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Ecological Relationships between Biotic and Abiotic parameters within the establishment of Fish Farming Cage Culture in the southern Caspian Sea

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ABSTRACT: This research examines the abundance and biomass of biota factor with the relation of some physicochemical parameters at the fish cage culture in the southern Caspian Sea (Kelarabad-Mazandaran, Iran) in 2013 to 2015. Seasonal sampling was conducted at three stations, station1 (fish cage site), station 2(at a distance of 500 m west), and station 3 (at a 50 meters east of the fish cages). The aims of this study were to investigate the relationship between the density and biomass of phytoplankton, zooplankton and macrobenthos and the concentration of some heavy metals and petroleum parameters. A total of 38 species of phytoplankton, 6 species of zooplankton and 7 species of macrobenthos were identified. The results showed that the highest concentration of DON and DIN was recorded in winter which showed a positive correlation between phytoplankton and nutrients. At the present study, the abundance and biomass of phytoplankton showed reduced in the spring but in contrast the density and biomass of zooplankton was highest which would be due to full feeding of predators, zooplankton. Comparison of Polycyclic Aromatic Hydrocarbons (PAHs) at different seasons showed that the highest amount was detected in spring and the highest concentration of Anthracene and Fluoranthene was in autumn. The results showed that the amount of pollutants in the Caspian Sea was less than the standard limited. There was not significant differences between petroleum amounts in various seasons (P>0.05). The environmental parameters analysis showed that 5 to 20 meter depths were considered as sensitive areas and a depth of 5 and 10-20 meter divided on two groups that represent the interactions between biotic and abiotic parameters on each other's activities.

Keywords**:** Biotic and abiotic groups, fish cages, Kelarabad, Caspian Sea

INTRODUCTION

Breeding fish in the sea to spread globally and although plenty of marine products for human consumption provides a mutually pressure on food supplies entering [33]. Caspian Sea due to its geographical location, unique resource of plants and animals, including sturgeon (Acipenseridae), bony fish (Cyprinidae) and Kilka fish (Clupeidae) has a great importance that any change in the Caspian Sea ecosystem will affect the creatures [14, 3]. Physicochemical variety of Situations River leading to the sea due to the entry industrial waste and sewage plants, urban and rural communities and changes the biotic and abiotic the Caspian Sea. Other factors like entry the new species from the Black Sea into the Caspian Sea e.g. Mnemiopsis leidyi [12, 39], climate changes and ballast water made changes the diversity and density of phytoplankton species [27] and zooplankton [40]. The adverse effects of human activities (anthropogenesis) on ecosystems will be also affected short and long-terms impacts [5]. The most common side effects of these activities or exposure to the extinction of many endangered species (both macroscopic and microscopic) damaged the biodiversity, habitat loss, habitat and living conditions [35]. The development of human civilization irreversible effects on ecosystems natural history of many events left. Algal blooms and bio-geochemical cycles as transitory impact properties in coastal waters is natural, but this happens in toxin-producing algae and a large number of non-toxic species of algae (algae harmful) and caused the ability have created huge biomass, creating ecological and environmental crisis C[11, 47]. So far, about 300 species in the world for producing microalgae bloom has been introduced which 50 species of them are capable of producing toxin. The annual number of cases of poisoning due to consumption of many fish, shellfish and other foods is reported to contaminate with toxic microalgae [47, 48]. Anthropogenic nutrient sources such as wastewater and sewage discharge from agricultural lands was increased considerable quantities of these materials for the growth of phytoplankton in the coastal strip, especially in summer [9]. According to the program through the establishment of marine cage by Iranian Fisheries Organization (IFO) for aquaculture development in the southern Caspian Sea, biotic groups, including phytoplankton, zooplankton, macrobenthos and abiotic contains pollutant and water physicochemical factors could be changed as a factor affecting environmental conditions. Since the published data on biotic and abiotic groups ranging after the establish of fish cage farming in the southern Caspian Sea (Kelarabad region) is lacking, the present study is useful to develop further researches to investigate the relationship between phytoplankton, zooplankton, macrobenthos, physico-chemical parameters, heavy metals and hydrocarbon petroleum in water and sediment after the establishment of marine fish cages. The results of the data are before the establishment of marine cages.

