabriciidae	*Manayunkia caspica*
	Spionida	Spionidae	*Streblospio gynobranchiata*
	Phyllodocida	Nereididae	*Hediste diversicolor*
Clitellata	Haplotaxida	Tubificidae	*Nais* sp.

The bivalve *C. glaucum* was the most abundant compared to other species in the summer of 2015. Based on Levene's test the data of this species showed no significant homogeneity of variance, but after square-root transformation data became significantly homogeneous ($p>0.05$). The Shapiro-Wilk normality test results showed that data were significantly normally distributed ($p>0.05$). The results of one way analysis of variance showed a highly significant difference among transects ($p<0.01$, Table 2), and LSD post hoc test revealed that this species was most abundant in station 3 in transects 2, 3 and 6 with a mean density of 51.4 for station 2 and 61.6 for station 3 and 44 for station 6; it showed medium abundance in station 3 in transects 2 and 4, and in station 2 of transect 3, also it is absent or least abundant in all other stations.

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Table 2: One-way ANOVA, of *Cerastoderma glaucum* in summer 2015, a sample of highly significant results.

ANOVA	Sum of Squares	Degrees of Freedom	Mean Square	F	P
Between groups	32383.122	17	1904.890	26.365	0.000
Within groups	5202.000	72	72.250	-	-
Total	37585.122	89	-	-	-

The amphipod *S. carausui* was the second most abundant species in the summer of 2015. Data of this species were not initially significantly homogeneous based on Levene's test, but after square-root transformation of data homogeneity of variance was achieved ($p>0.05$). The Shapiro-Wilk normality test results showed that data were significantly normal ($p>0.05$). Results of one way analysis of variance showed a highly significant difference among transects and sites with regards to this species ($p<0.01$, similar to Table 2). The post hoc test of LSD revealed that there were three groups of stations concerning intensity of individuals of *S. carausui*. This species was most abundant in station 2 of transect 6 with a mean density of 0.4 for station 2, medium intensity was found in stations 1 of transects 1, 2 and 4, and station 2 of transect 4 with a mean density of 2; it was either absent or least abundant in other stations.

The bivalve, *C. glaucum*, was the most abundant species in autumn, 2015. Data of *C. glaucum* in autumn 2015 based on Levene's test results were significantly homogeneous ($p>0.05$). The Shapiro-Wilk normality test results showed that data were significantly normal ($p>0.05$). A one-way ANOVA was performed, and the results showed that there were highly significant differences among transects ($p<0.01$, similar to Table 2). Results of LSD test showed that there are two groups of stations regarding abundance of *C. glaucum*; the first group is most abundant in station 3 of transects 4, 5 and 6 with a mean density of 10.33 for station 3, and the second group is least abundant and includes other sites. Based on Levene's test, data of oligochaete *Nais* sp. in autumn 2015 were not homogeneous, but after square-root transformation homogeneity of variance achieved ($p>0.05$). The Shapiro-Wilk normality test results showed that they were normally distributed ($p>0.05$). Results of one ANOVA showed that spatially there were highly significant differences among transects ($p<0.01$, similar to Table 2). According to the LSD test results in this season, the density of this species was divided into two groups: Stations 2 and 3 in transect 5 with a mean density of 10.6 for station 2 and 25.4 for station 3 were significantly more abundant, station 3 with a mean density of 25.4 had very significant differences from other stations.

The Balanidae family, was most abundant in winter 2016. Based on Levene's test data were homogeneous ($p>0.05$). The Shapiro-Wilk normality test results showed that data was

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normally distributed (p>0.05). A one-way ANOVA was performed, and results showed highly significant differences among transects (p<0.01, similar to Table 2). Results of the LSD test showed that there were three groups of sites which are significantly different; group one consisted of highly abundant stations with *Amphibalanus improvisus* species including station 3 in transect 6 and stations 2 in transects 3 and 5 with a mean density of 6 for station 3 and 6.2 for station 2; group two includes medium density of *A. improvisus* and is found in stations 3 in transects 3 and 5. Group three contains other sites that were least abundant.

