Iranian Journal of Fisheries Sciences 19(2) 525-540 2020
DOI: 10.22092/ijfs.2019.120647

Diversity and spatial distribution patterns of the benthic macrofauna communities in the southeast of the Caspian Sea (Golestan Province– Iran) in relation to environmental conditions

Aliakbarian A.[1]; Ghorbani R.[1]*; Fazli H.[2]; Salman Mahini A.[1]; Yelghi A.[3]; Naddafi R.[4]

Received: December 2016 Accepted: February 2017

Abstract

Biodiversity and structure of the benthic macrofauna communities were studied in the southeast the Caspian Sea (Golestan Province – Iran) during one year from October 2014 to September 2015. Seasonal samplings were done at 6 stations in 3 transects. Depth, temperature, salinity, pH, E.C., total organic matter and grain size were measured. More than 4,037 individuals belonging to five orders, Polychaeta, Oligochaeta, Bivalvia, Diptera and Amphipoda, and eight families including Nereididae, Spionidae, Amphartidae, Tubificidae, Smelidae, Cardiidae, Chironomidae and Gammaridae were identified. In terms of total individuals, *Streblospio gynobranchiata*, *Hypania invalida* and *Cerastoderma lamarcki*, were the most abundant species, and Polychaeta were dominant in the research region. The highest density of all species was observed in autumn (1515 ind m^2) and the lowest was observed in summer (698 ind m^2). The maximum diversity, richness, and evenness were 1.36, 0.6 and 0.98, respectively. The results of distance-based redundancy analysis (db-RDA) showed that environmental factors such as salinity, depth and substrate type were all important in detecting the distribution pattern of macrobenthic species in the research region. The dominant species, *S. gynobranchiata,* was distributed in the areas with smaller grain size and higher TOM and muddy sediments and had the most correlation with salinity, temperature, pH and E.C. Species such as *T. fraseri*. *H. invalida* and *P. robustoides* showed more dependency on TOM and mud factors in the spring and summer, while their dependency became lower in autumn and winter. *Abra ovate* was less influenced by all factors except the substrate.

Keywords: Community, Biodiversity, Macrofauna, Caspian Sea, Environmental factors, RDA

1-Department of Fisheries and Environment, Gorgan University of Agricultural Science and Natural Resources, P. O. Box: 386, Gorgan, Iran.

2- Caspian Sea Ecological Research Center, Iranian Fisheries Science Research Institute, Agricultural Research Education and Extension Organization, P.O.Box, 961, Sari, Iran

3-Inland Waters Aquatics Resources Research Center, Iranian Fisheries Science Research Institute, Agricultural Research Education and Extension Organization, Gorgan, Iran

4-Department of Aquatic Resources, Institute of Coastal Research, Swedish University of Agricultural Sciences, 74242 Öregrund, Sweden

*Corresponding author´s email: rasulghorbani@gmail.com

Introduction

The Caspian Sea is the world's largest landlocked body of water on Earth, containing approximately 40% of the global continental water mass (Dumont, 1998). Structurally, it is divided into three different parts. The central and southern parts are deep, 788 and 1,025 m in depth, respectively, with a marine type of water circulation and a salinity of 12-13 ppt which is usual of a number of continental seas. Various ecosystems as a result of different patterns of salinities and depth were created in this sea so that many different animals in accordance with their osmoregulation capacities can live in different parts (Taheri *et al.*, 2012). Although a great part of the Caspian Sea fauna is endemic, because of its long-term geographical isolation and independent evolution (Dumont, 2000), non-native immigrants from the Arctic basin, Black-Azov Seas (Atlantic-Mediterranean fauna), and fresh water habitats are inevitable among the native species (Zenkevitch, 1963). The Golestan Province is located to the east of the southern coast of the Caspian Sea along the Iranian border. The gradient and structure of the seabed in this area somewhat alter from mud and sludge on the Gomishan coast to gravel and sand on the Miankaleh coast. There is almost no tidal current. The major rivers existing in the vicinity of the sampling sites are Gorganrud and Atrak Rivers and the Atrak River joins the Caspian Sea in the Torkmanestan coast.

Macro-fauna as consumers in intermediate trophic levels, are essential agents of both bottom-up and top-down forces in the water system; they themselves represent resources and consumers for other levels of the food chain and resource restriction and predation are the factors that regulate their populations (Gogina *et al.*, 2010). Benthic macro fauna and macro algae are easy sampling organisms that many papers published on their distribution in specific environmental stresses (Ghorbanzadeh Zaferani *et al.,* 2017). Nutrient cycles, primary productivity, decomposition, and translocation of materials are the most important factors which are affected by benthic macrofauna (Wallace and Webster, 1996). In aquatic ecosystems, the presence or activities of macrofauna species often alter the flow of resources and physical ambience, thereby constructing or modifying habitats, which then effect all other organisms in the community (Gogina and Zettler, 2010). Moreover, benthic invertebrates play an important role on benthic feeding fish and even indirectly on feeding a group of pelagic fish. Macrofauna are the main food items for sturgeon fish, the very valuable and ancient species of Caspian Sea that caviar is derived from (Karpinsky, 1992; Haddadi Moghadam *et al.*, 2005). The most important factor in controlling the biomass and diversity of macrofauna in this Sea, is grazing pressure especially caused by young sturgeon (Karpinsky, 2010).

