Journal of the Marine Biological Association of the United Kingdom, 2011, 91(3), 607–613.
doi:10.1017/S0025315410000378

Community structure and biodiversity of shallow water macrobenthic fauna at Noor coast, South Caspian Sea, Iran

MEHRSHAD TAHERI AND MARYAM YAZDANI FOSHTOMI
Iranian National Center for Oceanography, 9, Etemadzadeh Avenue, West Fatemi Street, Tehran

For studying community structure and biodiversity of macrofauna, seasonal samplings were carried out along three different depths (5, 15 and 30 m) in four transects (12 stations) at Noor coast during 2005. Four higher taxa were determined. Polychaeta was the dominant group comprising 96.61 of the total individuals, followed by Bivalvia 1.35%, Oligochaeta 1.15% and Amphipoda 0.87%. Of the six encountered species, the polychaete, Streblospio gynobranchiata *accounted for 84.95 of the total population. Also,* Tubificoides fraseri *was observed in the Caspian Sea for the first time. During this study, density of macrofauna increased with depths, total organic matter and percentage of silt–clay. The highest density was obtained in winter and the lowest was observed in summer. Maximum diversity, richness, and evenness were obtained, 0.91, 1.05 and 0.88, respectively. Also, multivariate analysis separated differences of density between seasons and depths.*

Keywords: biodiversity, community structure, macrobenthic fauna, Caspian Sea, Iran

Submitted 16 September 2009; accepted 18 January 2010; first published online 2 June 2010

INTRODUCTION

Macrobenthic animals have an important role in marine environments as they are involved in mineralization, ventilation and mixing of sediments and cycling of organic matter (Snelgrove, 1998; Heilskov & Holmer, 2001). Density and distribution of them have been affected by various physical and chemical conditions such as depth, currents, seasons, sediment grain size, organic matter contents and contaminations of the sediments (Pearson, 1970; Nybakken, 1993).

The Caspian Sea is the largest landlocked water body on the Earth, containing 40% of the Earth's continental water mass (Dumont, 1998). It has low biodiversity which may be related to low salinity (1–13) and long-term geographical isolation and independent evolution (Birshtein *et al.*, 1968; Kasymov, 1994). On the other hand, great parts of its fauna are endemic (Dumont, 2000) hence, it could be interesting for the evolutionist in natural history, as well as for the geologist. Nowadays, biological invasions are one of the most important problems in this sea. Unfortunately some species were transported by ballast water into this sea through the Volga–Don canal (Grigorovich *et al.*, 2003). Also, oil extraction and petroleum production are the other main problems for living animals in this sea. These contaminations can impact on benthic populations as a result of discharge and seafloor deposition of drilling cuttings and associated muds, and chronic low level release of hydrocarbons.

Macrofauna are a major group of soft bottom animals in the Caspian Sea. They are one of the most abundant food items in the diet of sturgeon fish (Haddadi Moghadam *et al.*, 2005) and other benthivore fish. Although the ecology and biodiversity of macrobenthos have been studied in many parts of the world, 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). All the mentioned studies only provide animals' names and densities and there is no study on biodiversity and community structure. The purpose of this paper was to study macrobenthic community structure and biodiversity in the shallow water of the south Caspian Sea. These results can help us to evaluate environmental and man-made changes on fauna and also help in the management and conservation of the environment.

MATERIALS AND METHODS

Study area

Mazandaran Province is located in the middle of the southern beach of the Caspian Sea along the Iranian coast. The gradient and structure of the seabed are uniform in this area. There is almost no tidal current. The surface salinity to 30 m depth varies negligibly (Hadjizadeh Zaker *et al.*, 2007). No major rivers exist in the vicinity of the sampling sites but the most important phenomenon in these areas is strong rip currents so that a lot of swimmers are killed by it every year. Sampling was conducted on the Noor coast (between Royan and Rostamrood) within 51°59′35″ to 52°02′31″E and 36°35′25″ to 36°36′29″N (Figure 1).