MATERIAL AND METHODS

Seasonal sampling was carried out at three stations including station 1 (fish cage site), station 2 (500m west of the site) and station 3 (50 m east of the fish cages) in southern of the Caspian Sea (Mazandaran coast-Kelarabad) in 2012. The Table 1 showed that the latitude and longitude situation of sampling area.

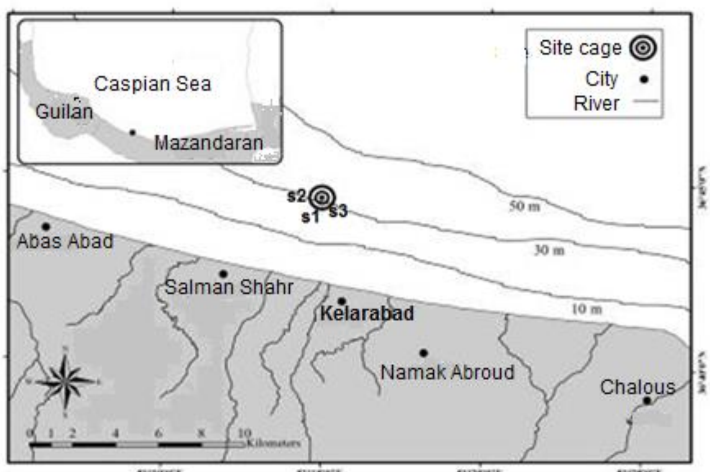


Figure 1: Sampling stations in the southern Caspian Sea (Mazandaran-Kelarabad)

Table 1: Latitude and longitude of the sampling stations in the southern Caspian Sea

Depth (m)	Geographic Latitude and longitude		Station
	N	E	
20	36° 43' 42"	51° 15' 31"	1
20	36° 43' 44"	51° 15' 14"	2
20	36° 43' 43"	51° 15' 32"	3

Phytoplankton samples were collected in 0.5-L dark bottles from the surface waters and preserved using buffered formaldehyde at a final concentration of 2.5% [49]. Samples were concentrated to a volume of ~20 ml by the sedimentation method, after keeping the samples stagnant for at least two weeks. The microphytoplankton present in a subsample of 1 ml, taken from the ~20 ml sample, was counted using a Sedgewick–Rafter cell under a phase-contrast binocular microscope. For nanoplankton analysis, 0.01-ml subsamples were scanned on a slide. The volume of each cell was calculated by measuring its diameter, length and width and calculate the number of phytoplankton cells per cubic meter was used [41, 20]. Volumes were converted to biomass assuming μm^3 to be equal to 1 pg [6, 49]. For species identification available identification keys were used [17, 45, 50]. Phytoplankton to gain weight, their size was measured and calculated using the geometric forms [26].

Non-gelatinous zooplankton samples were taken using a Juday net having a mesh size of 100 µm and a mouth opening of 0.1 m^2 from different layers (from bottom to 50 m, 50–20 m and 20 m to the surface) [34]. Samples were preserved with neutral formaldehyde to have a 4–5% final concentration for analyses in the laboratory. They were sub-sampled using a 1-ml Hensen–Stempel pipette and transferred to a Bogorov tray for counting. An inverted microscope was used for identification of non-gelatinous zooplankton. At least 100–150 individuals were counted per sample and calculate the number of zooplankton individual per cubic meter was used [36, 51].

Macrobenthos were collected with the Van veen Grab having a mouth opening of 0.1 m^2; wash separately with seawater from the sieve with a diameter of 500 µm mesh size net using sea water and immediately fixed to have a final neutral formaldehyde solution of ~10% for taxonomic analysis (until genus or species level) and enumeration under binocular microscope and calculate the number of macrobentic invertebrate individual per square meter was used [7, 28].

The water quality - physicochemical analysis of all process parameters measured in accordance with standard methods for water and sewage [13]. A spectrophotometer was used to measure nutrients and to measure heavy metals in water was performed according to standard methods [6, 48]. Then filtered seawater samples (0.45 micrometer paper) and increased 1.5 ml nitric acid (for fixed) were prepared for mining. Sample preparation for atomic absorption and concentration was measured injection. For the measurement of heavy metals in sediment samples freeze-drying method for analysis were prepared by dry deposition and then 0.3g sample is dried in a vial and poured it with a mixture of nitric acid (1.5ml) and hydrochloric acid (4.5ml) was kept at laboratory temperature for one night. Then on a hot plate (heater Digest) at 120 °C for 3 hours was done half digestion [29]. All metals by atomic absorption model Thermo, Electron Corporation AA Serio System of deuterium lamps were analyzed. Fe Cr, Cu, Zn by flame, Cd, Pb, Ni graphite furnace with cold vapor atomic was used to determine the concentration.