Over the past decade, the structure of benthic communities is influenced by stressful conditions in the southern coasts of this sea. The invasion of *Mnemiopsis leidyi* in this area, changed macrofauna diversity from domination by Crustacea to Bivalvia (Roohi *et al.*, 2010) and demersal feeder fish stocks (Fazli *et al*., 2012, 2013). In addition, *Streblospio gynobranchiata* became the dominant species of macrofauna (Taheri and Yazdani, 2011). On the other hand, heavy metals (Karbassi and Amirnezhad, 2004), waste water (Shahryari *et al.*, 2009), microbial pollution (Fereidouni *et al.*, 2006) and oil extraction (Taheri and Yazdani, 2011) are the main problems for living animals in this sea. The southeast coast of the Caspian Sea is the location of fishing cooperatives that carry out fishing activities seven months of the year. Fishing activities often cause disturbances on the bottom, besides affecting biomass and diversity of benthic organisms. Therefore, although analysis of community structures is useful for the management and conservation of the environment, only a few studies have described benthic animals of the south Caspian Sea (Kasymov, 1989; Tait *et al*., 2004; Parr *et al.*, 2007) especially on the Iranian border (Taheri *et al.*, 2007; Bandany *et al.*, 2008) and the macrofauna community of this area remains largely unknown. The purpose of this paper was to study macrobenthic community structure and biodiversity in the southeast Caspian Sea. These results can help us to evaluate environmental and man-made changes on fauna, and monitor the effect of invasive species and improve management of this area in the future.

Materials and methods

Study area

Sampling was conducted between the Gomishan and Miankaleh coasts within 36º 54´ 450´´ to 37º 13´ 355´´N and 53º 55´ 974´´ to 53º 47´ 080´´ E (Fig. 1)

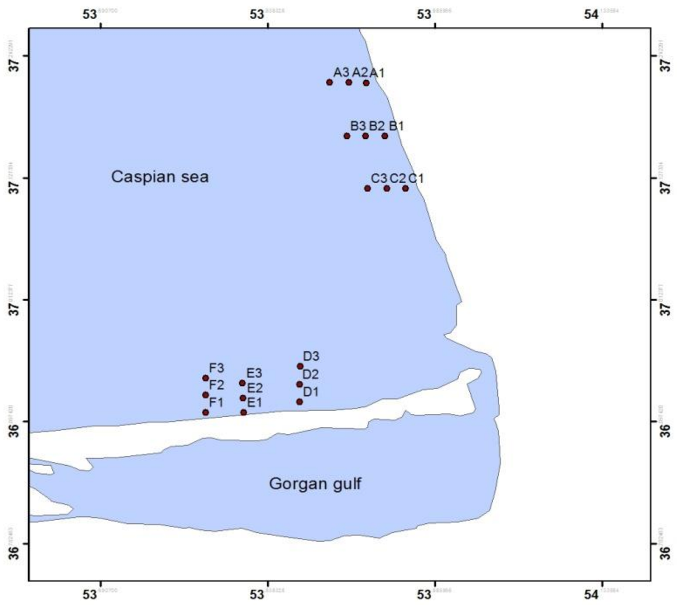

Figure 1: The map of stations in this study.

Sampling

Seasonal sampling was carried out at 6 stations in 3 transects (Fig. 1), ranging in depths from 0.5 to 8 meters, during October 2014-September 2015. At each station, three replicate samples of 25 cm^2 were collected using a Van Veen grab. In the field, the contents of each grab were gently sieved using a 0.5 mm mesh and the retained material was fixed in 4% buffered formalin and stained with Rose Bengal (Abrantes *et al.*, 1999). Then, the macrofauna were separated in the laboratory, identified and counted under a stereomicroscope. Another separate sediment samples was taken from the surface (≈4 cm) at each station using a Van Veen grab and stored in a clean plastic container to measure the percentage of the total organic matter (TOM) and the sediment grain size (MacLeod *et al.*, 2004). Total organic matter was determined by determining weight loss on ignition (4 hours at 550 °C) after drying (24 hours at 90°C) to a constant weight (Abrantes *et al.*, 1999). Grain size analysis was performed using a particle size analyzer. Nearly 150 g of each grab sample was submitted to standard dry-sieve through a series of mesh sizes (from 63 m to 2 mm) and mechanically shaken for 10 minutes. The sediments retained on each sieve were weighed and the percentage of each grain size category was determined (Diaz-Castaneda and Harris, 2004). Sediment fractions (gravel, sand, and silt–clay) were reported as percentages and defined pursuant to the Wentworth scale. Physicochemical data (depth, temperature, salinity and pH) of the water column were obtained using a CTD at each sampling station.

Analysis

The macrobenthic communities spatial distribution and diversity were described by univariate analysis based on the following parameters: abundance, species number (S), diversity (as Shannon–Wiener’s, H′), species richness (as Margalef’s, D), and evenness (as Pielou’s, J). At all stations, the mentioned parameter values per square meter were calculated. Collected data were tested for normality (using Shapiro–Wilk) and homogeneity of variance (using Levene’s test). Significance of all tests was accepted at $p \leq 0.05$. Whenever data were normal and homogeneous, one-way analysis of variance (ANOVA) was used to test the differences among the biological parameters (density, mean species number, diversity, richness and evenness). Distance-based redundancy analysis (db-RDA) was performed to identify the relationships among environmental variables and macrofauna assemblage structures using CANOCO software (ter Braak, 1986; ter Braak and Smilauer, 1998) with the software options set for forward selection to test the significance of environmental variables. All environmental and frequency data were natural log (X+1) transformed and normalized, and then plotted in two dimensional space. All figures dependent on analysis were made by Excel and Primer programs.

Results

Environmental conditions

Environmental factors are shown in Table 1. The total organic matter (TOM) values varied between 2.6 at station 6 in autumn and 6.36 at station 1 in summer. The maximum salinity was recorded at station 1 in autumn and the minimum was recorded at station 3 in winter. According to the grain size, the stations situated in the Gomishan region had the finest sediments while the stations in the Miankaleh region showed the coarsest sediments.

Community structure

Totally 4,093 individuals belonging to eight families were identified in the macrofauna samples from 18 stations (Table 2). Polychaeta, comprising 73.92% of the total individuals was the numerically dominant group and *Streblespio gynobranchiata* and *Hypania invalida* accounting for 40 and 25.9 %, respectively were the dominant species that were observed at all of the stations. Bivalvia (12.77%), Oligochaeta (6.54%) and Diptera (5.65%) were the next abundant groups. Amphipoda and the species *Pontogamarus robustoides* showed the lowest frequency. Polychaeta, with three species, had the highest diversity and density among other groups. In the present study, Amphartidae was nearly always found at the all stations. It seems it could live in different water and sediment conditions. Also, one species of Amphipoda and Diptera were observed (Table 2).