The gastropod *Pyrgula grimmi* was the second most abundant species in winter 2016. Data based on Levene's test were not initially homogeneous but after square-root transformation data homogeneity achieved (p>0.05). Shapiro-Wilk normality test results showed that data were normally distributed (p>0.05). One way ANOVA results showed highly significant differences among transects (p<0.01, similar to Table 2). Results of the LSD test showed that there were two groups of sites which are significantly different; group one with high abundance of *P.grimmi* in stations 2 and 3 of transects 5 and 6 with a mean density of 1 for station 2 and 12.8 for station 3. Group two contain other sites that were least abundant.

The gastropod species *P. grimmi* was most abundant in spring 2016. Based on Levene's test, data of abundance of this species was not initially homogenous, but after square-root transformation homogeneity of variance was achieved (p>0.05). Shapiro-Wilk normality test results showed that data were significant normal (p>0.05). One way ANOVA results showed highly significant differences among transects (p<0.01, similar to Table 2). Results of LSD test showed that there are two groups of sites which are significantly different; group one consisted of abundant stations with this gastropod species including stations 3 in transect 5 and 6 and stations 2 in transects 6 with a mean density of 17.2 for station 3 and 7.6 for station 2. Group two contains other sites that were least abundant.

In spring 2016 *Amphibalanus improvisus* was the second most abundant species. Data based on Levene's test was not homogenous initially, but after square-root transformation homogeneity of variance was achieved (p>0.05). The Shapiro-Wilk normality test results showed that data were normal (p>0.05). One way ANOVA results showed highly significant differences among transects (p<0.01, similar to Table 2). Results of LSD test showed that there were two groups of sites which are significantly different; group one consisted of stations abundant in Balanidae family, including station 2 in transect 5 and stations 3 in transects 4 and 6 with a mean density of 5.4 for station 2 and 7.3 for station 3. Group two contains other sites that were least abundant.

The bivalve *C. glaucum* was the third most abundant in spring 2016. Based on Levene's test data were significantly homogeneous (p>0.05). The Shapiro-Wilk normality test results showed significant normality of data (p>0.05). A one-way ANOVA was performed, and results showed highly significant differences among transects (p<0.01, similar to Table 2). Results of LSD test showed that there were three groups of sites which are significantly different; group one consisted of highly bivalve abundant stations, including station 2 in transects 1 and 5, and stations 3 in transects1, 4 and 6 with a mean density of 2.5 for station 2 and 3.3 for station 3. Group two contains medium intensities of this species and includes station 2 in transects 2 and 3. The rest of stations make the least abundant large group.

The most abundant species in summer 2016 was the gastropod *P. grimmi*. Levene's test results showed that data were significantly homogenous (p>0.05). Also, Shapiro-Wilk test of normality revealed significantly normal data (p>0.05). A one-way ANOVA was performed, and results showed highly significant differences among transects (p<0.01, similar to Table 2). Results of LSD test showed that there were three groups of sites which are significantly different; group one consisted of highly *P. grimmi* abundant stations, including station 3 in transect 6. Group two contains medium intensities of this species and includes station 2 in transect 6 with a mean density of 0.1 for station 2 and 1 for station 3. The rest of the stations make the least abundant large group.

The bivalve *Mytilaster lineatus* was second most abundant in summer 2016. Data were significantly homogeneous based on Levene's test (p>0.05). The Shapiro-Wilk test results showed that data were significantly normal (p>0.05). A one-way ANOVA was performed, and results showed highly significant differences among transects (p<0.01, similar to Table 2). Results of LSD test showed that there were two groups of sites which are significantly different; group one consisted of *M. lineatus* abundant stations, including stations 2 of transects 2 and 5, stations 3 of transects 5 and 6 with a mean density of 0.1 for station 2 and 0.3 for station 3. The rest of stations make thea least abundant group.

The polychaete *H. invalida* in summer 2016 was the third most abundant after two mollusc species of *M. lineatus* and *P. grimmi*. However, it has little effect in showing differences among transects and there were no significant differences between transects in this season regarding numbers of this species.

Results of Levene’s test showed that data of the polychaete *H. invalida* in summer 2016 were significantly homogeneous (p>0.05). Also, Shapiro-Wilk test of normality revealed a significant normality (p>0.05). One-way ANOVA was performed, and the results showed that there was no significant difference between transects (p>0.05). As a result, analysis of variance showed no significant difference between transects (Table 3). It indicated that this species was almost evenly distributed in the NBMP area in this season.

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Table 3: One-way ANOVA, of *Hypania invalida* in autumn 2015, a sample of not significant results.

