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Zoobenthic Crustaceans and Seasonal Distributions in Northern Coast of the Absheron Peninsula (Caspian Sea)

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Abstract

The aim of this study was to determine the zoobenthic crustaceans in northern coast of the Absheron Peninsula of the Caspian Sea. Samples were collected using a scoop net, a scraper tool and a Petersen dredge at 0.5-2.5 m depths from 23 stations in eight transects located in northern coast of the Absheron Peninsula of the Caspian Sea between 2008 and 2010. A total of 30 benthic crustacean species belonging to 6 orders were recorded during the course of this study. *Amphibalanusimprovisus*, *Niphargoides caspius* and *Palaemon elegans* were the dominant species during the study. Primary hydrographic conditions, such as temperature (7.3-27.0ºC), salinity (12.3-12.9‰), dissolved oxygen (4.42-7.54 ml L^{-1}) and pH (4.2-8.1) were recorded at each sampling station.

Keywords: Caspian Sea, Absheron Peninsula, Crustaceans, Ecology.

Absheron Yarımadası'nın Kuzey Sahili'nde (Hazar Denizi), Zoobentik Krustaseler ve Mevsimsel Dağılımları

Özet

Bu çalışmanın amacı Hazar Denizi’nin Abşeron Yarımadası’nın kuzey kıyılarında bulunan zoobentik krustase türlerini belirlemektir. Çalışmaya ait örnekler 2008-2010 yılları arasında Hazar Denizi’nin Abşeron Yarımadası’nda sekiz kesit halinde saptanan ve derinlikleri 0,5-2,5 m arasında değişen 23 istasyondan el kepçesi, kazıyıcı ve Petersen dreç kullanılarak toplanmıştır. Çalışma süresince 6 ordoya ait toplam 30 bentik krustase türü belirlenmiştir. *Amphibalanus improvisus*, *Niphargoides caspius* ve *Palaemon elegans* çalışma süresince baskın olarak bulunan türlerdir. Sıcaklık (7,3-27,0ºC), tuzluluk (‰12,3-12,9), çözünmüş oksijen (4,42-7,54 ml L^{-1}) ve pH (4,2-8,1) gibi temel hidrografik şartlar her örnekleme döneminde kayıt edilmiştir.

Anahtar Kelimeler: Hazar Denizi, Abşeron Yarımadası, krustase, ekoloji.

Introduction

The Caspian Sea is the biggest salty lake of marine origin in the world and the world's only original lake-sea and has no connection with any ocean. It lies between 47°13' and 36°34' of northern latitude and between 46°38'and 54°44' of eastern longitude (Zenkevich, 1956; 1963). Its level has been lowering slowly and has reached a depth of 27.20 m (Kasymov and Askerov, 2001). Constituting approximately 40% of continental surface waters, it is the world’s biggest body of brackish water (Dumont, 1998; 2000). Its water surface area is 374.000 km^2, water volume is 78,200 m^3, average depth is 209 m and maximum depth is 1,025 m. It consists of three parts as northern, middle and southern (Kasymov and Bagirov, 1983; Vakulovsky and Chumichev, 1998).

Hosting an endemic fauna, the sea is surrounded by Azerbaijan, Russia, the Islamic Republic of Iran, Kazakhstan and Turkmenistan (Kosarev and Yablonskaya, 1994; Dumont, 2000). This region contains intense oil and natural reserves, which are located mainly on the coasts. For example, most oil sources of Azerbaijan and 40% of those of Turkmenistan and Kazakhstan are located in the coastal region. This region is also significant in terms of gas transportation (Tolosa *et al*., 2004). However, fast developing petrol industry also brings some environmental problems. Some official solutions have been developed for such problems in Azerbaijan (Efendiyeva, 2000). However, monitoring the ecosystem changes in the region is important. The

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Absheron Peninsula, the study area, has been a gas and oil drilling region for a long time (Mehdiyeva *et al*., 2005). The region, where gas drilling activities have been conducted and pipelines have been built for over a century, has been polluted considerably. Especially Sumgait, where industrial plants are located, has been under the effect of terrestrial pollution.