The mean frequency and occurrence percentage of different macrofauna species in different seasons are shown in Table 3. This table showed that, the highest average density of macrofauna species was observed in spring (*S. gynobranchiata*) and the least was related to *Tubificoides fraseri* in winter. Oligochaeta (*T. fraseri*) were not seen in spring and summer and their frequency was confined to winter. *S. gynobranchiata* was the dominant species in all seasons except in autumn when*H. invalida* along with *S. gynobranchiata* were the common species, while the species like *A. ovata*, *C. albidus* and *P. robustoides* reached the lowest levels. Seasonal changes in mean values of density (±standard deviation) in all stations are shown in Table 4. The maximum density among stations belonged to station 1 which was slightly different from station 3 in autumn. Also, the minimum frequency of all species was observed in station 6 in summer (Table 4). One-way ANOVA analyses showed significant differences in mean species number, diversity, richness and evenness among stations. All frequency data were natural log (X+1) transformed and normalized. The highest mean number of species (0.74) was obtained at station 4 and the lowest (0.64) was at station 1. The highest diversity index (1.36) was obtained at station 4 while the lowest (1.2) was observed at station 1. The maximum and minimum of evenness index were obtained at stations 4 and 1, respectively, while the maximum richness index was recorded in station 5, but stations 1 and 3 showed the minimum value of richness (Table 5).

The results of distance-based redundancy analysis (db-RDA) revealed that, environmental variables had significant effects on the spatial distribution of macrobenthic animals, (Fig. 2). The lines of Shanon index showed that Gomishan zone was more variable than Miankaleh in all seasons except spring. The RDA demonstrated that in all seasons, sand was the only influential factor in Miankaleh region while the others were less effective. TOM, mud and depth were the factors that were more related to the Gomishan region. The RDA also revealed relationships among 8 species and environmental variables (Fig. 2). *S. gynobranchiata* was distributed in regions with smaller grain size and higher TOM and mud. This species showed the most dependency on salinity, temperature, pH and E.C. *T. fraseri* also was dependent on these factors in autumn and winter (the seasons in which this species was found). *H. invalida* and *P. robustoides* were found in regions with more TOM and smaller grain size. *A. ovate* was less influenced by all factors except sand, and thus, this species was found mainly in sandy regions. All factors were equally affected *C. albidus* and *N. diversicolor*, and *C. lamarcki* was mainly found in the regions in which the grain size was larger.

Table 1: Average values of environmental factors measured in this study.

Season	Station	Temp.(C°)	Salinity	E.C.	pH	Sand	Mud	TOM
Spring	1	19.13	10.2	1.75	7.9	19.20	80.7	6.07
	2	19.66	10.2	1.71	8.04	26.21	73.7	5.34
	3	19.16	10.2	1.72	8.01	36.22	63.7	5.51
	4	20.06	10.2	1.6	8.02	32.7	67.29	3.3
	5	19.73	10.3	1.6	8.03	22.88	77.12	3.03
	6	19.66	10.36	1.73	8.06	55.76	44.23	4.5
Summer	1	30.0	11.6	1.91	8.02	19.1	80.8	6.36
	2	31	10.46	1.73	8.05	25.5	74.4	5.49
	3	30.7	10.4	1.69	8.1	31.6	68.3	5.53
	4	31.2	10.4	1.79	8.05	60.2	39.7	3.9
	5	30.8	10.4	1.85	8.06	66.8	33.1	3.75
	6	30.9	10.4	1.7	8.04	75.1	24.8	4.02
Autumn	1	15	11.1	1.73	8.4	31.42	68.5	3.96
	2	15.03	10.9	1.75	8.4	32.15	67.8	3.51
	3	15.13	10.7	1.77	8.4	31.02	68.9	3.32
	4	15.03	10.73	1.73	8.3	61.52	38.4	3.21
	5	15.2	10.13	1.71	8.36	69.36	30.6	3.03
	6	14.7	10.23	1.75	8.16	72.06	27.9	2.6
Winter	1	9.2	9.2	1.33	8.6	33.09	66.91	5.02
	2	9.1	9	1.41	8.5	32.77	67.2	4.90
	3	8.76	8.5	1.58	8.6	32.63	67.36	4.5
	4	9.6	9.5	1.62	8.4	56.67	43.32	3.15
	5	9.33	9.23	1.50	8.4	56.68	43.31	3.2
	6	9.8	9.43	1.67	8.3	59.98	40.02	2.86

Table 2: List of macrobenthic invertebrate species identified in the south-east Caspian Sea.

Order	Family	Genus	Species	Percent
Polychaeta	Nereididae	*Nereis*	*Nereis diversicolor*	6.99
	Spionidae	*Streblospio*	*Streblospio gynobranchiata*	40
	Ampharetidae	*Hypania*	*Hypania invalida*	25.9
Oligochaeta	Tubificidae	*Tubicifoides*	*Tubificoides fraseri*	6.54
Bivalvia	Smelidae	*Abra*	*Abra ovata*	1.62
	Cardiidae	*Cerastoderma*	*Cerastoderma lamarcki*	11.15
Diptera	Chironomidae	*Chironomus*	*Chironomus albidus*	5.65
Amphipoda	Gammaridae	*Pontogammarus*	*Pontogammarus robustoides*	2.06

Table 3: Density and occurrence percentage of each family in each season in m^2.

Order	Family	Spring	per%	Summer	per%	Autumn	per%	Winter	per%
Polychaeta	Nereididae	24	2.60	36	5.15	156	10.3	41	4.27
	Spionidae	565	61.3	324	46.43	377	24.9	461	48.15
	Ampharetidae	206	22.34	144	20.64	437	28.85	317	33.1
Oligochaeta	Tubificidae	0	0	0	0	243	16.03	7	0.73
Bivalvia	Smelidae	11	1.2	19	2.72	10	0.67	8	0.83
	Cardiidae	51	5.53	77	11.06	269	17.75	25	2.7
Diptera	Chironomidae	46	5	59	8.45	10	0.67	90	9.4
Amphipoda	Gammaridae	19	2.06	39	5.6	13	0.85	9	0.93
Sum		922	100	698	100	1515	100	958	100

Table 4: Mean±SD of Species number (*S*), diversity (*H'*), richness (*D*) and evenness (*J*) in all stations of the south east Caspian Sea.