ANOVA	Sum of Squares	Degrees of Freedom	Mean Square	F	P
Between groups	702.400	17	41.318	1.405	0.160
Within groups	2118.000	72	29.417	-	-
Total	2820.400	89	-	-	-

The polychaete *M. caspica* was the fourth abundant in summer 2016. Results of Levene's test showed that data were significant homogeneous (p>0.05). The Shapiro-Wilk normality test results showed that data were significantly normal (p>0.05). One-way ANOVA was performed, and the results showed that there was no significant difference between transects (p>0.05). As a result, analysis of variance showed no significant difference between transects (similar to Table 3). Examining distribution of the species in autumn 2015, some species, such as *C. glaucum*, *A. kolesnikovi* and *S. carausui* were present almost in all depths. *M. lineatus* was not present in transects one, two and three and showed a sparse presence in other transects. Distribution of the species individuals in winter 2016 were examined and showed that some species, such as *S. carausui*, were present in all depths and transects. Some other species such as *M. lineatus*, *Nais* sp. and *P. pectinatum* were not present in transects one, two and three and showed a sparse presence in other transects.

Distribution of species specimens were studied in spring 2016 showing that some species, such as, *S. carausui* and *A. improvisus* were present almost in all stations. Some species, such as *A. kolesnikovi*, were not found in transect one, two and three and showed a sparse presence in other sites. Also, species distribution was studied in summer 2016, some species, such as, *M. lineatus*, *S. carausui* and *H. invalida* were present almost in all depths and transects.

The structure of macrobenthos

In summer 2015, composition of macrobenthos showed that bivalvia and gastropoda accounting for 66% were the most abundant in the environment, followed by amphipoda with the highest density, Polychaeta, Oligochaeta and cumacea were in a similar rank. In the autumn of 2015, composition of macrobenthos showed that bivalvia and gastropoda with 38% were the most abundant, then oligochaeta with 30%, amphipoda with 13% and cumacea with 3% were observed. In winter 2016, due to lower air temperature, composition of macrobenthos showed that abundance of macrobenthos was changed and decreased, so after bivalvia and gastropoda, Balanidae family, polychaeta and cumacea, were in the next rank. In the spring of 2016, the composition of macrobenthos showed that bivalvia and gastropoda showed the largest numbers in the environment, followed by cumacea, amphipoda and Polychaeta. Similarly, in summer 2016 bivalvia and gastropoda, showed the greatest abundance with polychaeta and amphipoda, cumacea in the next rank (Fig. 2).

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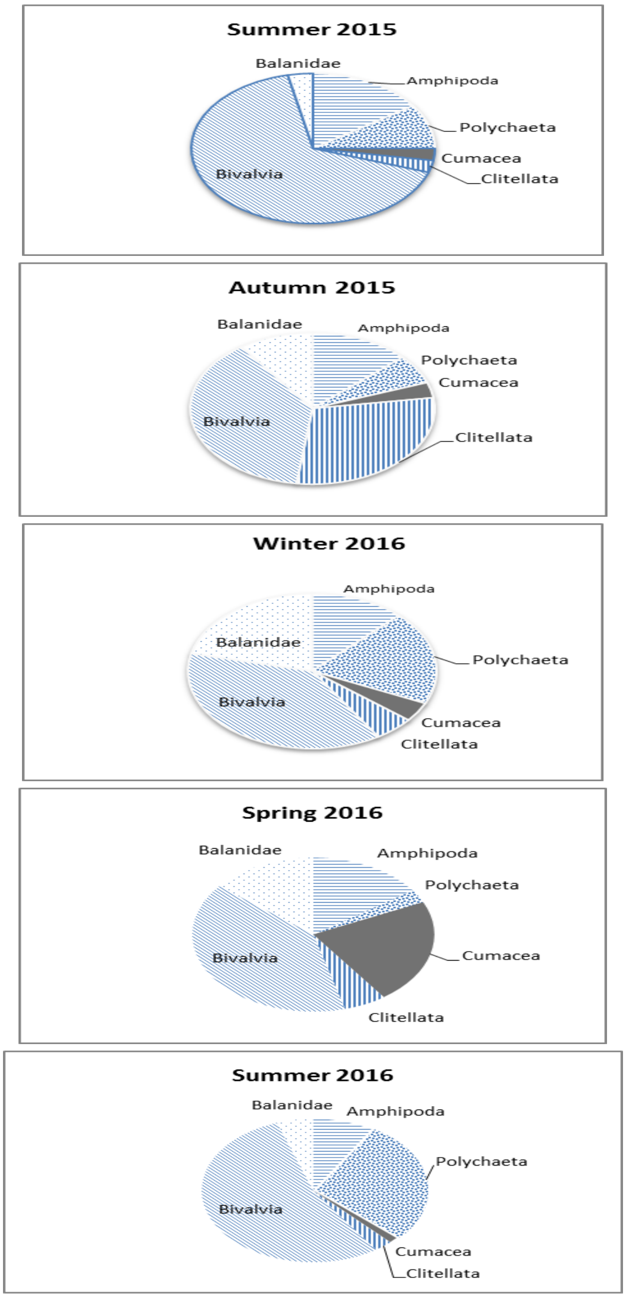