It is known that the crustacean diversity in the Caspian Sea is high and, therefore, the sea is even called the "Crustacea Sea"(Cristescu *et al*., 2003). There are 1246 free-living animals in the sea. 122 species belong to benthic crustaceans. Of these species, 74 species belong to the order of Amphipoda and 20 species to the order of Mysidacea (Bondarenko, 1985; Kasymov and Askerov, 2001). There are some studies about the crustacean fauna of the sea carried out in various parts of the this region by Sars (1893a, 1893b; 1896), Derzhavin (1939, 1956), Aliev (1968), Azizov (1993, 2000), Kasymov and Askerov (2001). These researchers studied the species composition, the distribution of biotopes and the approximate average biomass of the benthic crustaceans in the sea.

Zoobenthic crustaceans play an important role in the nutrition of fish and are biological indicators as well (Kasymov, 1987). However, the number of studies conducted in the Absheron Peninsula is low. The aim of this study is to determine the zoobenthic crustacean species existing in northern coast of the Absheron Peninsula of the Caspian Sea, where there is no detailed study on the species composition and their ecological properties.

Materials and Methods

This study was carried out in northern coast of the Absheron Peninsula of the Caspian Sea (settlement Haji ZeynalabdinTagiyev, Sumgait, Corat, Novkhani, Pirshagi, Bilgah, Buzovna and Mardakan). Bottom samples were collected at 0.5-2.5 m depths from 23 stations in eight transects located in northern coast of the Absheron Peninsula of the Caspian Sea between 2008 and 2010. For a more accurate study of the fauna of benthic crustaceans, the samples were collected from dirty and clean parts of the coastal zones, coastal rocks and cliffs as well as the floating things in the water and between plants and algae (Figure 1).

Qualitative samples were collected with a scoop net and a scraper tool while the quantitative samples were collected with Petersen dredge with a capture area of 0.025 m^2 (used for washing a sieve number 21).The representatives of each group were counted and weighed.

All specimens were preserved in 4% formaldehyde solution. Collection and processing of samples were carried out by the methods of Kasymov (2000) and Romanova (1983), and the species were identified using "Atlas of invertebrates of the Caspian Sea" (Bershtein *et al*., 1968) and "A Key to Freshwater Invertebrates of the European part of USSR" (Kutikov and Starobogatov, 1977).

Some ecological parameters such as water temperature, salinity, dissolved oxygen, pH of water and structure of biotopes in the study area were measured using a multi-parameter device.

In determining zoobenthic species diversity, the formula suggested by Shannon-Weaver was used (Zar, 1984). Bray-Curtis similarity index was used to test the similarity between the sampling stations and multi-dimensional scaling (MDS) was used to analyse the regional distribution pattern (Clarke and Warwick, 2001). For these analyses, firstly log (x+1) conversion was applied on raw information. Simpson Diversity (1/D) and Margalef's index (d) values were calculated