To search for petroleum in the 300-500 grams of sediment deposition were taken at any station and separately aluminum foil and put it in the drying machine for freeze-drying. Then a 5 to 10 freezed-drying grams of sample was poured into a special filter paper and transferred to Automatic soxtherm. After adding 250-300ml of n- hexane solvent mixture and dichloromethane (50:50), mining operations was done with this device for one to *two* days. Laboratory samples after the process was condensed as much 15 ml with a rotary device. In the final stage 10 ml by the flow of nitrogen gas was condensed to 2 ml. To read the concentration of the petroleum composition solution was injected into the HPLC system and were compared with the original standard and the efficiency was calculated [29]. For statistical analysis, Excel and SPSS software were used for comparison test between means using analysis of variance (ANOVA) and all statistical tests were performed at the level of 5% [8]. MVSP software was used for the comparison of ecological relations of some parameters.

RESULTS

Identify biological groups

Phytoplankton

A total of 38 species of phytoplankton were determined which belonged to 5 phyla including Bacillariophyta, Pyrrophyta, Cyanophyta, Chlorophyta and Euglenophyta (Table 2). The results showed Bacillariophyta had the highest biodiversity species (57.9%) and Chlorophyta showed the minimum with 2.6%.

Table 2: List of phytoplankton species identified in the southern Caspian Sea (Mazandaran- Kelarabad)

Bacillariophyta	Pyrrophyta	Cyanophyta	Chlorophyta
Cerataulina plagica	*Exuviaella cordata*	*Lyngbya* sp.	*Binuclearia lauterbornii*
Chaetoceros convolutus	*Glenodinium behningii*	*Nodollaria spumgina*	
Chaetoceros peruvianus	*Goniaulax polyedra*	*Oscillatoria* sp.	**Euglenophyta**
Chaetoceros meriablis	*Gymnodinium variabile*	*Oscillatoria leimusa*	*Trachelomonas spiculifera*
Chaetoceros socialis	*Peridinium achromaticum*	*Spirulina laxissma*	*Euglena acus*
Coscinodiscus gigas	*Prorocentrum obtusum*		
Cyclotella menenghiniana	*Prorocentrum scutllum*		
Cymatopulora solea	*Prorocentrum praximum*		
Melosira moniliformis	*Prorocentrum scutllum*		
Nitzschia sp.			
Nitzschia acicularis			
Nitzschia closterium			
Nitzschia reversa			
Nitzschia tenuirostris			
Pseudonitzschia seriata			
Rhizosolenia calcaravis			
Rhizosolenia fragilissima			
Skletonema costatum			
Skletonema subsalsum			
Thalassionema nitzschoide			
Thalassiosira caspica			
Thalassiosira incerta			

Zooplankton

Zooplankton species composition showed 6 species belonged to four families, including Acartidae and Asplanchnidae each with 1 species, Balanidae and Podonidae each with two species (Table 3).

Table 3: List of zooplankton species in the southern Caspian Sea (Mazandaran-Kelarabad)

Meroplankton	Holoplankton	
Cirripedia	**Rotatoria**	**Copepoda**
Balanidae	**Asplanchnidae**	**Acartidae**
Balanus sp. *cypris* (Costa, 1778)	*Asplanchna priodonta* (Gosse, 1850)	*Acartia tonsa* (Dana, 1849)
Balanus sp. *nauplii* (Costa, 1778)	**Cladocera**	
Bivalvia larvae (Linnaeus, 1758)	**Podonidae**	
	Podon polyphemoides (Leuckart, 1859)	
	Evaden anonyx (G.O. Sars, 1897)	

Macrobenthos

A total of 5 families of macrobenthos were identified that belonged to 6 genera and 7 species (Table 4).