Figure 2: The combination of macrobenthic group abundances in Boojagh National Marine Park.

In general, the greatest numbers of amphipoda were in the spring of 2016 and the lowest density was in the summer of 2016. Polychaeta were the most abundant in summer 2016 and least abundant in spring 2016. Cumacea were the most abundant in spring 2016 and least abundant in summer 2016. Bivalvia and gastropoda were the most abundant in summer 2015 and least abundant in winter 2016 also Balanidae family were the most abundant in winter 2016 and least abundant in summer 2015.

Temporal distribution of macrobenthic species

There was no change in the total number of species of macrobenthos in all sampling seasons and sixteen species were identified. The highest abundance of macrobenthos was

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observed in summers of 2015 and 2016. In the summer of 2016, species richness decreased compared to the previous year and the lowest rate was observed in spring and winter of 2016 (Fig. 3). Cumacea was the least abundant in all seasons, oligochaeta and clitellata were in the next rank of least abundant species (Fig. 4).

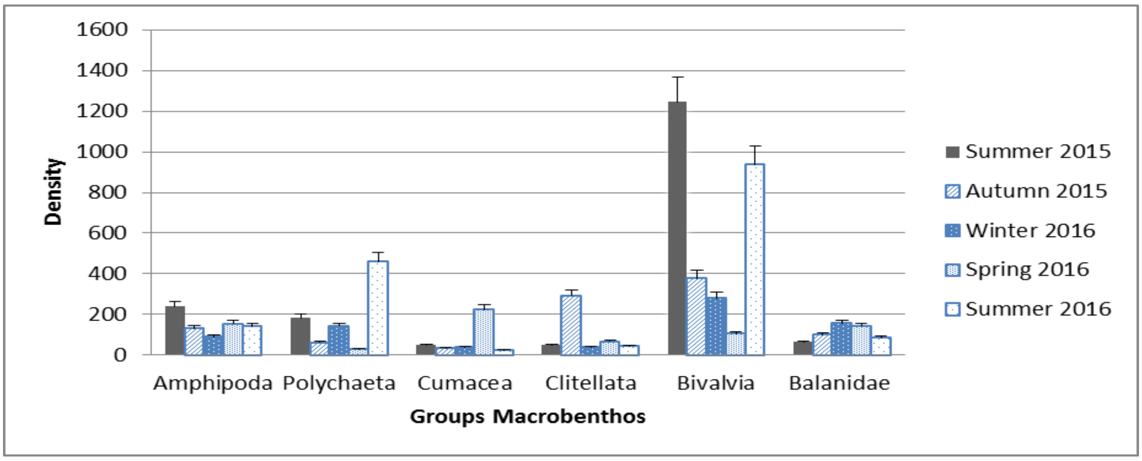

Figure 3: Density of macrobenthic groups (numbers per square meter) in Boojagh National Marine Park (Error bars show standard deviation).