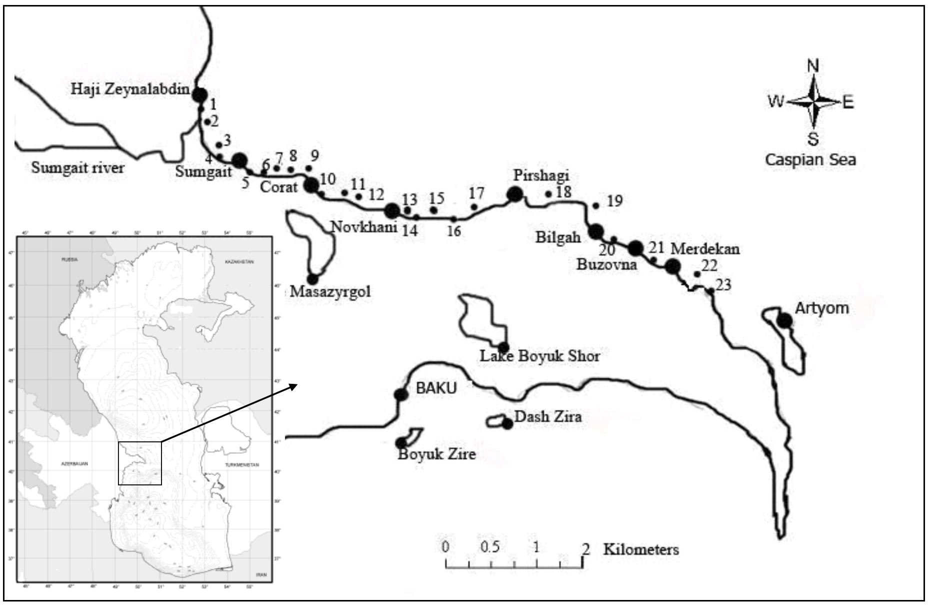

Figure 1. Map of the investigated area.

using Biodiversity program (Simpson, 1949; Margalef, 1968).

Results

In this study which was conducted in the Absheron Peninsula of the Caspian Sea between 2008 and 2010, 30 species that belong to 6 orders of crustaceans were identified. Water temperature, salinity, oxygen content and the active reaction (pH) of water were also determined. The information related to the sampling stations and the temperature (ºC), salinity (‰), and dissolved oxygen (ml L^{-1}) values areshown in Table 1.

The list of species and ecological properties at the sampling stations are provided in Table 2.

In this study, five species were (*A. improvisus, B. eburneus, P. elegans, P. adspersus, R. harrisii*) of Mediterranean origin, two species (*O. caspius, S. entomon*) of Arctic origin, one species (*A.leptodactylus*) of fresh water and the others of autochthonous fauna (Kasymov, 1987). Among these faunal groups Caspian indigenous (73%) was the dominant one.

Seasonal changes in the quantitative distribution and biomass of crustaceans in the Absheron coast of the Caspian Sea between 2008 and 2010 were given in Table 3, Figures 2 and 3.

Amphipods were the dominant group in terms of number of species and individuals. The number of species ranged seasonally from 6 to 10. In all seasons, *A.improvisus* was dominant by number and biomass.

Shannon's diversity index values for sampling stations were determined. Simpson's diversity index and Margalef's index confirmed that the above results were correlated with the other parameters. The minimum values of Simpson's diversity index (10.02) and Margalef's index (3.741) were observed at Station 8 while the maximum values of Simpson's diversity index (21.28) and Margalef's index (5.584) were recorded at Stations 1, 3 and 23 (Table 4).

The results apparently showed that the lowest species diversity was at Station 8 since it is highly polluted. Of the stations studied those with intense pollution were Stations 1, 2, 3, 4, 7 and 8. It was observed that Shannon's diversity values were close to each other. The lowest value (*H'*= 3.591) was recorded at Station 8 with intense petrol pollution and the highest (*H'*= 4.392) at Stations 1 and 3.

In order to analyse the Bray-Curtis similarity index and regional distribution pattern, multi-dimensional scaling (MDS) methods were used and the similarities between stations were determined. The similarity between the stations was very high (Figure 4, Figure 5).

As seen at Figure 3 and 4, the stations in the sampling region were considerably similar. Although mainly two groups were formed, there was a high level of similarity between these two groups as well. The reason was choosing sampling stations which were very close to one another in order to define the region more precisely. Despite the differences in sampling seasons, similarity was high.

Discussion

During the study, temperature varied between 7.3 and 27.0°C. The lowest temperature value was

