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The Influence of Salinity Variations on Zooplankton Community Structure in South Caspian Sea Basin Estuary

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Abstract In order to better understanding the impact of changes in salinity on zooplankton community structure, investigations on the physicochemical characteristics, phytoplankton, and zooplankton component of an estuarine zone in South-Eastern Caspian Sea was carried out for one year between March, 2011 and July, 2012. The study showed notable seasonal variation in the components investigated. Salinity and water flow rate regime seemed a major determinant of the composition, abundance and seasonal variation of encountered estuarine biota. Rain events associated with reducing salinities and inflow associated with decreasing salinities may be key hydro-meteorological forcing operating in the estuary. The collection of juvenile forms (Zooplankton) recorded probably points to the suitability of the estuary characteristics to serve as breeding ground and place of refuge for diverse aquatic species.

Keywords Caspian Sea, Estuarine, Zooplankton, Diversity, Physicochemical

1. Introduction

River mouths are common hydrological features of South-Eastern features of Caspian Sea and form part of the numerous ecological niches associated with the Caspian coastal environment. These mouths of the region are usually connected to lagoons and find their way to the sea via the mouth all year round. Over the years, the ecosystem, particularly in the agricultural areas, are enduring stress-induced changes as a result of steadily yet increasing human activities and associated effects. Unregulated and unrestricted deposition of wastes is the key to most of these imposed human related effects. In the aquatic ecosystem, the phytoplankton is the foundation of the food web, in providing a nutritional base for zooplankton and subsequently to other invertebrates, shell and fishes. The ecological significance played by these biological systems in coastal aquatic ecosystems cannot be easily understated. Ecological and particularly trophic interrelationships are well known to occur among phytoplankton, zooplankton, fishes and shellfish in aquatic ecosystems. There is a dearth of available materials on ecological investigation into the hydro-climatic conditions especially in relation to the composition and distribution of biota at different trophic levels within coastal aquatic ecosystems in south Caspian Sea region. Salinity is amongst the most important environmental factors with the potential to significantly influence estuarine communities [11]. Therefore, fluctuations in salinity and other environmental factors (e.g. temperature, pH, nutrients and pigments) on both spatial and seasonal scales, play major ecological roles promptly controlling the composition and distribution of estuarine species [10, 5]. This is true, given that only select species are able to cope with major environmental shifts [4]. We report here the zooplankton structure changes of a fluctuating river mouth in south Caspian Sea with the aim of gaining better understanding into aspects of trophic level interrelationship within this estuarine ecosystem.

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2. Material and Methods

2.1. Description of the Study Area

The brackish water estuary is located near to the Caspian Sea Ecologic Institute, in Mazandaran province of Iran. Six stations were selected that stations 1 to 4 and 6 being in the estuarine area whereas station 5 is located in the sea area (Figure 1). The estuary is not deep (≤1m), not tidal but sheltered. It is fed by water from the adjoining Tajan River at calm sea situations and when there is any storm the water of the lagoon is mixed with the sea water incomes. The region is located in south-Eastern Caspian Sea coasts and hence exposed to two distinct seasons, the wet (October-April) and

dry season (May-September).

2.2. Physical and Chemical Variables

Water temperature, salinity, total suspended substances (TSS), and pH were determined in water samples. Water temperature, salinity, and pH were measured in situ with a thermometer, an ATAGO S/Mill-E refractometer, and a HI9813 pH meter (Hanna Instruments), respectively. In order to determine the concentration of TSS, water samples were filtered through pre-weighed GF/C Whitman filters, which were subsequently dried at 80°C for about 24 h and reweighed. Water residence time for the studied area, delimited in Figure 1 by the two lines, was calculated on the basis of river flow data and the average water volume corresponding to this area. Samples for the quantification of N-NO3 and N-NO2 were filtered through GF/C Whatman filters and frozen for later analysis on a TecatorFIAstar 5020 Analyzer equipped with a Hitachi U-3200 spectrophotometer. N-NO3 and N-NO2 was determined.

2.3. Zooplankton Sampling

Zooplankton sampling was carried out utilizing 55 µm plankton net. Net drifting manner was vertically from bottom to sea surface level. Then each sample was fixed in 4% formalin using the ambient water for dilution before be brought to the laboratory.