Zone	Station	Spring	Summer	Autumn	Winter
Gomishan	1	1.75 ± 0.19^{a}	1.26 ± 0.05^{b}	2.1 ± 0.3^{a}	1.8 ± 0.35^{ab}
	2	1.78 ± 0.09^{a}	1.44 ± 0.07^{a}	1.91 ± 0.05^{ab}	1.75 ± 0.9^{abc}
	3	1.75 ± 0.06^{a}	1.31 ± 0.05^{b}	2.05 ± 0.2^{a}	1.96 ± 0.12^{a}
Miyancaleh	4	1.65 ± 0.1^{a}	1.24 ± 0.01^{b}	1.58 ± 0.16^{b}	1.48 ± 0.1^{bc}
	5	1.56 ± 0.2^{a}	1.27 ± 0.1^{b}	1.68 ± 0.03^{b}	1.34 ± 0.35^{c}
	6	1.67 ± 0.08^{a}	1.07 ± 0.04^{c}	1.81 ± 0.2^{ab}	1.51 ± 0.12^{bc}

Table 5: Mean species number (*S*), diversity (*H'*), richness (*D*) and evenness (*J*) during this study.

Station	species number (S)	Pielou's(J)	Shannon–Wiener's(H′)	Margalef's(D)
1	0.64 ± 0.06^{b}	0.86 ± 0.07^{b}	1.2 ± 0.1^{b}	0.52 ± 0.04^{c}
2	0.73 ± 0.01^{a}	0.97 ± 0.01^{a}	1.35 ± 0.02^{a}	0.54 ± 0.007^{bc}
3	0.70 ± 0.03^{ab}	0.93 ± 0.04^{ab}	1.29 ± 0.05^{ab}	0.52 ± 0.02^{c}
4	0.74 ± 0.005^{a}	0.98 ± 0.006^{a}	1.36 ± 0.009^{b}	0.59 ± 0.02^{a}
5	0.72 ± 0.04^{ab}	0.95 ± 0.06^{ab}	1.32 ± 0.09^{ab}	0.6 ± 0.03^{a}
6	0.71 ± 0.04^{ab}	0.94 ± 0.05^{ab}	1.31 ± 0.08^{ab}	0.57 ± 0.02^{ab}

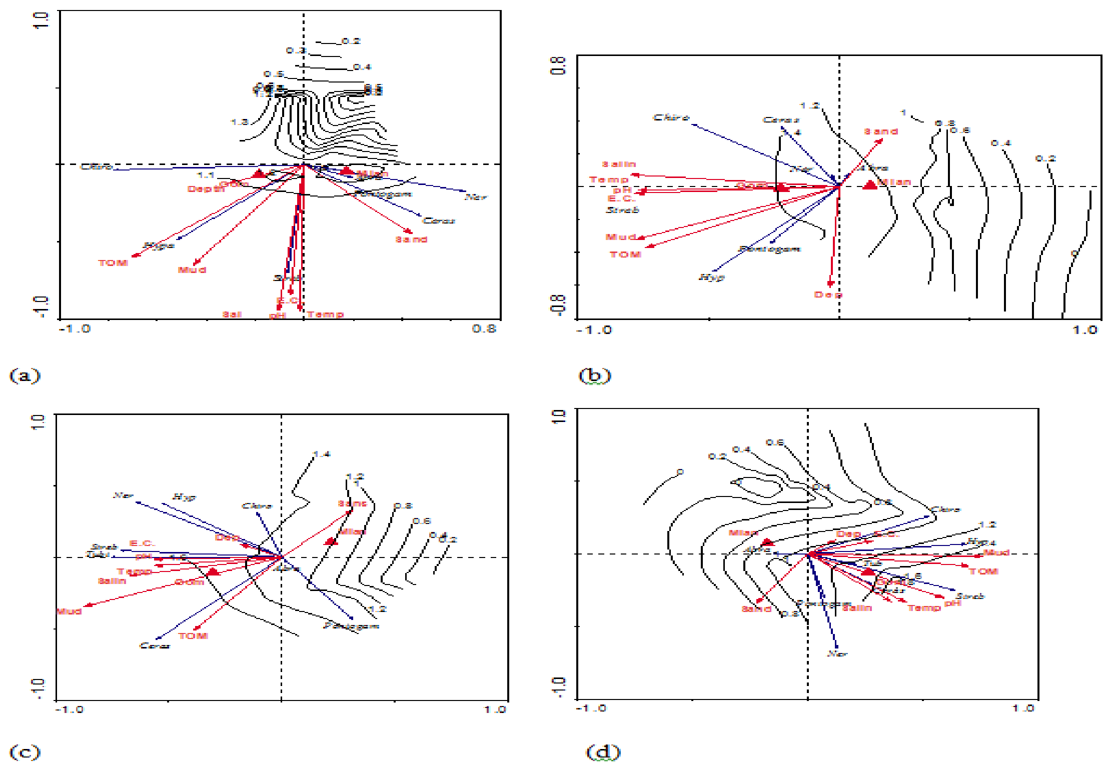

Figure 2: Results of distance-based redundancy analysis (db-RDA) biplots: (a) Spring (b) Summer (c) Autumn (d) Winter. Arrows indicate environmental variables and different species in the south-east Caspian Sea.