Table 1. Properties of the sampling stations

Station Number	Date	Depth (m)	Temperature (°C)	Salinity (‰)	Dissolved Oxygen (ml L^{-1})	Active reaction (pH)
1	21.11.08	0.5	12.0	12.3	7.32	7.6
2	27.02.09	0.75	13.7	12.4	6.31	5.6
3	22.03.09	0.5	16.0	12.3	6.05	5.1
4	28.03.09	1	17.0	12.6	7.21	6.2
5	06.04.09	0.75	18.4	12.5	5.46	5.8
6	29.04.09	1.25	18.5	12.4	4.98	7.1
7	11.05.09	1.5	21.0	12.5	7.54	8.1
8	25.05.09	0.5	22.3	12.9	7.14	5.2
9	03.06.09	2	22.5	12.6	4.78	4.5
10	19.06.09	2.5	23.0	12.3	4.42	4.2
11	29.06.09	2	26.0	12.6	5.62	6.5
12	06.07.09	2.5	25.3	12.9	4.89	8.1
13	14.07.09	1.5	27.0	12.4	6.25	7.6
14	25.07.09	1.5	25.6	12.6	5.23	7.1
15	09.08.09	2	24.5	12.8	7.12	6.3
16	18.08.09	1	23.0	12.7	6.35	4.9
17	02.09.09	0.5	21.0	12.5	7.48	5.2
18	21.09.09	2.5	18.0	12.4	5.11	6.3
19	2.10.09	0.5	15.6	12.9	6.49	6.9
20	22.10.09	1	16.1	12.6	6.34	5.4
21	06.11.09	2.5	14.3	12.4	5.48	4.8
22	09.11.09	1.5	14.1	12.3	5.09	5.9
23	18.01.10	1.5	7.3	12.7	6.22	7.9

Table 2. List of species and ecological properties at the sampling stations

Species	Depth m	T ºC	S ‰	DO ml l^{-1}	Activate Reaction (pH)	Bottom Structure
CIRRIPEDIA						
*Balanusimprovisus*Darwin,1854	0.5-2.5	7.3-27.0	12.3-12.9	4.42-7.54	4.2-8.1	R+SIS+SSH
B.eburneus Gould., 1841	0.5-2.5	7.3-27.0	12.3-12.9	4.42-7.21	4.2-8.1	SI+SIS+SSA
MYSIDACEA						
*Paramysis baeri*Czerniavsky, 1882	0.5-2.5	12.0-27.0	12.3-12.9	4.42-7.32	4.2-8.1	R+S+SSA
P. loxolepis (Sars, 1895)	0.5-2.5	7.3-27.0	12.3-12.9	4.78-7.32	4.5-8.1	R+S+SI
P. intermedia (Czerniavsky, 1882)	0.5-2.5	7.3-27.0	12.3-12.9	4.42-7.54	4.2-8.1	SIS+SSH
Mysis microphthalma Sars,1895	0.5-2.5	7.3-27.0	12.3-12.9	4.89-7.54	4.8-8.1	SI+SA
Paramysis lacustris (Czerniavsky, 1882)	0.5-2.5	7.3-27.0	12.4-12.9	4.78-7.54	4.5-7.6	SA+SI
P. grimmi (Sars,1895)	0.5-2.5	7.3-27.0	12.3-12.9	4.89-7.54	5.6-7.54	SSA+SSH+SI
CUMACEA						
Schizorhamphus bilamellatus (Sars,1894)	0.5-2.5	7.3-27.0	12.3-12.9	4.42-7.54	4.2-8.1	SSA+SI
S. eudorelloides (Sars,1894)	0.5-2.5	7.3-27.0	12.3-12.9	4.78-7.54	4.5-8.1	SSA+S
Pterocum apectinatum (Sowinsky,1893)	0.5-2.5	7.3-25.6	12.3-12.9	4.42-7.54	4.2-8.1	R+SI
Pterocuma grande Sars,1914	0.5-2.5	7.3-27.0	12.3-12.9	4.42-7.54	4.2-8.1	R+SIS+SSH
Pterocuma rostratum (Sars,1894)	0.5-2.5	7.3-27.0	12.3-12.9	4.89-7.54	5.1-8.1	SIS+SI
Pseudocuma (*Stenocuma*) *gracile*(Sars, 1894)	0.5-2.5	7.3-27.0	12.3-12.9	4.78-7.21	4.5-8.1	SIS+SA+S
AMPHIPODA						
Dikerogammarus haemobaphes (Eichwald, 1841)	0.5-2.5	7.3-26.0	12.3-12.9	4.42-7.48	4.2-8.1	R+SIS+SSH
Paraniphargoides grimmi(Sars,1896)	0.5-2.5	7.3-26.0	12.3-12.9	4.42-7.54	4.2-8.1	SIS+SSH+R
Paraniphargoides abbreviatus (Sars,1894)	0.5-2.5	12.0-25.6	12.3-12.8	4.42-7.54	4.2-7.6	SSA+SSH+SI
Obesogammarus crassus (Sars,1894)	0.5-2.5	7.3-26.0	12.3-12.9	4.42-7.48	4.2-8.1	SSA+SSH
*Niphargoides caspius*Sars, 1894	0.5-2.5	7.3-27.0	12.3-12.9	4.42-7.54	4.2-8.1	R+SIS+SSH
Pontogammarus maeoticus(Sowinsky, 1894)	0.5-2.5	16.0-27.0	12.3-12.7	4.78-6.35	4.5-7.6	SIS+SA
Stenogammarus similis(Sars,1894)	0.5-2.5	7.3-27.0	12.3-12.9	4.42-7.54	4.2-8.1	SIS+SSA
*Chaetogammaru spauxillus*Sars, 1896	0.5-2.5	7.3-26.0	12.3-12.9	4.42-7.54	4.2-8.1	SI+SSA+SSH
Chelicorophium chelicorne (Sars,1895)	0.5-2.5	7.3-25.6	12.3-12.9	4.78-7.54	4.5-8.1	SIS+SSA
*Chelicorophium robustum*Sars,1895	0.5-2.5	12.0-25.3	12.3-12.9	4.42-7.54	4.2-8.1	SIS+SSA
Onisimus caspius(Sars,1896)	0.75-2.5	7.3-25.6	12.4-12.9	4.78-7.54	4.5-8.1	R+SIS+SA
ISOPODA						
*Saduriaentomon*Linnaeus, 1758	0.5-2.5	7.3-27.0	12.3-12.9	4.42-7.54	4.2-8.1	R+SIS+SSH
DECAPODA						
Palaemon elegans Rathke, 1837	0.5-2.5	7.3-27.0	12.3-12.9	4.42-7.54	4.2-8.1	R+SIS+SSH
Palaemon adspersus Rathke, 1837	0.5-2.5	7.3-27.0	12.3-12.9	4.42-7.54	4.2-8.1	R+SIS+SSH
Astacus leptodactylus Escholtz, 1823	0.5-2.5	7.3-27.0	12.3-12.9	4.42-7.48	4.2-7.6	SIS+SA+SI
Rhithropanopeus harrisii (Gould, 1841)	0.5-2.5	7.3-27.0	12.3-12.9	4.42-7.54	4.2-8.1	R+SIS+SSH