Data collection

Seasonal samplings were carried out along three different depths (5, 15 and 30 m) in four transects (12 stations in

Corresponding author:
M. Taheri
Email: mehrshadtaheri@yahoo.com

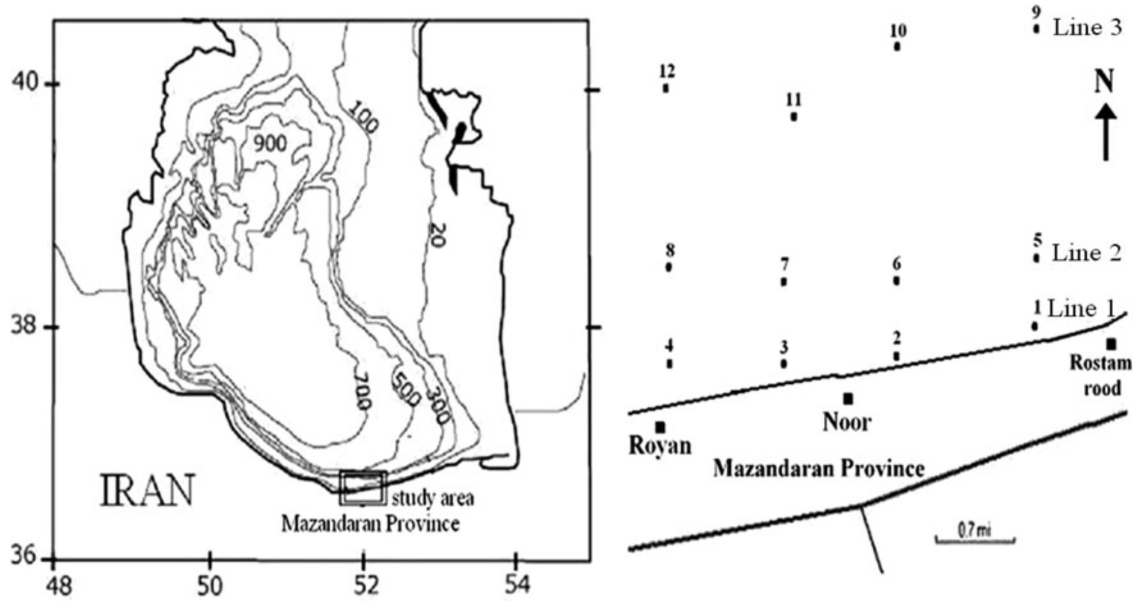

Fig. 1. Map of sampling area.

total) during 2005 (Figure 1). Three replicate samples were collected at each station using a 250 cm^2 Van Veen grab (Mistri *et al.*, 2002). The contents of each grab were gently sieved in the field using 0.5 mm mesh and retained material fixed in 4% buffered formalin and stained with rose Bengal (Abrantes *et al.*, 1999). In the laboratory, macrofauna were sorted under stereomicroscope, identified and counted.

Another three separated replicate sediment samples were taken on each station for measured percentage of total organic matter (TOM) and sediment grain size by 250 cm^2 Van Veen grab. Sediment from the surface (≈4 cm) was sub-sampled and stored in a cleaned plastic container (MacLeod *et al.*, 2004). Total organic matter was determined by weight loss on ignition (4 hours at 550°C) after drying (24 hours at 70°C) to constant weight (Abrantes *et al.*, 1999). To determine sediment particle size nearly 150 g of each grab sample was submitted to standard dry-sieve through a series of mesh sizes (from 63 μ 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 & Harris, 2004).

The macrobenthic community structure was described by univariate analysis based on the following parameters: density, species number (*S*), diversity (as Shannon–Wiener's, *H′*), richness (as Margalef's, *D*), and evenness (as Pielou's, *J*). The mentioned parameter values per square metre were calculated at all stations. Prior to analysis, data were tested for normality (using Shapiro–Wilk) and homogeneity of variance (using Levene's test). Significance of all tests was accepted at $P < 0.05$. Whenever data were normal and homogeneous, two-way analysis of variance (ANOVA) (station × season) was used to test for temporal and spatial differences in the physical parameters (TOM, sand and silt–clay percentage) and biological parameters (density, diversity, richness and evenness). Tukey's test was used to assess significant differences between stations and seasons. The significance level adopted was $P < 0.05$. The correlation of ecological indices with percentage TOM, sand and silt–clay, were determined using the Pearson's rank-correlation coefficient. The frequency of occurrence (F%) of the species was calculated according to Arasaki *et al.* (2004). Based on this matter, we classified the species as constant ($F > 50\%$), common ($10\% \leq F \leq 50\%$) and rare ($F < 10\%$).