Discussion

Although a lot of species of macrofauna were reported in the Caspian Sea (Birshtein *et al.*, 1968; Kasymov, 1994), in comparison, the biodiversity of Caspian Sea is lower than the other seas like the Black Sea and the Barents Sea (Zenkevitch, 1963). Low salinity, i.e., (maximum 13 ppt) probably is one of the main reasons, because for true freshwater species it is too high, but for marine origin species it is too low. Therefore, these conditions are just favorable for brackish water species (Mordukhai-Boltovskoi, 1979; Karpinsky, 2005). The second reason may be the long geographical isolation of the Caspian Sea from the Black Sea (open seas), which began about 5-6 million years ago, which is adequate time for the evolution of unique fauna (Zenkevitch, 1963), meaning that great parts of the Caspian fauna are endemic (Dumont, 2000). The south Caspian Sea, with 13 ppt salinity and the highest depth, is a unique ecosystem (Taheri *et al.*, 2012). In the shallow Iranian waters, less than 22 species of macrofauna have been reported (Roohi, *et al.*, 2010; Taheri and Yazdani, 2011; Ghasemi, 2014). In the present study, eight species of macrofauna were identified. In Gorgan Bay, Saghali *et al.* (2012) found 13 families while Taheri *et al.* (2012) obtained 8 families of macrofauna in the south of the Caspian Sea. In the Baku Bay, Kasymov (1989) found 9 species of macrobenthos while Tait *et al.* (2004) obtained 62 and Parr *et al.* (2007) identified 71 species of macrofauna in the south of Baku, Azerbaijan. It should be mentioned that the present study was carried out in shallow waters. Although, in the Caspian Sea some different orders of macrofauna were reported, we did not find communities of small forms such as Cumacea and Mysidacea that had been reported by Kasymov (1994) for the south Caspian Sea. A similar result was obtained in Gorgan Bay (Saghali *et al*., 2012; Taheri *et al.*, 2012) and Noor Coast (Taheri and Yazdani, 2011). It is necessary to note that different parts of the Caspian Sea have variable structures in terms of macrofauna communities, because of different environmental conditions (Kasymov, 1994). High species diversity among the macrofauna in marine ecosystems belongs to polychaetes while fewer than ten species have been known in the Caspian Sea up to now (Birshtein *et al.*, 1968; Kasymov, 1989, 1994; Grigorovich *et al.*, 2003; Tait *et al.*, 2004). In this study, only three species of polychaetes were found. Similar results were observed in the Gorgan Bay and the south-west of the Caspian Sea (Taheri *et al*., 2007; Bandany *et al.*, 2008), the Gorgan Bay and the south-east of the Caspian Sea (Taheri *et al.*, 2012) and the south of Baku, Azerbaijan (Parr *et al.*, 2007). The community structure of southern Caspian polychaetes before 2005, was primarily dominated by members of the Ampharetidae and Nereididae, particularly *H. invalida* that was the endemic polychaete (Kasymov, 1994; Soleimani, 1994; Hashemiyan, 1998; Karpinsky, 2002; Parr *et al*., 2007; Roohi *et al*., 2010). However, after the arrival of *S. gynobranchiata*, the dominance has been replaced by this species (non-indigenous) (Parr *et al*., 2007). This disappearance may be related to the invasion of *S. gynobranchiatac* and *T. fraseri* into 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.*, 2011, 2012), it appears that *S. gynobranchiata* is able to outcompete native ampharetids in shallow waters and displace them at greater depths in the southern Caspian Sea (Ghasemi, 2014). In addition, high salinity in brackish waters and low biodiversity in the southern parts of the Caspian Sea may be the reason that species with a marine origin such as *S. gynobranchiata* can live easily at high densities in this part (Kasymov, 1994; Taheri and Yazdani, 2011). During the past century, a lot of exotic species entered the Caspian Sea (Grigorovich *et al.*, 2003). Originally *Tubificoides fraseri* had been reported in North America (Brinkhurst, 1986) but there was not any report from the Caspian Sea before 2005 (Birshtein *et al.*, 1968; Kasymov, 1989, 1994; Grigorovich *et al.*, 2003; Tait *et al.*, 2004). Taheri and Yazdani (2011) first reported the existence of this species in the Caspian Sea. They had guessed it was transported into the Caspian Sea by ballast water via the Volga–Don canal. In this study, we observed one species of oligochaeta which is similar to results reported by Taheri and Yazdani (2011) on the Noor coast, Taheri *et al.* (2012) and Saghali *et al*. (2012) in Gorgan Bay, while six species were reported in the south Caspian Sea (Parr *et al*., 2007). One of the most important groups of macrofauna in the Caspian Sea is mollusca that have been observed in all parts of it (Malinovskaja *et al.*, 1998; Parr *et al.*, 2007; Roohi *et al.*, 2010). In our study, bivalvia, with two species, in terms of diversity and density were in second place and they were observed in most stations. In other studies, one species (*Cerastoderma lamarcki*) of bivalvia was reported in Mazandaran Province (Ghasemi, 2014; Taheri and Yazdani, 2011) and two species were reported in Gorgan Bay (Taheri *et al.*, 2012). Also, we did not find any Gastropoda. Similar results were reported in the Noor coast (Taheri and Yazdani, 2011) and Gorgan Bay (Taheri *et al.*, 2012). Also, Ghasemi and Kamali (2014) reported one species of *Pyrgula* sp. in Mazandaran Province and Saghali *et al.* (2012) reported three species in Gorgan Bay, while 16 species were observed in Azerbaijan (Parr *et al.*, 2007). Identification of Amphipoda, an important component of aquatic ecosystems that was reported in Caspian Sea, is really difficult (Karpinsky, 2005). One species of Amphipoda (*P. robustoides*) was found in the present study. It is one of the most common Ponto-Caspian Amphipods. Its native range includes coastal zones of the Caspian (Grabowski, 2011). Dedju (1980) describes this species as strictly phytophilous. However, the species is often found also on stony or sand-muddy bottom (Carausu *et al.*, 1955, own data). Similar results were obtained by Ghasemi (2014), Taheri *et al.* (2012), Taheri and Yazdani (2011) and Saghali *et al.* (2012), but in the Mazandaran Province, 11 species of Amphipods were observed (Ghasemi and kamali, 2014). Also, four species were reported by Roohi *et al.* (2010) in the south Caspian Sea. But in different parts of this sea different numbers of Amphipoda were reported (Malinovskaja *et al.*, 1998; Tait *et al.*, 2004; Parr *et al.*, 2007). Unfortunatelly, the invasion of the *Mnemiopsis leidyi* into this sea, caused a decrease in the abundance of benthic crustacean. It could be related to the predation of their larvae by *M. leidyi* (Roohi *et al.*, 2010). *Chironomus albidus* is just one species of insects that was reported in the southern part of the Caspian Sea (Parr *et al.*, 2007) and we observed it in the western and eastern parts, but it was not found in the Noor coast (Taheri and Yazdani, 2011). Furthermore, three species (Malinovskaja *et al.*, 1998) of Hirudinea in the northern part of this sea and one species in the southern part (Parr *et al.*, 2007; Roohi *et al.*, 2010) were reported but no species was found in the present study. Similar results were reported by Saghali *et al.* (2012), Taheri and Yazdani (2011), Ghasemi (2014) and Taheri *et al.* (2012). Due to the number of species and their abundance and biomass, our results and those of other researchers suggest a high degree of variability in the macro-benthic fauna in the southern Caspian Sea (Kasymov, 1989; Soleimani, 1994; Hashemiyan, 1998; Karpinsky, 2002; Parr *et al*., 2007; Taheri *et al.*, 2007; Bandany *et al.*, 2008; Roohi *et al.*, 2010; Taheri and Yazdani, 2011;