3. Results

3.1. Physical and Chemical Variables

Water temperatures ranged between 25.83°C in station 6 and 28.24°C in station 4 but no significant differences were found between stations (Table 1). Salinity ranged between 3.51 and 12.5 ppt throughout the year. Salinity values were higher during summer months and were reduced by increased rainfall and river input. For whole water column, site 1 had significantly ($p < 0.001$) lower salinity than other stations (Table 1) because it is the closest site to the Tajan River. pH values were constant throughout the year with an average value of 8.01 ± 0.45. TSS was relatively constant throughout the year and annual means ranged between 3142.90 and 11274.81 mg .l-1. TSS values were significantly ($p < 0.05$) higher for station 5 and significantly ($p < 0.01$) lower for station 1 and 6 (Table 1).

Figure 1. Study area and collecting stations shown as numbers 1-6

Table 1. Annual values of the several of Physicochemical and biological variables at different stations in the south Caspian Sea basin estuary

Station Number	S‰	pH	T°C	TSS	N-NO3	N-NO2	N-NH4
1	3.51	7.99	27.76	3142.90	5.40	1.20	26.25
2	9.37	8.12	27.16	5780.92	7.60	0.00	17.07
3	9.63	8.27	27.30	8864.61	1.70	0.00	20.55
4	8.23	8.22	28.24	7552.37	3.30	0.00	22.40
5	12.50	7.13	26.24	11274.81	20.00	0.00	24.22
6	4.52	8.34	25.83	3878.80	12.30	0.00	21.55
Standard errors	1.36	0.18	0.37	1262.04	2.77	0.20	0.98

The studied period corresponded to a dry year and the Tajan annual river flow value was less than half of the average of the last 30 years. River flow fluctuated greatly during the study period with a maximum value in November (81.3 m3. s-1) and a minimum in August (1.5 m3. s-1). These values correspond, approximately, to water residence times in the upper mouth with 8 and 26 days, following to wet and dry periods. With the exceptions of June, October, and November, water residence times were considerably higher than average values (Fig. 2). Long residence times of water flow due to low discharges were observed in dry years. High values of primary production in term of chlorophyll **a** are estimated to be related to the combination of these two impacts.

3.2. Zooplankton

Twenty species belonging to four main groups of Copepoda, Cladocera, Rotatoria and protozoa and mero-zooplanktons including Cirripedia and Lamellibranchia larvae in study area were identified. The dispersion of genera showed that: 15 genera in river situated stations, 19 ones in estuarine stations and 18 genera in the sea front area were sampled. Maximum number of genera present was observed in spring months and in estuarine area and its mouth. During this period protozoan groups such as Foraminifera were much abundant Figure (3) and Table (2) shows species variation expressed in Shannon index. During summer the estuarine stations including 17 genera represented high abundance of diversity and the population consisted mainly from Rotatoria and Protozoa. Zooplankton distribution during autumn season showed that Copepods (mainly *Acartiatonsa*) represented dominant species in the zooplankton diversity structure.