For understanding which sediment characteristics had the greatest influence on faunal composition and structure, principal component analysis (PCA) was applied to a correlation matrix of three sediment characteristics. Percentage of TOM, sand and silt–clay are plotted in two-dimensional space. Before this analysis, data of sediment characteristics had been standardized by: $y = (x - x_m)/s_x$, where y = standardized variable, x = not standardized variable, x_m = mean value of x and s_x = standard division of x. Data on the density of species were employing multivariate statistical methods of classification and ordination. The data were

Table 1. Mean sediment variable measured during this study.

	TOM			Sand			Silt–clay		
	Line 1	Line 2	Line 3	Line 1	Line 2	Line 3	Line 1	Line 2	Line 3
Winter	1.66	2.9	4.26	97.46	78.92	53.53	2.57	15.65	45.64
Spring	2.31	3.37	4.48	97.38	92.89	77.73	2.46	6.01	22.22
Summer	2.75	3.56	6.24	97.45	93.08	66.86	2.72	4.91	33.04
Autumn	2.38	2.8	5.48	97.5	91.27	70.37	2.49	7.1	28.83

TOM, total organic matter.

transformed by Log (x + 1). Similarity was calculated using the Bray–Curtis coefficient. Non-metric multidimensional scaling (nMDS) was used to analyse changes of macrofauna communities over the experimental period. Species with one individual and oligochaeta were eliminated for these analyses (Diaz-Castaneda & Harris, 2004). All the data from the four stations at each depth (three replicates, totaling 12 samples from each depth) were considered as a line (L1= 5 m, L2= 15 m and L3= 30 m) and the lines from different seasons were compared (Figure 1).

RESULTS

The benthic environment

The percentage of TOM, sand and silt–clay are shown in Table 1. Two-way ANOVA revealed significant differences among stations and seasons and also their interaction (Table 2). Maximum TOM was obtained in summer while minimum was observed in winter. Maximum and minimum percentages of sand were obtained in spring and winter, respectively. Maximum percentage of silt–clay was obtained in winter while the lowest amount was observed in spring.

The result of the PCA is shown in Figure 2. Two first axes explained 98.28% of the total variance which indicated the study area could be divided in two regions based on the sediment characteristics. Group PCA I corresponded to the areas with shallow and intermediate depth area (5 and 15 m) and high percentage of sand and PCA II to deeper area (30 m) with high percentage of TOM and silt–clay.

Community structure

Polychaeta numerically dominated the macrofauna during this study. The mean proportion of Polychaeta was 96.61% of all the individuals. The next abundant groups were: Bivalvia, 1.35%, Oligochaeta, 1.15% and Amphipoda, 0.87%.

In the present study, three species of Polychaeta, *Nereis diversicolor*, *Hypania invalida* and *Streblospio gynobranchiata*, one species Bivalvia, *Cerastoderma lamarcki*, one species Amphipoda, *Pontogammarus maeoticus* and a few species of oligochaetes with a new alien to the Caspian Sea, *Tubificoides fraseri* (the other species were not identified) were observed. Presence and F% of them are shown in Table 3.

Two-way ANOVA revealed significant differences in densities among stations and seasons, also, significant interactions were observed so that the maximum of it was obtained in winter (Table 2). According to Tukey's test maximum and minimum densities were obtained in winter and summer, respectively. In general, density increased with depth. This increase was observed in all seasons (Table 4). It is necessary to mention that *S. gynobranchiata* was the dominant species during this study so that density of it was 84.95% of the total of obtained density.

Ecological indices

The ecological indices which include species number (*S*), diversity (*H′*), richness (*D*) and evenness (*J*) were calculated at each station (Figure 3). Two-way ANOVA revealed significant differences in diversity, richness and evenness among stations and seasons. Also, a significant interaction was

Table 2. Results of two-way ANOVA (station, season and interaction) on all of the analyses.