Ghasemi *et al.,* 2014). In this study, *S. gynobranchiata* accounting for 40% of the total individuals was the numerically dominant species that were observed at all of the stations, and *A. ovate* representing 1.62% of the total individuals was the lowest species in terms of number. In this study, maximum diversity (1.36) and richness (0.98) were very low. Similar results were obtained in the south Caspian Sea (Taheri *et al*., 2007; Bandany *et al*., 2008; Taheri and Yazdani, 2011). The value of these indices could be related to the small number of macofauna in the sampling and the existence of the dominant species (*S. gynobranchiata*) with very high density in each season.

Results obtained from CANACO software indicated clear spatial differences in macrobenthic assemblage structures in relation to environmental variables such as grain size, TOM, depth and other factors in the southeast of the Caspian Sea. Numerous research have shown that the spatial distribution of macrobenthic invertebrates along shallow waters is related to environmental variables (Gogina and Zetller, 2010; Taheri and Yazdani, 2011; Saghali *et al.*, 2012; Ghasemi *et al.*, 2014). Also, the results of Mehdipour *et al.*(2018) indicated that temperature, nitrate, silicate, phosphate and nitrite were the most important factors in the composition and abundance fluctuation of hard substratum macro invertebrates communities, in Caspian Sea. Thus, the results of the present study are consistent with those of past studies. While Taheri *et al.* (2012) reported that they did not find any significant correlations between the density of macrofauna and all the environmental conditions, they suggested that macrofauna assemblages were controlled by other factors such as different kinds of pollution like heavy metals and rural and agricultural waste water. Based on the results of RDA analyses, the type of sediment (sand vs. mud) is one of the factors responsible for the spatial distribution of macrobenthic species in terms of feeding types (Gray, 1974; Nanami *et al.*, 2005; Taheri and Yazdani, 2011; Martins *et al.*, 2013; Ghasemi *et al.*, 2014). This means that, suspension-feeders (e.g., bivalves) are more abundant in a sandy flat in which water speed prevents accumulation of detritus on the bottom and current activity brings more potential food to the suspension-feeders than would weaker currents. In contrast, deposit-feeders (e.g., polychaetes) are more abundant in a muddy flat in which the weak currents allow organic matter to settle down and provide an adequate source of nutrition for a large number of deposit-feeders. In this study, *A. ovate* showed the most relevance with sand factor in comparison to others, while *C. lamarcki* displayed the lower dependency on the type of sediment. In contrast, three species of polychaete (*S. gynobranchiata, N. diversicolor, H. invalida*) were deposit-feeders and were more abundant in regions with small grain size. In addition, in deeper areas TOM and mud increased, and since *S. gynobranchiata* was numerically the dominant macrobenthic and the fact that it is a deposit feeder (Cinar *et al.*, 2005; Ghasemi *et al.*, 2014) a higher density of macrobenthos found in deeper water may be related to TOM percentage increase (as a food) and sand percentage decrease. These results obtained from the present study are consistent with the results of other researchers about macrobenthic invertebrates (Nanami *et al.*, 2005; Taheri and Yazdani, 2011; Martins *et al.*, 2013; Ghasemi *et al.*, 2014). Seasonal density variation of the macrofauna may depend on many factors such as breeding activity of macrofauna and predator pressure (Kevrekidis, 2005; Taheri and Yazdani, 2011). The highest density of macrofauna was observed in autumn. This may be related to density of *T. fraseri* and *C. lamarcki* that were maximal in this season. The lowest density of macrofauna was recorded in summer; it may be related to the higher predation rate as the reproduction season for many benthivorous fish in the Caspian Sea starts from late winter to late spring. Higher metabolic rate, because of an increase in temperature, associated with higher feeding intensity of predators can be the other reason for the lowest density in summer.

In conclusion, the present results demonstrated very low biodiversity in terms of macrofauna in the southeast Caspian Sea, and indicated significant correlations between the density of macrofauna and various environment conditions.

Acknowledgments

The authors are so thankful to Firuz A. for the assistance in the field samplings. A special thanks is due to Mrs. Karami who checked the English of this paper. This research was supported by the Gorgan University of Agricultural Sciences and Natural Resources.

Refrences

Abrantes, A., Pinto, F. and Moreira, M.H., 1999. Ecology of polychaete, *Nereis diversicolor*, in the Canal de Mira (Ria de Averio, Portugal): Population dynamics, production and ogenic cycle*Acta Oecologica*, 20(**4**), 267-283.