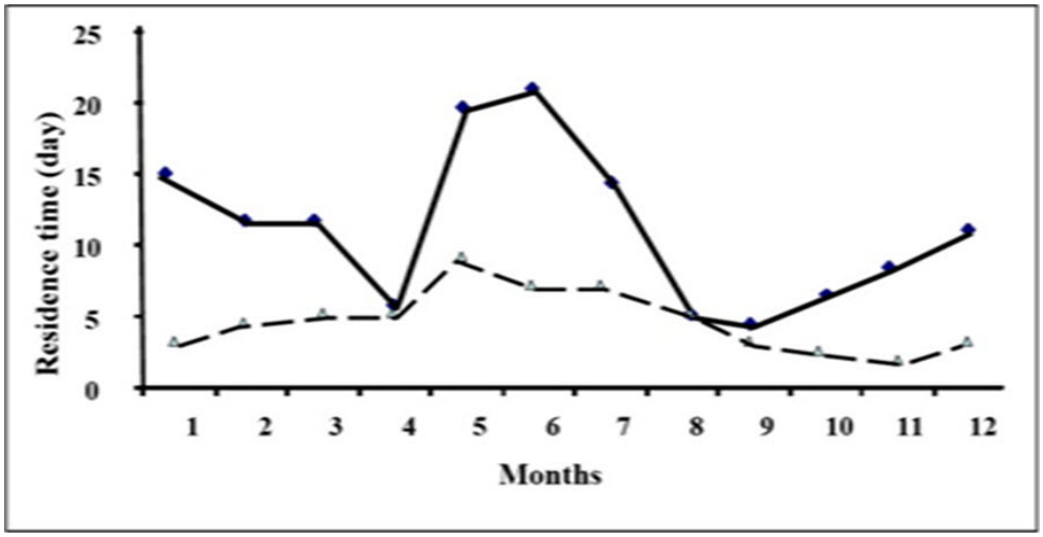

Figure 2. Tajan river residence time during the studied period (continuous line) and average of last 30 years (stripped line)

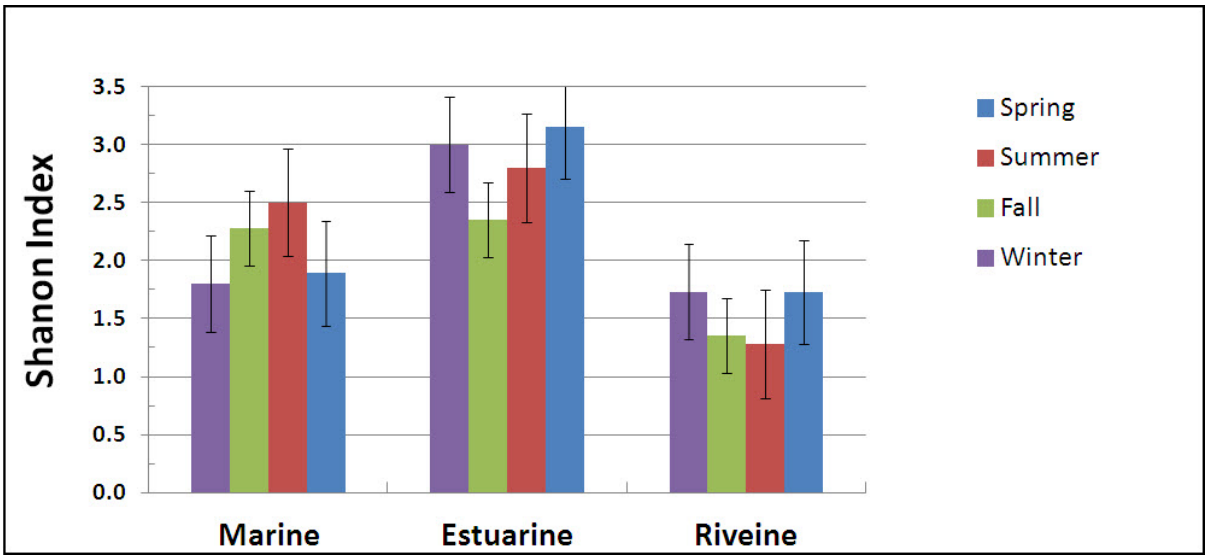

Figure 3. Variations of Shannon Biodiversity index during seasons comparing three zones of river, estuary and the sea

Table 2. Composition and abundance of Zooplankton species in term of presence or absence in each station sampling

Phylum	Zooplankton Genera	Station					
		Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Protozoa	*Foraminifera sp.*	✓	✓	✓	✓	✓	✓
	Tintiopsis sp.	✓	✓	✓	✓	✓	✓
	Difflugia sp.	✓	✓	✓	✓	✓	✓
Rotatoria	*Branchionous sp.*	✓	✓	✓	✓	✓	✓
	Keratella sp.	✓	✓	✓	✓	✓	✓
Copepoda	*Acartia sp.*		✓	✓	✓	✓	✓
	Acartia nauplius	-	✓	✓	✓	✓	✓
	Calanipeda sp.	-	✓	✓	✓	✓	✓
	Cyclops sp.	-	✓	✓	✓	✓	✓
	Eurytemora sp.	-	✓	✓	✓	✓	-
	Halicyclops sp.	-	✓	✓	✓	✓	-
Cladocera	*Bomina sp.*	✓	✓	✓	✓	-	✓
	Polyphemus sp.	✓	✓	✓	✓	-	✓
Meroplanktons	*Fish egg*	✓	✓	✓	✓	✓	✓
	Lamilibranchia sp.	✓	✓	✓	✓	✓	✓
	Tintinidium sp.	✓	✓	✓	✓	✓	✓
	Cypris sp.	✓	✓	✓	✓	✓	✓
	Hypania sp	✓	✓	✓	✓	✓	✓
	Ostracoda sp.	✓	✓	✓	✓	✓	✓
	Nereis larve	-	-	✓	✓	✓	-