T: Temperature, S: Salinity, DO: Dissolved Oxygen R: Rock; S: Stone; SA: Sand; SSH: Sand-Shell; SSA: Silt-Sand, SIS: Silt-Shell, SI: Silt

recorded in winter and the highest in summer, as expected. The temperature values recorded during this study were similar to those of previous studies (Dumont, 1998). The salinity values ranged between 12.3 and 12.9‰. The Caspian Sea is known to be a remnant of the ancient the Thetis Ocean, or to be more precise, its gulf-Parathetis and to have been isolated due to terrestrial movements (Aladin and Plotnikov, 2004). The salty water of the sea has transformed into brackish in time (Cristescu *et al.*, 2003; Karpinsky *et al.*, 2005). The salinity of the sea shows the characteristic of brackish waters (Karpinsky *et al.*, 2005). The values determined in the study were in agreement with this structure of the sea. The lowest pH value (4.2) was observed at Station 10 and the highest (8.1) at Station 7 and 12. pH values were approximately 8.1 in northern part (Kosarev and Kostianayov, 2005) and low in the middle (Kasymov and Askerov, 2001). The reason for the lowest values was thought to result from performing the samplings on the coast.

Western and eastern coasts of the middle Caspian Sea are characterized with high oxygen content due to the effect of cold waters and atmosphere of the sea. Oxygen shows homogeneous distribution due to the vertical mixtures in winter. While the oxygen content was approximately 7-9 ml L^{-1} in winter, it was approximately 6-6.5 ml L^{-1} in summer (Tuzhilkin *et al.*, 2005). In this study, it was observed that the dissolved oxygen content decreased to 4.42 ml L^{-1} (Station 10) in summer months. The highest dissolved oxygen content (7.54 ml L^{-1}) was recorded in spring (Station 7).