	TOM%		Sand%		Silt–clay%		Density		Diversity		Richness		Evenness	
	F	*P*	F	*P*	F	*P*	F	*P*	F	*P*	F	*P*	F	*P*
Station	442.79	0.00	249.28	0.00	272.05	0.00	92.20	0.00	5.86	0.08	26.58	0.00	26.67	0.00
Season	41.51	0.00	22.98	0.00	18.47	0.00	22.79	0.00	2.26	0.00	6.85	0.00	12.88	0.00
Interaction	10.28	0.00	7.42	0.00	7.23	0.00	17.95	0.00	2.26	0.04	1.87	0.09	9.27	0.00

TOM, total organic matter.

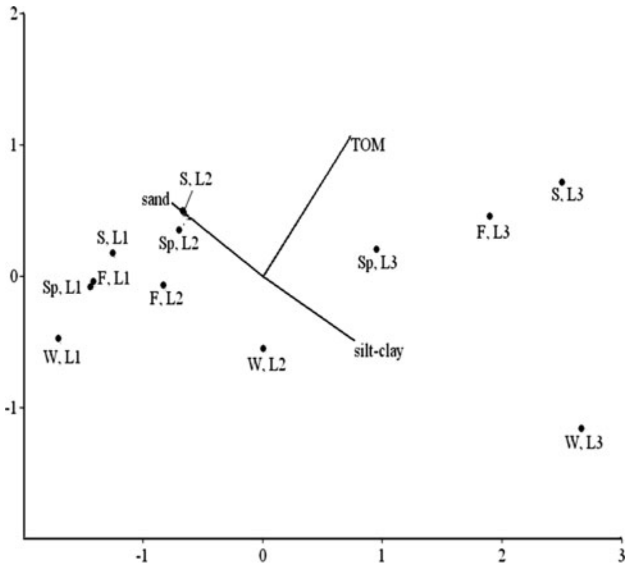

Fig. 2. Principal component analysis spatial presentation of stations based on sediment characteristics. W, winter; Sp, spring; S, summer; F, fall (autumn); TOM, total organic matter. L1= line 1, L2= line 2 and L3= line 3.

observed among them except in evenness so that the maximum of these effects could be in winter (Table 2). The highest number of species (6 species) was obtained in line 1 in autumn and the lowest (3 species) was in line 3 in winter. The highest diversity (0.91) and richness (1.05) was in line 1 in autumn but the lowest (0.14 and 0.23, respectively) observed in winter. Maximum and minimum values of evenness were obtained in line 1 in summer (0.88) and line 3 in winter (0.15), respectively. In general, the values of the mentioned indices decreased with depths at all seasons. Also, Table 5 presents the minimum and maximum value of each index and its correlation with the measured factors of sediments.

Multivariate analysis

The Bray–Curtis analysis (Figure 4) separated four groups in relation to the sediment characteristics and depths: (A) comprised four lines at 5 m depth, density of this group was the lowest (211–455 ind/m^2); (B) joined four lines at 15 m depth, density of this group was 1022–2211 ind/m^2; (C) formed by three lines and density of this group was 3124–4211 ind/m^2; and (D) comprised one line with the highest density value, its density was 10,548 ind/m^2.

The nMDS ordination plot for the complete data is shown in Figure 5. The groups of lines separated by nMDS were very similar to those generated with the Bray–Curtis coefficient. Stress value was 0.018.

Table 4. Mean number of species recorded (per m^2) in each season during this study.