4. Discussion

In Tajan river estuary, the wide availability of organic matter in the sediment, coupled with low water exchange and high temperatures during the summer may promote dystrophic crises. In addition, the water inlet of the adjacent small stream, issued from agricultural activity, is very likely to be enriched by remains of fertilizers, feces and nutrients [13]. This leads to an increase in primary and secondary production, and may contribute to the establishment of dystrophic conditions [13]. Azzoniet all [3] showed that, in this lagoon, there was an accumulation of free sulphide in the Rhizosphere of the Ruppia meadow during late summer as a result of an imbalance between sulphate reduction rates and sulphide reoxidation rates. As well as directly inhibiting sea grass growth, dystrophic events undoubtedly have a lethal effect on macro benthic fauna. Consequently, decreases in macro benthic abundance and biomass might be related not only to the oxygen depletion, but also to the high production of toxic free sulphide, as has already been documented in the Comacchio lagoon complex [12]. The macro benthic assemblage structure and composition and the environmental conditions found in Tajan river estuary, were very similar to those found in a shallow lagoon in the Bay of Cadiz [2]. However the number of species was relatively low compared to the assemblages described in the other estuaries such as Valli di Comacchio estuary and other brackish waters [7] and same estuaries in northern Adriatic lagoons [8,9]. After the late summer crisis, followed by high salinities, the macro benthic assemblages had an appearance of greater homogeneity among the stations as a consequence of an overall reduction in abundance and biomass. More stable conditions including flow characteristics, increased light penetration and marine situation experienced in the dry season could have encouraged the development of a richer plankton community. The increase of phytoplankton caused zooplankton biomass but not its diversity. Similar observations have been made for the Lagos lagoon.

In this study, it is suggested that there are likely a direct relationship between increasing salinity, phytoplankton diversity of zooplankton species and abundance was also recorded. It is possible that an increased diversity of phytoplankton observed during the dry season gave rise to a richer Zooplankton biomass. High air and water temperatures recorded during the summer season are typical for the region. The high biological oxygen demand value may be a reflection of the amount of decomposition of materials within the estuary and arising from the surrounding rich riparian stream vegetation. Higher plankton diversity was recorded in the dry season contrarily to the wet periods. Some species are referred for the first time in the Tajan mouth: *Actinocyclus octonarius*, *Chaetoceros rubsecundus*, Moreover, the diatoms (*Chaetoceros simplex*, and *Thalassionema nitzschoides* were not mentioned yet in Iranian coastal and estuarine waters. The species, *Skeletonema costatum*, is regarded as potentially harmful algae because it frequently occurs in bloom proportions. All the other species referenced appeared only in minor concentrations throughout this study. Diversity index values were lower than ones usually found in marine waters, but within the range of coastal and estuarine communities. Mistri et al [8] has also reported higher microalga abundance in the dry season of summer but associated with unfavorable condition for higher faunal trophic levels within the estuary.

Among the zooplankton, whereas cladocerans and cyclopoid copepods were clearly the dominant forms in fresh/ brackish water situations, the calanoid copepods were clearly the dominant forms in higher brackish water situations. Similarly, according to Tackx et al. [14], in an investigation on zooplankton of Schelde estuary (Belgium), whereas the brackish water zone was dominated by calanoid copepods, cyclopoid copepods together with several cladocerans species dominated the freshwater and low brackish water transect of the estuaries. The presence of any accumulation and development stages in the plankton of known estuarine and marine species may point to the suitability of the shallow waters as a nursery and feeding ground for a variety of aquatic organisms. It seems that the higher the zooplankton diversity, the more stable the planktonic community [6]. Results from this study agree with Albaret and Lae [1] in Ebrie Lagoon in West Africa. These effects have been documented in other coastal areas of the world including the Gulf of Thailand, South Africa and Lagos lagoon, Nigeria.

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