The zoobenthic crustaceans with the greatest mean biomass in northern coast of the Absheron Peninsula of the Caspian Sea were noted in spring and summer (63.63-72.13 g/m^2) while the smallest average biomass was noted in autumn and winter (47.86-34.58 g/m^2). The seasonal changes observed in the intensity of the zoobenthic crustaceans were not surprising. It is known that the structure of biotic communities shows seasonal changes depending on temperature (Leppakoski and Olenin, 2000).

Studying the distribution composition of crustacean species in northern coast of the Absheron Peninsula of the Caspian Sea, five types of biotopes were identified. These were sand, sand-shell, silt-sand, silt-shell and silt. The highest species diversity was observed in the silt-shell biotope (30 species) while the lowest in the sand biotope (8-10 species).

Table 3. Seasonal changes in the quantitative distribution and biomass of crustaceans in the Absheron coast of the Caspian Sea between 2008 and 2010

Groups	Spring		Summer		Autumn		Winter		Average	
	no/m^2	g/ m^2	no/m^2	g/ m^2	no/m^2	g/ m^2	no/m^2	g/ m^2	no/m^2	g/ m^2
CIRRIPEDIA	51	11.87	79	15.81	49	9.76	29	8.90	52	11.59
Amphibalanus improvisus	32	7.45	51	10.20	38	7.57	20	6.14	35	7.84
B. eburneus	19	4.42	28	5.61	11	2.19	9	2.76	17	3.75
MYSIDACEA	12	0.49	14	0.90	16	1.36	6	0.56	13	0.85
Paramysis baeri	1	0.04	2	0.13	1	0.08	1	0.09	1	0.09
P. loxolepis	3	0.12	2	0.13	4	0.40	0	0	2	0.16
P. intermedia	1	0.04	3	0.19	1	0.08	2	0.19	2	0.13
Mysis microphthalma	2	0.08	1	0.06	2	0.17	2	0.19	2	0.13
Paramysis lacustris	4	0.17	4	0.26	5	0.40	1	0.09	4	0.23
P. grimmi	1	0.04	2	0.13	3	0.23	0	0	2	0.11
CUMACEA	96	2.48	125	3.71	63	2.99	87	3.61	94	3.21
Schizorhamphus bilamellatus	28	0.73	41	1.32	17	0.81	26	1.08	28	0.99
S. eudorelloides	19	0.50	26	0.84	12	0.57	14	0.58	18	0.63
Pterocuma pectinatum	6	0.13	11	0.36	5	0.24	8	0.33	8	0.27
Pterocuma grande	12	0.31	20	0.32	10	0.47	9	0.37	13	0.37
Pterocuma rostratum	14	0.37	8	0.26	7	0.33	16	0.66	11	0.40
Pseudocuma (Stenocuma) gracile	17	0.44	19	0.61	12	0.57	14	0.59	16	0.55
AMPHIPODA	131	19.56	151	21.14	131	13.7	102	11.64	129	16.51
Dikerogammarus haemobaphes	16	2.37	25	3.50	14	1.65	16	1.96	18	2.37
Paraniphargoides grimmi	8	1.19	12	1.68	9	1.06	4	0.49	8	1.11
Paraniphargoides abbreviatus	14	2.07	17	2.38	12	1.42	8	0.08	12	1.49
Obesogammarus crassus	6	0.89	5	0.70	7	0.83	6	0.74	6	0.79
Niphargoides caspius	22	3.26	26	3.64	16	0.12	9	1.11	18	2.03
Pontogammarus maeoticus	18	2.67	21	2.94	21	2.48	18	2.21	20	2.58
Stenogammarus similis	11	1.78	14	1.96	12	1.41	8	0.98	11	1.53
Chaetogammarus pauxillus	14	2.07	18	2.52	17	2.01	12	1.48	15	2.02
Chelicorophium chelicorne	7	1.04	6	0.84	8	0.95	6	0.74	7	0.89
Chelicorophium robustum	10	1.48	4	0.56	11	1.30	9	1.11	9	1.11
Onisimus caspius	5	0.74	3	0.42	4	0.47	6	0.74	5	0.59
ISOPODA	3	0.08	5	0.12	2	0.06	1	0.03	3	0.07
Saduriaentomon	3	0.08	5	0.12	2	0.06	1	0.03	3	0.07
DECAPODA	53	29.15	78	30.42	48	19.99	11	9.84	48	22.29
Palaemon elegans	21	11.55	36	14.04	22	9.16	5	4.47	21	9.80
Palaemon adspersus	16	8.80	21	8.19	16	6.66	3	2.68	14	6.53
Astacus leptodactylus	10	5.50	14	5.46	6	2.50	2	1.79	8	3.81
Rhithropanopeus harrisii	6	3.30	7	2.73	4	1.67	1	0.90	5	2.15
TOTAL	346	63.63	452	72.1	309	47.86	236	34.58	339	54.52