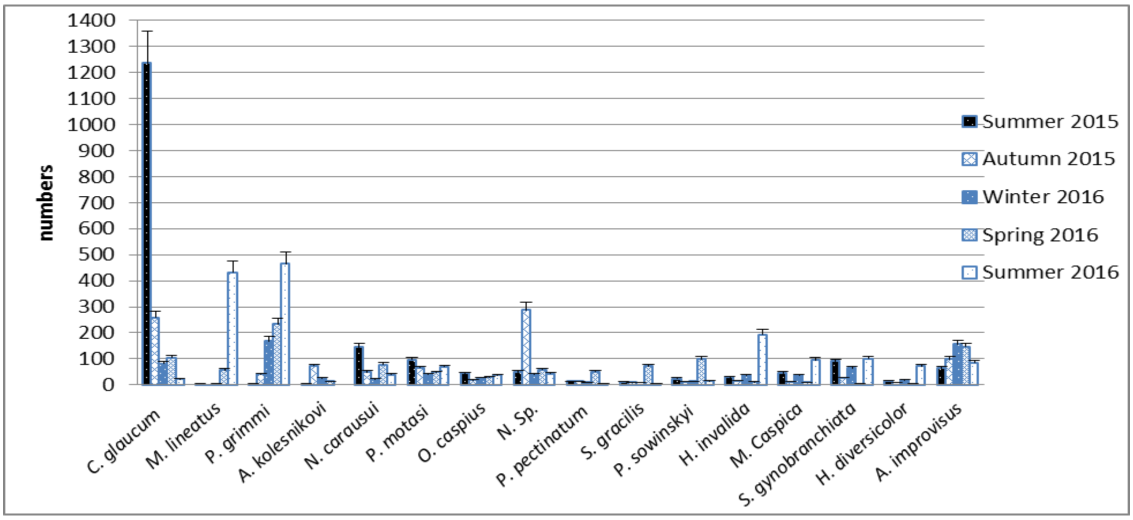

Figure 4: Macrobenthic species in Boojagh National Marine Park (error bars show standard deviation).

In the general characterization of the macrobenthos with 16 species (43% of the macrobenthic species), gastropoda was the most diverse taxon. Malacostraca comprised 6 species (18.7%), polychaeta 4 species (14.6%), clitellata 1 species (8.1%), gastropoda 4 species (49.1%) and 1 species (9.1%) for Hexanauplia. Most of the species of macrobenthos were observed at the depth of ten meters and then five and one meters. The average density in summer 2015 with the total number of 1827 samples and with an average of 356 individuals per square meter was the highest of other seasons, followed by the density in summer 2016, fall 2015, winter 2016 and spring 2016.

The species with the highest density were the gastropoda and Hexanauplia, *C. glaucum* (present in 27% of the samples), *P. grimmi* (14.4%) and *A. improvisus* (8.7%). The sites with the highest abundance of macrofauna were situated on the western part of the coastal banks, transect numbers 4, 5, 6. Macrobenthic abundances were dominated by gastropoda, polychaeta and amphipoda depending on the area considered. Gastropoda (mainly the species: *C. glaucum*, *P. grimmi* and *M. lineatus*) and Polychaeta dominated the fauna of the coastal banks, but the dominance of polychaeta increased towards the more nearshore areas, whereas the relative density of the gastropoda increased. Crustacea and polychaeta were dominant on the sandy and muddy beaches.

Studies showed that due to fishing operations in two transects one and two in autumn 2015, the density of macrobenthos showed significant reduction (Fig. 5). According to research, fishing operations can damage the sea floor and cause the loss of macrobenthos.

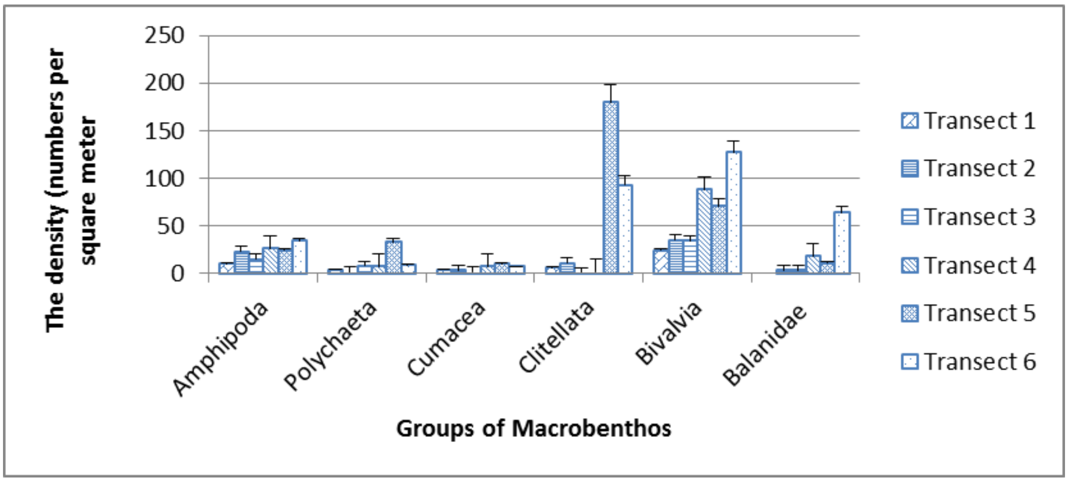

Figure 5: Group density of species in transects in Boojagh National Marine Park (error bars show standard deviation).