Table 4: List of macrobenthos species in the southern Caspian Sea (Mazandaran-Kelarabad)

Phylum	Class	Family	Species
-	Oligochaeta	-	-
Annelida	Polychaeta	Spionidae	*Streblospio gynobranchiata*
		Amphartidae	*Hypania invalida*
			Hypaniola kawalewski
		Nereidae	*Hediste diversicolor*
Arthropoda	Crustacea	Pseudocomidae	*Pseudocuma diastyloides*
			Pseudocuma graciloides
Mollusca	Bivalvia	Cardiidae	*Cerastoderma glaucum*

Abundance and biomass of biological groups

Phytoplankton and zooplankton abundance at the different seasons showed the highest in winter with an average of 58207000±16971800 ind./m^3 (individual per cubic meter) and the lowest in the summer with an average of 310000±562045 ind./m^3. In contrast, the highest and lowest abundance of zooplankton was observed in spring and winter with average of 366.2±106.2 and 82.8±40.5 ind./m^3, respectively (Figure 2A). Significant differences in terms of abundance and biomass created in different seasons ($P<0.05$). There were also fluctuations trends in phytoplankton and zooplankton biomass at different seasons as well. The results showed that the highest and lowest biomass of phytoplankton was in winter and autumn with an average 1783±324.3 mg./m^3 (milligram per cubic meter) and 12.2±4.5 mg./m^3, respectively. The maximum and minimum biomass of zooplankton was in spring and winter with 2.82±1.7 and 0.7±0.3 mg./m^3, respectively (Figure 2B).