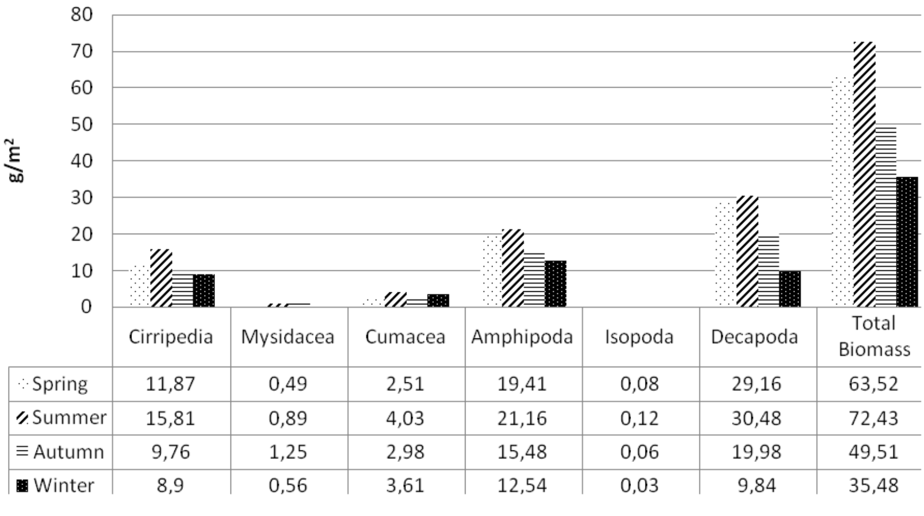

Figure 2. Biomass alteration of zoobenthic groups in the Absheron coast of the Caspian Sea between 2008 and 2010.

To conclude, in this study zoobenthic species diversity in the Absheron Peninsula of the Caspian Sea, where there is no detailed study, was determined and the seasonal distribution of the species in various depths and biotopes was studied. In the study area, the effects of pollution on the number of individuals and species diversity were observed. The influence of environmental and anthropic factors on the

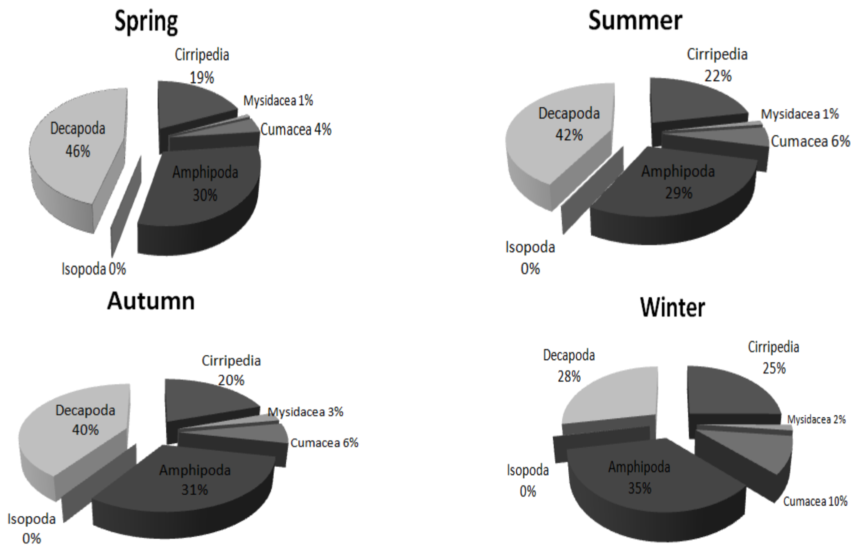

Figure 3. Biomass percentage of zoobenthic groups in the Absheron coast of the Caspian Sea between 2008 and 2010.