	Line 1	Line 2	Line 3
Winter	211.11 ± 33.77	2211.11 ± 309.62	10548.89 ± 1616.24
Spring	455.55 ± 100.34	3124.77 ± 307.61	4211.11 ± 156.76
Summer	245.77 ± 40.13	1022.22 ± 113.97	1718.22 ± 161.76
Autumn	255.55 ± 47.10	1500 ± 185.69	4003.556 ± 510.37
Annual mean	292 ± 55.34	1964.77 ± 229.22	5129.44 ± 611.28

DISCUSSION

In the present study, six species of macrofauna were identified. In the Baku Bay, Kasymov, (1989) found 9 species while Tait *et al.* (2004) obtained 62 and Parr *et al.* (2007) showed 71 species of macrofauna in the south of Baku, Azerbaijan. It should be mentioned that the present study was carried out at shallow water while Tait *et al.* (2004) and Parr *et al.* (2007) had sampled from shallow water to near 800 m depth. Although a lot of species of macrofauna were reported in the Caspian Sea (Birshtein *et al.*, 1968; Kasymov, 1994), we did not find any communities of small forms such as Cumacea and Mysidacea in the study area. A similar result was obtained by Guseinov (2005) in Dagestan Region.

Although polychaetes have high species diversity among the macrofauna in marine ecosystems, 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 them were found. Similar results were observed in the Gorgan Bay—south-west of the Caspian Sea—(Taheri *et al.*, 2007; Bandany *et al.*, 2008) and the south of Baku, Azerbaijan (Parr *et al.*, 2007). Also, our result showed the macrofauna was numerically dominated by Polychaeta as the same result had been obtained by Parr *et al.* (2007). On the other hand, *Streblospio gynobranchiata* was the dominant species during this study but according to Parr *et al.* (2007), *Hypania invalida* was the dominant species before arrival of *S. gynobranchiata* to the Caspian Sea. In other words, after arrival of *S. gynobranchiata* to this sea, the community structure of macrofauna has been changed. The same result was reported by Kotta *et al.* (2001) after the invasion of *Marenzelleria viridis* in the north of the Baltic Sea. In the other seas, higher number of species has been reported, for

Table 3. Frequency of occurrence during this study. L1 = line 1, L2 = line 2 and L3 = line 3.

	Winter			Spring			Summer			Autumn		
	L 1	L2	L3	L 1	L2	L3	L 1	L2	L3	L 1	L2	L3
Streblospio gynobranchiata	0	100	100	16.66	100	100	100	100	100	91.66	100	100
Nereis diversicolor	25	75	100	8.33	83.33	100	16.66	66.66	83.33	33.33	25	100
Hypania invalida	100	33.33	0	100	100	100	25	0	0	75	8.33	0
Pontogammarus maeoticus	50	8.33	0	100	16.66	0	0	0	0	33.33	8.33	0
Cerastoderma lamarcki	0	0	0	0	0	0	100	100	16.66	58.33	83.33	83.33
Oligochaeta	8.33	33.33	50	41.66	85.33	16.66	8.33	25	66.66	8.33	16.66	33.33

https://doi.org/10.1017/S0025315410000378 Published online by Cambridge University Press