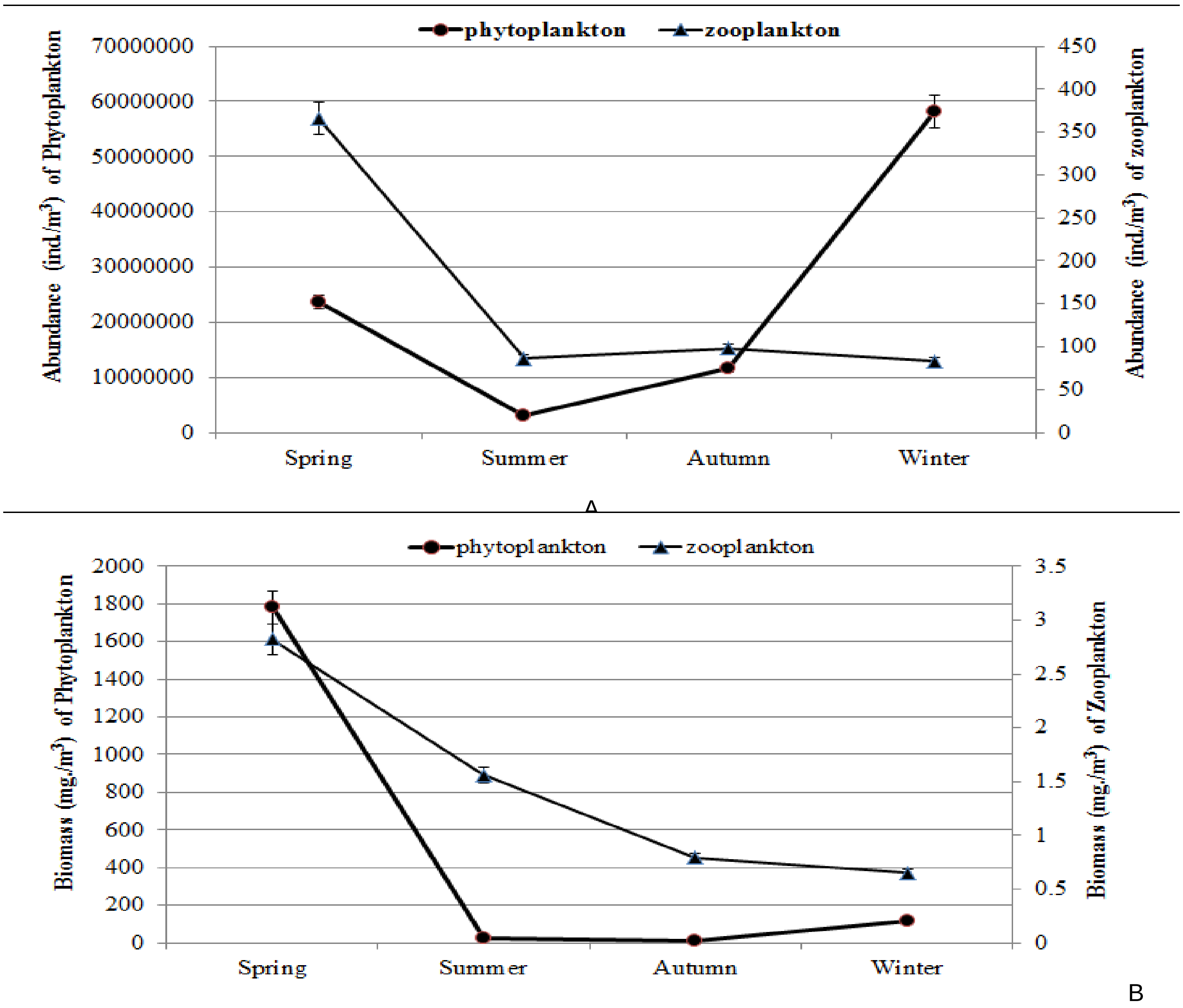


Figure.2: Changes of (A) Phytoplankton and (B) Zooplankton abundance and biomass at different seasons in the southern Caspian Sea (Mazandaran-Kelarabad)

Macrobenthos abundance and biomass showed decreased at different seasons from spring to winter. The highest and lowest abundance and biomass was recorded in autumn with mean 883.3±354 ind./m^2 (individual per