Bandany, Gh.A., Akrami, R., Taheri, M., Molla-Gholamali, M. and Yelghi, S., 2008. Distribution, abundance and biomass of polychaete in the north coast of Gorgan Bay. *Iranian Scientific Fisheries Journal*, 16, 45–52.

Birshtein, Y.A., Vinogradov, L.G., Kondakov, N.N., Astakhova, M.S. and Romanova, N.N., 1968. Atlas of Invertebrates of the Caspian Sea. Pishchevaya Promyshlennost, Moscow. pp. 178-220.

ter Braak, C.J.F., 1986. Canonical correspondence analysis: a new eigenvector method for multivariate direct gradient analysis. *Ecology*, 67, 1167-1179.

ter Braak, C.J.F. and Smilauer, P., 1998. CANOCO reference manual and user’s guide to Canoco for windows: Software for canonical community ordination (Version 4). Microcomputer Power, Ithaca, New York. 351 P.

Brinkhurst, R.O., 1986. Taxonomy of the genus *Tubificoides lastockin* (Oligochaeta, Tubificidae): species with bifid setae. *Canadian Journal of Zoology*, 64, 1270-1279.

Carausu, S., Dobreanu, E. and Manolache, C., 1955. Amphipoda forme salmastre si de apa dulce. Fauna Rep. popul. Romine, Crustacea. 4 P.

Cinar, M.E., Ergen, Z., Dagli, E. and Petersen, M.E., 2005. Alien species of spionid polychaetes (*Streblospio gynobranchiata* and *Polydora cornuta*) in Izmir Bay, eastern Mediterranean. *Journal of the Marine Biological Association of the United Kingdom*, 85, 821–827.

Dedju, I.I., 1980. Amfipody presnykh i solonovat ykh vod jugozapada SSSR. Iz d. „Shtiinca“, Kishinev. Eggers T.O. and Martens A. 2001: Bestimmungsschlüssel der Süßwasser-A mphipoda Crustacea) Deutschlands, Lauterbornia. 42 P.

Diaz-Castaneda, V. and Harris, L., 2004. Biodiversity and structure of the polychaeta fauna from soft bottoms of Bahia Todos Santos, Baja California, Mexico. *Deep-Sea Res*, II(**51**), 827-847.

Dumont, H.J., 1998. The Caspian Lake: History, biota, structure, and function. *Limnology and Oceanography*, 43, 44-52.

Dumont, H.J., 2000. Endemism in the Ponto-Caspian fauna, with special emphasis on the Onychopoda (Crustacea). *Advances in Ecological Research*, 31, 181-196.

Fazli, H., Daryanabard, G.R., Abdolmaleki, S. and Bandani, G. A., 2013. Stock assessment and management implications of golden grey mullet (*Liza aurata* Risso, 1810) in Iranian waters of the Caspian Sea. *Journal of Applied Ichthyology*, *29*, 431–436.

Fazli, H., Daryanabard, G., Salman Mahiny, A., Abdolmaleki, S., Bandani, G. and Bandpei, M.M. A. 2012. Fingerling release program, biomass trend and evolution of the condition factor of Caspian Kutum during the 1991–2011 period. *Cybium*, *36*(4), 545–550.

Fauchald, K. and Jumars, P.A., 1979. The diet of worms: A study of polychaete feeding guilds. *OMBAR*, 17, 193-294.

Fereidouni, S., Modir Rousta, H. and Azin, F., 2006. The first report of avian cholera in Miankaleh Wetland, Southeast Caspian Sea. *Podoces*, 1(**1/2**), 71-75.

Ghasemi, A.F., 2014. Species composition of benthic macroinvertebrates on the coast line vegetated rocky substrates of the southern Caspian Sea. *Transylvanian Review of Systematical and Ecological Research*, 16, 57-61.

Ghasemi, A.F. and Kamali, M., 2014. Benthic macroinvertebrates along the haraz downstream in southern caspian sea basin: In gradient of the physicochemical parameters. *International Journal of Zoology*, 2014, 1-7.

Ghasemi, A.F., Clements, J.C., Taheri, M. and Rostami, A., 2014. Changes in the quantitative distribution of Caspian Sea polychaetes: Prolific fauna formed by non-indigenous species. *Journal of Great Lakes Research*, 40(3), pp.692-698.

Ghorbanzadeh Zaferani, S.Gh., Machinchian Moradi, A., Mousavi Nadushan, R., Sari, A.R. and Fatemi, S.M.R., 2017. Spatial and temporal patterns of benthic macrofauna in Gorgan Bay, south Caspian Sea, Iran. Iranian Journal of Fisheries Sciencees, 16(1), 252-274.

Gogina, M.A., Glockzin, M. and Zettler, M.L., 2010. Distribution of benthic macrofaunal coenoses in the western Baltic Sea with regard to near-bottom environmental parameters. Modelling and prediction. *Journal of Marine Systems*, 80(**1–2**), 57-70

Gogina, M. and Zettler, M.L., 2010. Diversity and distribution of benthic macrofauna in the Baltic Sea: Data inventory and its use for species distribution modelling and prediction. *Journal of Sea Research*, 64(**3**), 313-321.

Grigorovich, I.A., Therriault, T.W. nad MacIsaac, H.J., 2003. History of aquatic invertebrate invasions in the Caspian Sea. *Biological Invasions*, 5, 103-115.

Grabowski, M., 2011. NOBANIS– invasive alien species fact sheet– *Pontogammarus robustoides*. From: Online Database of the European Network on Invasive Alien Species – NOBANIS www.nobanis.org, Date of access x/x/201x

Gray, J.S., 1974. Animal–sediment relationships. *Oceanography and Marine Biology, An Annual Review*, 12, 223-261.

Haddadi Moghadam, K., Parandavar, H., Pajand, Z. and Chubian, F., 2005. Feeding habits of sturgeon fishes in shallow coastal waters of Guilan Province, southern Caspian Sea. *Iranian Science Fisheries Journal*, 14(**3**), 37-48.