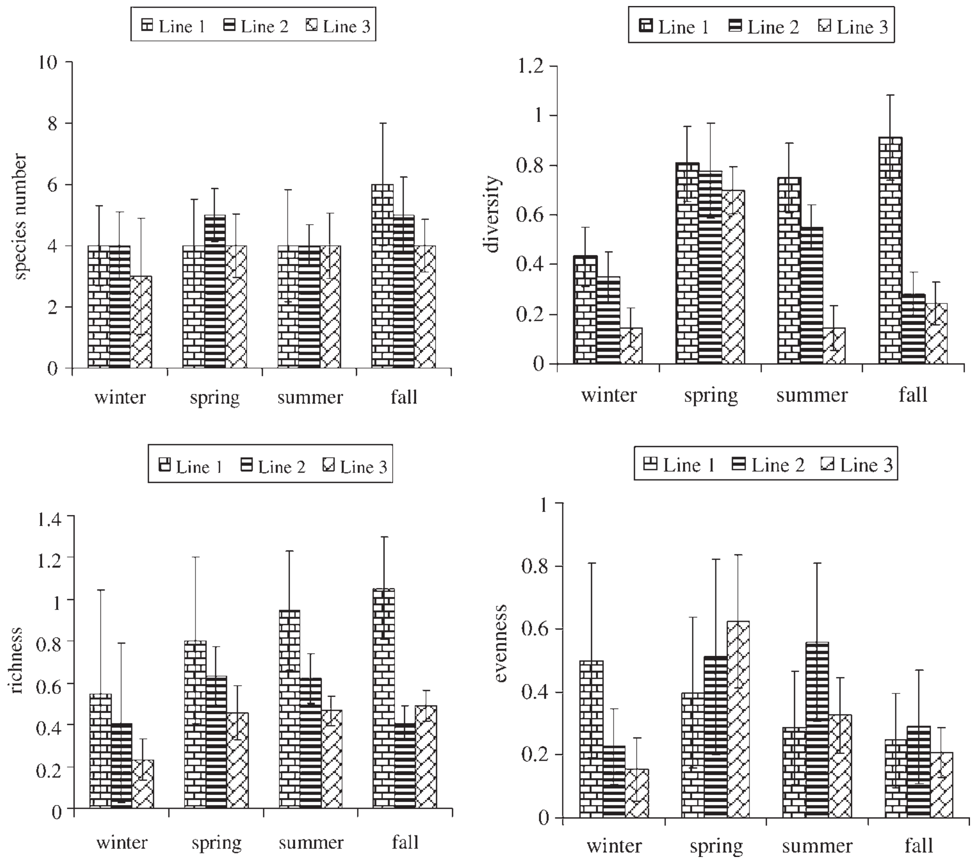

Fig. 3. Species number (*S*), diversity (*H′*), richness (*D*) and evenness (*J*) during this study.

example, in the Black Sea (Bulgarian region), 1192 species of macrofauna were reported (Golemansky, 2007).

Salinity in brackish waters is one of the most important factors influencing distribution and dispersal of animals (Leppakoski & Olenin, 2000). The south Caspian Sea has the most amount of salinity among all parts of this sea (about 13) and the lowest biodiversity in this part could be related to high salinity because a large number of the Caspian Sea fauna are endemic and adapted to live in waters with low salinity (Dumont, 2000). In this case, biodiversity in the southern parts is low and species with marine origin such as *Streblospio gynobranchiata* can live easily with high density in this part (Kasymov, 1994).

During the last century, a lot of alien species arrived into the Caspian Sea (Grigorovich *et al.*, 2003). *Tubificoides fraseri* had been originally 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) so our study must be the first report of the existence of this species in the Caspian Sea. We guess it was transported into the Caspian Sea by ballast water via the Volga–Don canal.

Sediment grain size and TOM are two of the most important characteristics of macrobenthos dispersal (Nybakken, 1993; Diaz-Castaneda & Harris, 2004). In this study, it was observed that the percentage of TOM and silt–clay increased with depths but sand percentage decreased (Table 1).

Table 5. Minimum (Min) and maximum (Max) values of the ecological indices measured. Pearson's rank-correlation coefficient value among the indices, total organic matter (TOM), sand and silt–clay.

Indices	Min	Max	TOM	Sand	Silt–clay
S	3	6	−0.011	0.249	−0.242
H′	0.14	0.91	−0.243	0.496**	−0.397**
D	0.23	1.05	−0.228	0.466**	−0.432**
J	0.15	0.88	−0.229	0.447**	−0.381**

**, $P < 0.01$.

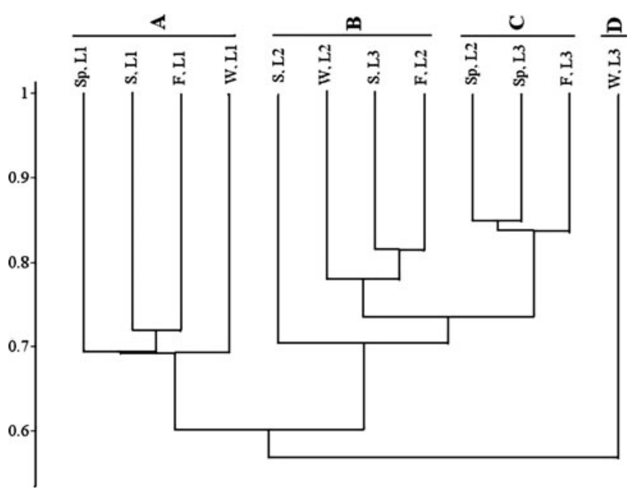

Fig. 4. Similarity among lines using the Bray–Curtis coefficient. W, winter; Sp, spring; S, summer; F, fall (autumn). L1= line 1, L2= line 2 and L3= line 3.