Discussion

In this investigation after identifying samples with identification references, sixteen species were identified belonging to twelve families, nine classes and five orders. Most of the macrobenthos species were observed at the depth of ten meters. The average density of samples identified in summer 2015 was more than other seasons followed by that in summer 2016, autumn 2015, winter 2015 and spring 2015.

Although eight species of polychaeta have historically inhabited the Caspian Sea, only four species were observed in this study. Prior to 2005, the community structure of the southern Caspian Sea polychaeta was primarily dominated by members of Ampharetidae and Nereididae families, particularly *H. invalida* (Hashemiyan, 1998; Karpinsky, 2010; Kasymov, 1994; Parr *et al*., 2007; Roohi *et al*., 2010; Soleimani, 1994; Snelgrove and Butman, 2004).

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However, our results coupled with those of Taheri *et al*. (2012) suggest that since 2005 their dominance has been replaced by *S. gynobranchiata*. Similar results have also been observed in the Gorgan Bay, where the Ampharetidae *H. kowalewskii* disappeared soon after the arrival of *S. gynobranchiata* (Bandany *et al*., 2008; Taheri *et al*., 2009, 2012).

Hence, the arrival of *S. gynobranchiata* likely resulted in the displacement in the dominance of Ampharetidae in the southern Caspian Sea, as only low abundances of *H. invalida* currently exist in this area. Because Ampharetids and *S. gynobranchiata* inhabit similar habitats and are both considered surface deposit feeders (Zenkevitch, 1963; Fauchald and Jumars, 1979; Taheri *et al*., 2009, 2012), it appears that *S. gynobranchiata* is able to outcompete native Ampharetids in shallow waters and displace them to greater depths in the southern Caspian Sea. Likewise, because *H. diversicolor* occupy overlapping habitats, it can also be a potential competitor. Because *H. diversicolor* preys on large organisms, it becomes suppressed and increases in abundance (Smith, 1963). Hence, *H. diversicolor* is usually confined to fresher waters, greater depths, and high-sulfidic sediment areas where it is able to tolerate extreme conditions, albeit at the expense of competitive ability (Miron and Kristensen, 1993; Kristensen, 1988, 2001; Ghasemi *et al*., 2014).

With respect to the number of species and their abundance, our results and those of other investigators suggest a high degree of variability in the macro-benthic fauna in the southern Caspian Sea (Kasymov, 1994; Soleimani, 1994; Hashemiyan, 1998; Parr *et al*., 2007; Bandany *et al*., 2008; Karpinsky, 2010; Roohi *et al*., 2010; Taheri and Yazdani, 2010; Taheri *et al*., 2009, 2011, 2012; Ghasemi *et al*., 2014). This variability can be attributed to differences in environmental conditions in the Caspian Sea (Kasymov, 1994). Our results show that the highest abundances of *S. gynobranchiata* in summer and *H. diversicolor* occur in summer and winter, and *H. invalida* in summer and winter.

These trends could be related to the timing of their reproduction and recruitment. The presence of young individuals of *H. diversicolor* and *S. gynobranchiata* with lower density in summer and winter samples is indicative of the effect of reproduction and larval settlement. Furthermore, reproductive activities of these species have previously been observed to occur during the warmer months (Taheri *et al*., 2009, 2012) while the reproductive peak of *H. invalida* has been typically observed in March (Taheri *et al*., 2012). The distribution of macrobenthos in the Caspian Sea may also be controlled by fish predation (Kasymov, 1994; Karpinsky, 2010; Taheri and Yazdani, 2010). Distribution would be expected to increase with decreasing predation pressure and vice versa. Reduced predation pressure may have resulted from over exploitation of the fish stock and invasion of the ctenophore *Mnemiopsis leidyi* and may be expected

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to occur wherever fishing nets are deployed. Floating fishing nets are widely used in shallow waters (less than 15 m depth) in autumn and winter when all macrobenthos species were found to be abundant.