Table 4. Index score distribution of crustaceans in the Absheron coast of the Caspian Sea between 2008 and 2010

Station	SimpsonsDiversity (1/D)	SimpsonsDiversity (D)	Margalef'sindex (d)	H' (log2)
1	21.282	0.047	5.269	4.392
2	18.528	0.054	5.259	4.327
3	21.276	0.047	5.441	4.392
4	18.333	0.055	5.421	4.301
5	15.93	0.063	4.364	4.077
6	13.103	0.076	4.163	3.846
7	12.186	0.082	4.476	3.903
8	10.024	0.1	3.741	3.591
9	11.673	0.086	4.531	3.798
10	10.409	0.096	4.192	3.730
11	13.457	0.074	4.478	3.890
12	18.713	0.053	4.798	4.212
13	10.373	0.096	4.485	3.757
14	11.866	0.084	4.718	3.931
15	16.429	0.061	4.522	4.097
16	16.195	0.062	4.478	4.033
17	12.864	0.078	4.119	3.744
18	14.161	0.071	4.82	4.046
19	12.536	0.08	4.884	3.949
20	13.735	0.073	5.465	4.067
21	13.9	0.072	4.57	3.985
22	17.651	0.057	4.877	4.149
23	17.56	0.057	5.584	4.237

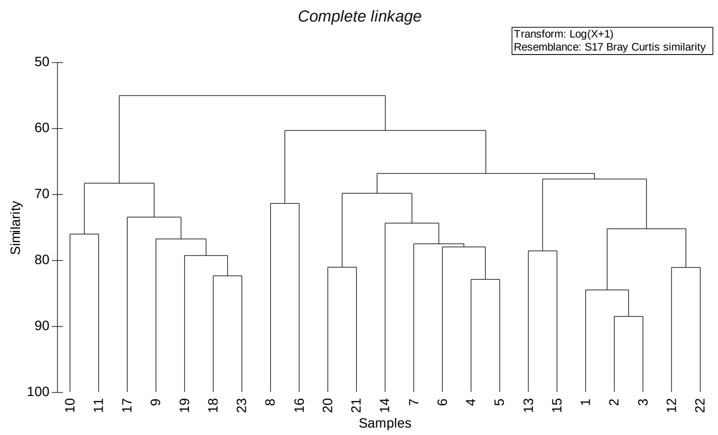

Figure 4. Similarity between the sampling stations.

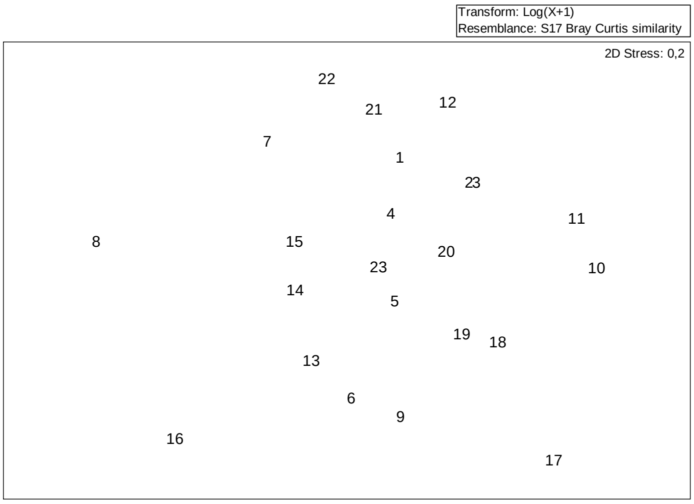

Figure 5. MDS ordination of the stations produced with Bray–Curtis average clustering technique.

distribution of crustacean species was also investigated. Finally, there is a clear need for further detailed studies in this area.

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