https://doi.org/10.1017/S0025315410000378 Published online by Cambridge University Press

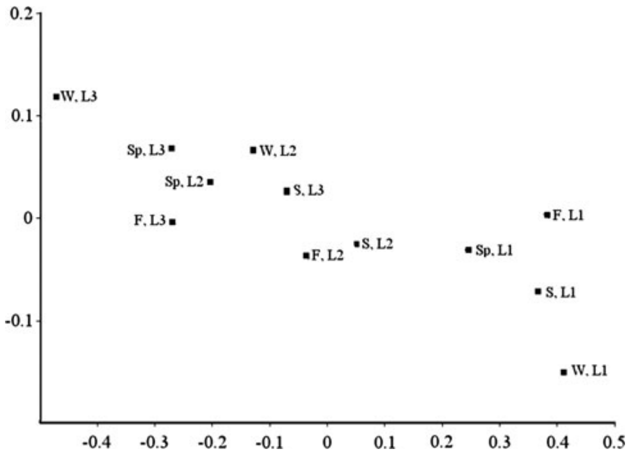

Fig. 5. Non-metric multidimensional scaking plot of macrofauna communities. W, winter; Sp, spring; S, summer; F, fall (autumn). L1= line 1, L2= line 2 and L3= line 3.

Principal component analysis divided the study area in two different areas: (i) shallow and intermediate depth area (5 and 15 m) with high sand percentage; and (ii) deeper area (30 m) with the high percentage of TOM and silt–clay. Because *Streblospio gynobranchiata* was numerically dominant of macrofauna and with regard to this fact it is a deposit feeder (Cinar *et al.*, 2005) a higher density of macrobenthos found in deeper water may be related to TOM percentage increase (as a food) and sand percentage decrease.

Rip current is the most important phenomenon in the southern parts of the Caspian Sea. Although its velocity was not measured in the present study, maximum rip backwash velocities can reach to 1.6 m/s (McLachlan & Hesp, 1984). Rip current can disturb the sediment surface and transport fine parts to a deeper area (MacMahan *et al.*, 2005) and also it can wash the meiofauna, macrofauna and zooplankton (macrofauna larvae) so that the distribution of them is related to rip current (McLachlan & Hesp, 1984). Also, it can wash TOM and indirectly effects the availability of organic matter used as food for macrofauna. Hence, it could be said that the effect of the rip current on sediment, TOM and washing macrofauna is another reason for increasing density with depths.

Seasonal density variation of the macrofauna is related to: (i) reproduction activity of macrofauna; and (ii) predator pressure (Mistri *et al.*, 2002; Kevrekidis, 2005). The highest density of macrofauna was observed in winter. This may be related to density of *S. gynobranchiata* that was maximal in this season (Taheri *et al.*, 2009). The lowest density of macrofauna at all the sampled depths was recorded in summer; it may be related to: (i) the higher predation rate as reproduction season for many benthivore fish in the Caspian Sea starts from late winter to late spring; and (ii) higher metabolic rate, due to increase in temperature, associated with higher feeding intensity of predators.

Maximum species number (6), diversity (0.91) and richness (1.05) were very low. Similar results were obtained in the Gorgan Bay for Polychaeta (Taheri *et al.*, 2007; Bandany *et al.*, 2008). The value of these indices could be related to the small number of macofauna and existence of *Streblospio gynobranchiata* as the dominant species with very high density in each season.

The multivariate analyses indicated four macrobenthic groups related to sediment characteristics and depths. Stations with the low percentage of TOM and silt–clay and high percentage of sand were observed at group A with 5 m depth. This group had the lowest density. In group B, density of macrofauna increased rather than group A. Finally, in groups C and D, the highest densities were observed. The result of nMDS plot was observed to be very similar to similarity analysis. There is not any report about community structure of macrofauna at the south of the Caspian Sea. Hence we cannot compare the results of this study to other studies.