square meter) and 0.52±0.2 g./m^2 (gram per square meter), respectively. The lowest abundance and biomass was also occurred in winter with a mean of 143.3±56.4 ind./m^2 and 0.07±0.03g./m^2, respectively (Figure 3). There was significant differences in macrobenthos abundance and biomass at different seasons ($P<0.05$).

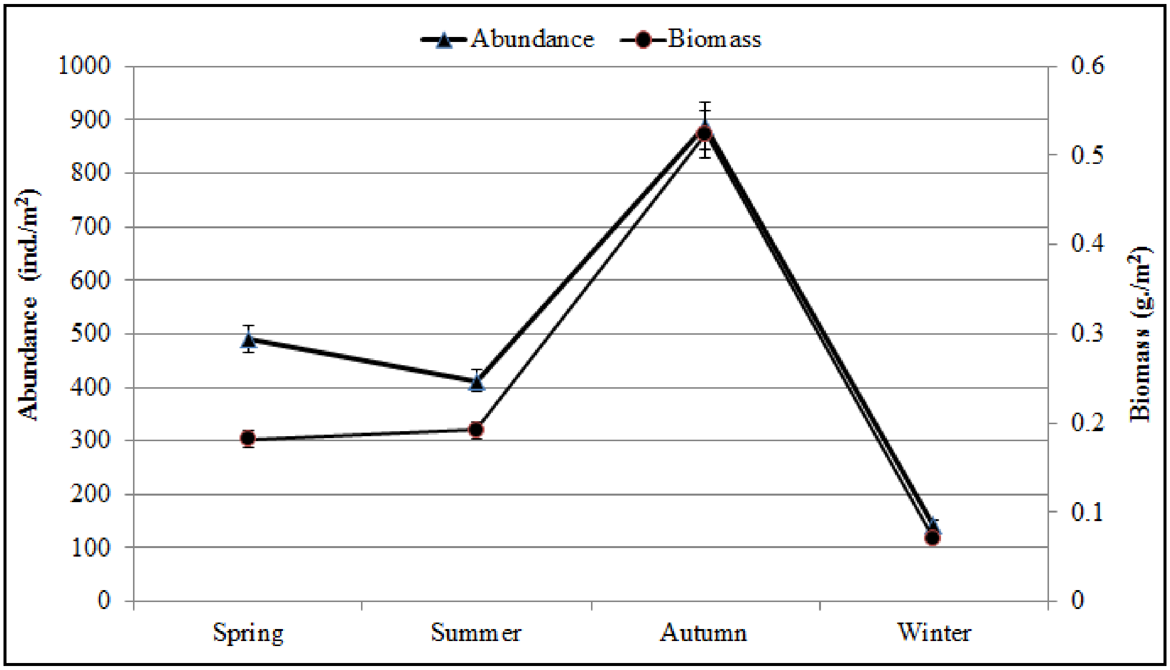
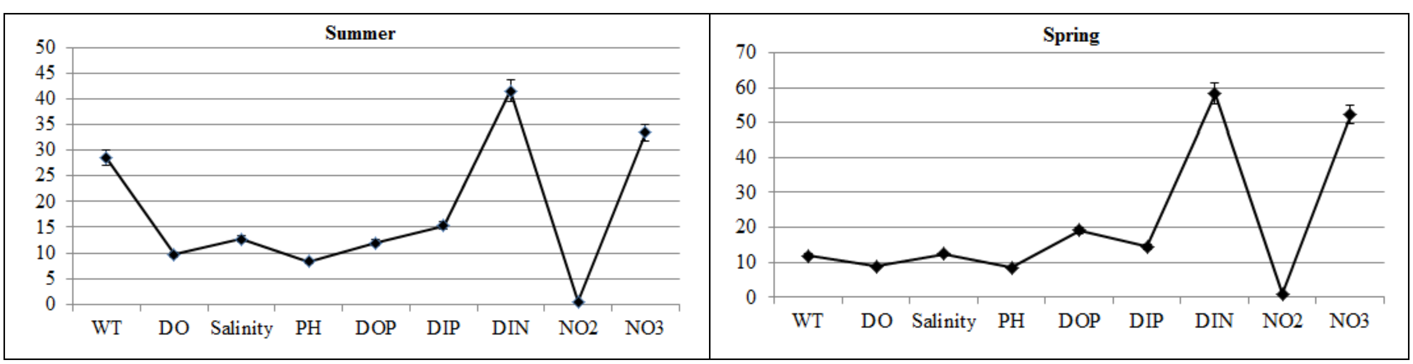