Hashemiyan, K.A., 1998. Distribution and seasonal changes of biomass and diversity of dominant macrobenthoses of Southern Coasts of the Caspian Sea. (M.Sc. Thesis) Tarbiat Moddares University. Page 112.

Karbassi, A.R. and Amirnezhad, R., 2004. Geochemistry of heavy metals and sedimentation rate in a bay adjacent to the Caspian Sea. *International Journal of Environmental Science and Technology*, 1(**3**), 191-198.

Karpinsky, M.G., 1992. Aspects of the Caspian Sea benthic ecosystem. *Marine Pollution Bulletin*, 24(**8**), 384-389.

Karpinsky, M.G., 2002. Ecology of the benthos of the Middle and Southern Caspian. VNIRO, Moscow, 283.

Karpinsky, M.G., 2005. The Caspian Sea environment. In: Kostianoy A, Kosarev A (eds) Biodiversity: The Handbook of Environmental Chemistry. Springer-Verleg. pp. 159-173.

Karpinsky, M.G., 2010. Review: The Caspian Sea benthos: Unique fauna and community formed under strong grazing pressure. *Marine Pollution Bulletin*, 61, 156-161.

Kasymov, A.G., 1989. Abundance of zooplankton and zoobenthos in Baku

Bay, Caspian ea. *Oceanology*, 28(**4**), 524-526.

Kasymov, A.G., 1994. Ecology of the Caspian Lake. Azerbaijan Publishing, Baku. 238 P.

Kevrekidis, T., 2005. Population dynamics, reproductive biology and productivity of *Streblospio shrubsolii* (Polychaeta: Spionidae) in different sediment and salinities in a Mediterranean lagoon (Monolimni Lagoon, Northern Aegean). *International Review of Hydrobiology*, 90, 100-121.

MacLeod, C.K., Crawford, C. and Moltschaniwskyj, N.A., 2004. Assessment of long term change in sediment condition after organic enrichment: defining recovery. *Marine Pollution Bulletin*, 49, 79-88.

Malinovskaja, L.V., Filippov, A.A., Osadchikh, V.F. and Aladin, N.V., 1998. Benthic macroinvertebrates of the northern Caspian Sea during recent rises in water-level. *International Journal of Salt Lake Research*, 7, 211-233.

Martins, R., Quintino, V. and Rodrigues, A.M., 2013. Diversity and spatial distribution patterns of the soft-bottom macrofauna communities on the Portuguese continental shelf. *Journal of Sea Research*, 83, 173-186.

Mehdipour, N., Gerami, M.H. and Nemati, H., 2018. Assessing benthic health of hard substratum macrobenthic community using soft bottom indicators and their relationship with environmental condition. *Iranian Journal of fisheries Science*, 17(**4**), 641-656.

Mordukhai-Boltovskoi, F.D., 1979. Composition and distribution of Caspian fauna in the light of modern data. *Internationale Revue der gesamten Hydrobiologie und Hydrographie*, 64, 1-38.

Nanami, A., Saito, H., Akita, T., Motomatsu, K.I. and Kuwahara, H., 2005. Spatial distribution and assemblage structure of macrobenthic invertebrates in a brackish lake in relation to environmental variables. *Estuarine, Coastal and Shelf Science*, 63(**1**), 167-176.

Parr, T.D., Tait, R.D., Maxon, C.L., Newton, F.C. and Hardin, J.L., 2007. A descriptive account of benthic macrofauna and sediment from an area of planned petroleum exploration in the southern Caspian Sea. *Estuarine, Coastal and Shelf Science*, 71, 170-180.

Roohi, A., Kideys, A. E., Sajjadi, A., Hashemian, A., Pourgholam, R., Fazli, H., Ganjian Khanari, A. and Eker-Develi, E., 2010. Changes in biodiversity of phytoplankton, zooplankton, fishes and macrobenthos in the Southern Caspian Sea after the invasion of the ctenophore *Mnemiopsis Leidyi*. *Biological Invasions*, 12, 2343-2361.

Saghali, M., Bagherof, R., Patimar, R., Hosseini, S.A. and Makhtoumi, N.M., 2012. Distribution, abundance and live mass of macrobenthoses in Gorgan Bay and southeast of Mazandaran, Golestan province. *Journal of Marine Science and Technology Research*, 7(**4**), 45-56.

Shahryari, A., Kabir, M.J. and Golfirozy, K., 2009. Evaluation of microbial pollution of Caspian Sea at the Gorgan Gulf. *Journal of Gorgan University of Medical Sciences*, 10(**2**), 69-73.

Soleimani, A., 1994. A preliminary study of benthic fauna in southern coastal waters of the Caspian Sea. Iran. *Fish Science Journal*, 3, 41-56.

Taheri, M., Seyfabadi, J. and Yazdani Foshtomi, M., 2007. Ecological study and species identification of polychaetes of Gorgan Bay (Bandargaz Coast). *Iranian Journal of Biology*, 20, 286-294.

Taheri, M. and Yazdani, M., 2011. Community structure and biodiversity of shallow water macro benthic fauna at Noor coast, South Caspian Sea, *Iranjournal of the Marine Biological Association UK*, 91(**3**), 607-613.

Taheri, M., Yazdani, M., Noranian, M. and Mira, S.S., 2012. Spatial distribution and biodiversity of macrofauna in the southeast of the Caspian Sea, Gorgan Bay in relation to environmental conditions. *Ocean Science Journal*, 47, 113-122.

Tait, R.D., Maxon, C.L., Parr, T.D., Newton, F.C. and Hardin, J.L., 2004. Impact assessment and benthic recruitment following exploration drilling in the South Caspian Sea. 7th SPE international conference on health, safety, and environment in oil and gas exploration. *Calgary. Canada. Mar*, 12, 29-31.

Wallace, J.B. and Webster, J.R., 1996. The role of macroinvertebrates in stream ecosystem function. *Annual Review of Entomology*, 41, 115-139.

Zenkevitch, L.A., 1963. Biology of the USSR seas. AN SSSR, Moscow. 956 P.