ACKNOWLEDGEMENTS

The authors are so thankful to Professor Christer Erséus and Mr Sebastian Kvist from the Department of Zoology, Gothenburg University, Sweden for identification of *Tubificoides fraseri*. We are also thankful to Mrs Shima Yazdani, A. Rashidi, A. Aliarab and R. Jamshidi for their assistance.

REFERENCES

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 oogenic cycle. *Acta Oecnologica* 20, 267–283.

Arasaki E., Muniz P. and Pires A.M. (2004) A functional analysis of benthic macrofauna of the São Sebastiao Channel (southern Brazil). *Marine Ecology* 25, 249–263.

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.* Moscow: Pishchevaya Promyshlennost.

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

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.

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 Research 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.

Golemansky V. (2007) Biodiversity and ecology of the Bulgarian Black Sea invertebrates. *Biogeography and Ecology of Bulgaria* 82, 537–554.

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

Guseinov M.K. (2005) Zoobenthic communities of the Dagestan region of the Caspian Sea. *Russian Journal of Marine Biology* 31, 7–13.

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 Scientific Fisheries Journal* 14, 37–48.

Hadjizadeh Zaker N., Ghafari P. and Jamshidi S. (2007) Physical study of the southern coastal waters of the Caspian Sea, off Babolsar, Mazandaran in Iran. *Journal of Coastal Research* 50, 564–569.

Heilskov A.C. and Holmer M. (2001) Effect of benthic fauna on organic matter mineralization in fish-farm sediment: importance of size and abundance. *Journal of Marine Science* 58, 427–434.

Kasymov A.G. (1989) Abundance of zooplankton and zoobenthos in Baku Bay, Caspian Sea. *Oceanology* 28, 524–526.

Kasymov A.G. (1994) *Ecology of the Caspian Lake*. Baku: Azerbaijan Publishing.

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.

Kotta J., Orav H. and Sandberg-Kilpi E. (2001) Ecological consequence of introduction of the polychaete *Marenzelleria* cf. *viridis* into shallow-water biotope of the northern Baltic Sea. *Journal of Sea Research* 46, 273–280.

Leppakoski E. and Olenin S. (2000) Xenodiversity of the European brackish water seas: the North American contribution. *Marine Bioinvasion. Proceedings of the first National Conferences, January 24–27, Massachusetts Institute of Technology*, pp. 107–119.

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.

McLachlan A. and Hesp P. (1984) Faunal response to morphology and water circulation of a sandy beach with cusps. *Marine Ecology Progress Series* 19, 133–144.

MacMahan J.H., Thornton Ed B., Stanton T.P. and Reniers Ad J.H.M. (2005) RIPEX: observation of a rip current system. *Marine Geology* 218, 113–134.

Mistri M., Fano E.A., Ghion F. and Rossi R. (2002) Disturbance and community pattern of polychaetes inhabiting Valle Magnavacca (Valli di Comacchio, Northern Adriatic Sea, Italy). *Marine Ecology* 23, 31–49.

Nybakken J.W. (1993) *Marine biology: an ecological approach*. New York: Harper Collins College Publishing, 445 pp.

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.

Pearson T.H. (1970) The benthic ecology of Loch Linnhe and Loch Eil, a sea–loch system on the west coast of Scotland. The physical environment and distribution of the macrobenthic fauna. *Journal of Experimental Marine Biology and Ecology* 5, 1–34.

Snelgrove P. (1998) The biodiversity of macrofauna organism in marine sediments. *Biodiversity and Conservation* 7, 1123–1132.

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., Seyfabadi J., Abtahi B. and Yazdani Foshtomi M. (2009) Population changes and reproduction of an alien spionid polychaete, *Streblospio gynobranchiata*, in shallow waters of the south Caspian Sea. *JMBA Marine Biodiversity Records* 2, e 40.

and

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*. Society of Petroleum Engineers. Seventh SPE international conference on health, safety, and environment in oil and gas exploration and held in Calgary, Alberta, Canada, March, 29–31. 86709, 12 pp.

Correspondence should be addressed to:
M. Taheri
Iranian National Center for Oceanography
9, Etemadzadeh Avenue, West Fatemi Street, Tehran
email: mehrshadtaheri@yahoo.com