Figure 3: Changes of macrobentic abundance and biomass at different season in the southern Caspian Sea (Mazandaran-Kelarabad)

Environmental parameters

Physicochemical parameters in water

A total of 10 parameters were examined, including water temperature (WT), Dissolve oxygen (DO), salinity, PH, Dissolve Organic Phosphate (DOP), Dissolve Inorganic Phosphate (DIP), Dissolve Organic Nitrogen (DIN), nitrite ($NO2^-$), nitrate ($NO3^-$), respectively. Figure 4 show that the average various forms of physicochemical changes of water at the different seasons. The results showed that the lowest water temperature was measured in winter and highest in summer, the dissolved organic phosphate (DOP) showed a decreasing trend from spring to winter. The dissolved inorganic nitrogen (DIN) in all seasons was the highest amount compared to other parameters, so that the lowest amount was in summer with an average of 43.5±7.2µg/l (microgram per liter) and the highest in winter with of 76.7±16.2µg/l. There was significant difference between DIN at different seasons ($P<0.05$). The amount of dissolved organic nitrogen (DON) in different seasons has fluctuated. The concentration of DON in spring, summer, autumn and winter was 839.5±35.2, 769.2±12.3, 616.9±20.7 and 871.3±9.3 µg/l, respectively. There was no significant difference in terms of DON at different seasons ($P>0.05$).



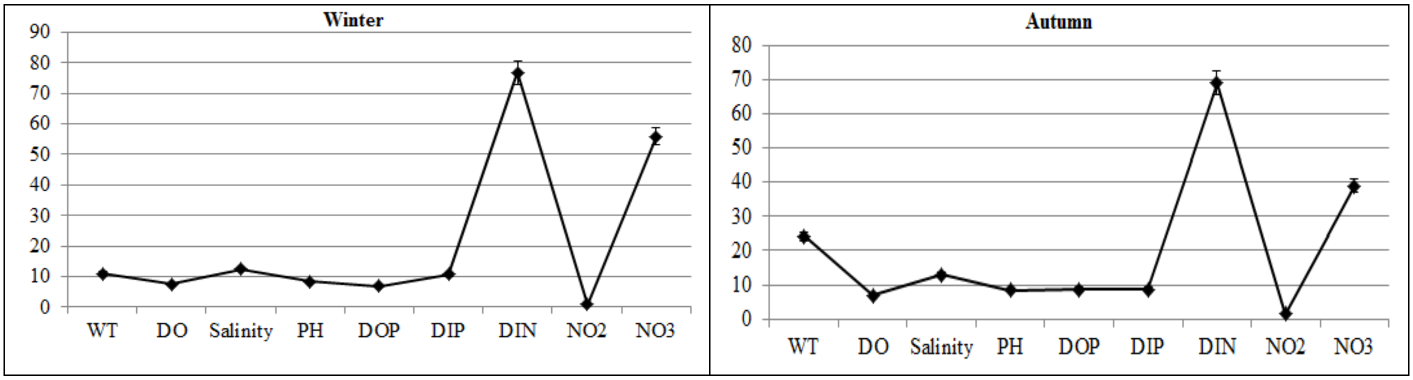


Figure 4: Mean changes of water physic-chemical parameters in the southern Caspian Sea (Mazandaran-Kelarabad)