On the other hand, the lowest distribution of all four polychaete species in spring may be attributed to predation because predation rates of benthivorous fish increase from late winter to late spring (Kasymov, 1994; Karpinsky, 2010). Increased feeding intensities of these fish have been attributed to their reproductive activities and higher metabolic rates as temperatures increase in the spring (Kasymov, 1989; Taheri and Yazdani, 2010).

In the total 5 season samplings, gastropoda was highest with an average density of 588 per square meter, class malacostraca with an average 225 per square meter, class polychaeta with an average 175 per square meter, category Lepadiformes with an average 109 per square meter and finally Clitellata category with an average density of 98 per square meter was the lowest.

In summer 2015, *C. glaucum* was considred as permanent and other species were considered accidental. In autumn 2015, two species: *C. glaucum* and *Nais* sp. were seen as temporary species and other species were observed accidentally and were not seen as permanent in this season. In winter and spring of 2016 all species were observed accidentally and did not show any permanent or temporary species. In summer 2016, only two species *M. lineatus* and *P. grimmi* were introduced as temporary species and other species were considered accidental. In general, it can be concluded that only *C. glaucum* is considered as a temporary species and the rest of species were observed accidentally.

In general, in each season the average harvest of macrobenthos was about 16%. The overall average percentage of total seasonmacrobenthos in the highest to lowest were: bivalves, 47.26%; polychaeta, 13.22%; amphipoda, 12.95%; Balanidae family, 10.80%; oligochaeta 9.09% and cumacea, 6.65%. As well as that, generally bivalvia and amphipoda in summer 2015, bivalves and oligochaeta in autumn 2015, bivalvia and polychaeta in winter 2016, bivalves and cumacea in spring 2016, and bivalves and polychaeta in summer 2016, were the largest and most abundant and most numerous of macrobenthos. The main reason for the reduction of macrobenthos in winter, maybe was due to overwintering of benthic fish in the southern Caspian Sea (Morin, 1999; Newell and Seiderer, 2011). Density of amphipoda in summer 2015 and winter 2016 was less than other seasons. Macrobenthos density reduction in winter can be due to consumption by fish that eat benthos, and factors such as decrease in water temperature, and biological activities such as feeding and reproduction (Vanosmael, 2002; Mills, 2006; Cabioch, 2009; Buchanan, 2014). Based on Olivier and Vallet (2006) and (Ruddick and Ovidio, 2009) first (habitat boundaries) and fourth (statistical assemblages) approaches to distinguish between assemblages. The

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relation of recurring groups of soft-bottom animals and depth zones was first described by Petersen (1914). Jones (2005), Heip and Basford, 2005, Dufrene and Legendre (2007), Degraer, 2009, Dewarumez and Davoult (2010) put forward an alternative classification of species groupings based on depth characteristics, followed by several other authors (Thorson, 1997; Kingston and Rachor, 2002; Fromentin, 2007; Gray, 2010; Desroy and Warembourg, 2012).

Stations 2 in transect of 1, 5 and station 3 in transects 1, 4 and 6 were densely populated, stations 2 in two transects 2 and 3 were medium-density and the rest of stations were in a large group of low-density. It seems that stations with medium depth, and deeper stations tend to be more populated. This is probably due to the presence of insoluble particles in the depths of coastal currents and higher waves (Duineveld, 2010).

Overall, the average macrobenthos in summer 2015 had increased substantially compared with other seasons and bivalvia and polychaeta were the most identified macrobenthos. In summer 2015 density of amphipoda was the most and in winter 2016 it was less than in other seasons. Also, at a depth of one meter the density was higher than in other depths. Density of polychaete was higher in the summer of 2016 and lower in the fall of 2015 than in the other seasons. The density of cumacea was higher in spring 2016 and lower in summer 2016 than in other seasons. Also, it was higher at the depth of ten meters than in other depths. The density of oligochaeta was more in autumn 2015 and less in winter 2016 than in other seasons. The density of bivalves was higher in summer 2015 and lower in spring 2016 than in other seasons. The density of Balanidae family was higher in winter 2015 and lower in summer 2015 than in other seasons. Their density was higher at a depth of ten meters.

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