Ecological correlation between environmental parameters was calculated at different water layers and classified into two groups; 10 and 20 layers in the first class with Pearson coefficient of 1 (100%) and the second class (5m) with the first layer 0.981 Pearson similarity coefficient (Figure 5A). Ecological correlation of environmental parameters among themselves showed that some factors have the highest correlation. Generally, these relationships were formed to class 15 (Figure 5B) that the first class, DIN with NH_4 and NO_3^- with first-class correlation coefficients 1(100%) and EC and TDS correlation coefficients were 0.997. The lowest correlation between TP and DOP with a Pearson similarity coefficient was 0.365. There is not significant different between physicochemical parameters at the various seasons ($p>0.05$) but significant different between groups of parameters ($p<0.05$).

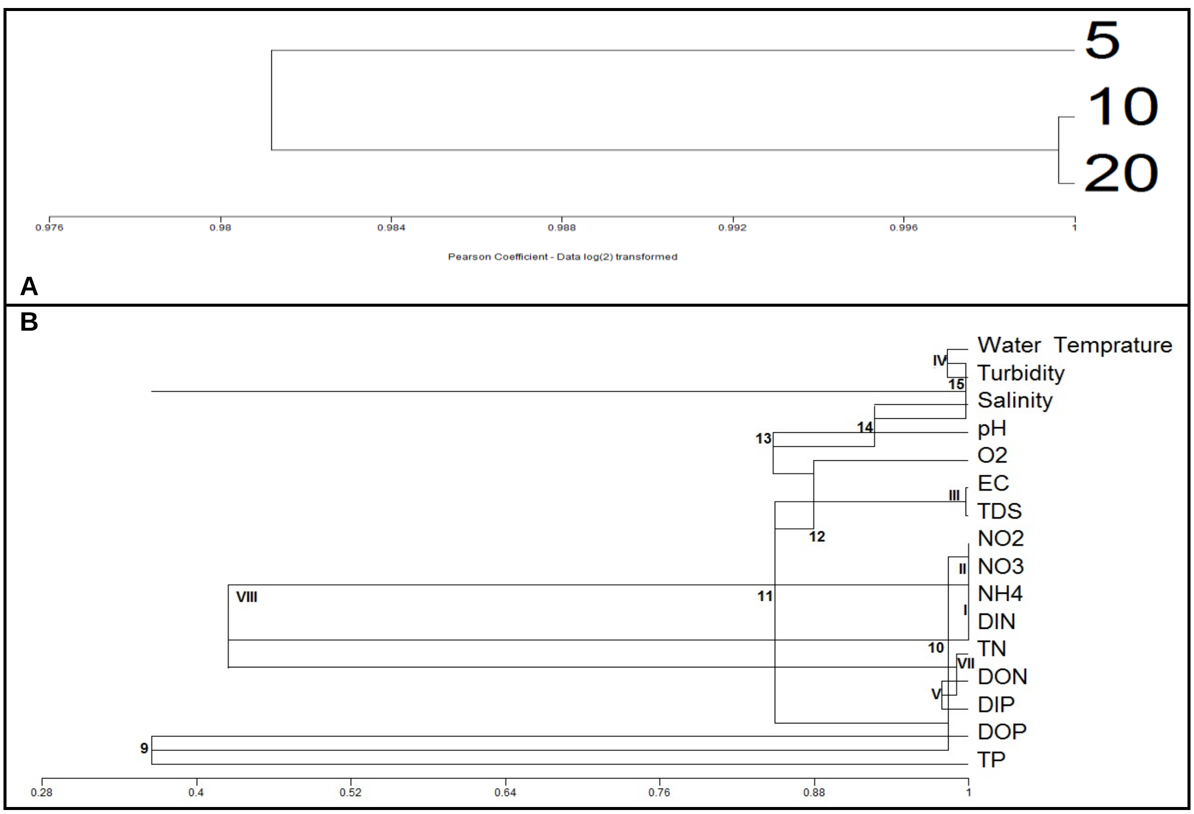
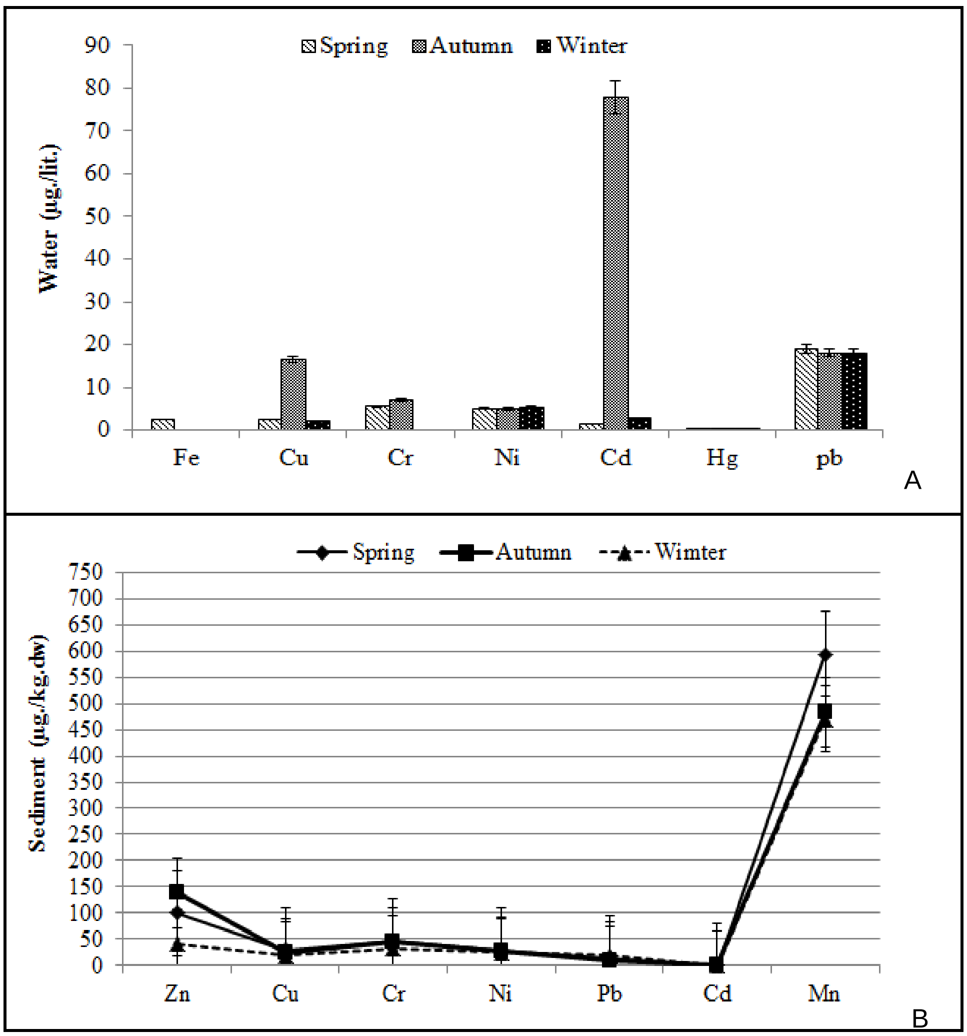


Figure 5: The dendogram of cluster analysis of water physicochemical parameters based on various layer of water (A) annually (B) in the southern Caspian Sea (Mazandaran-Kelarabad); TP= Total Phosphate, TN= Total Nitrogen, TDS= Total Dissolves Solids, EC= Electricity Consumption

Pollutants in water column and sediment

A total of nine metals contain Fe, Zn, Cu, Cr, Pb, Ni, Mn, Cd and Hg was studied. The results showed that the highest concentration of Cd was in autumn with an average of 77.8± 38.4µg per liter and Hg with the lowest concentrations in autumn with 0.009±0.00µg./l (Figure 6A). No significant difference was observed between heavy metals in water column of different seasons (P>0.05) but there is significant difference between groups of heavy metals (p<0.05). The heavy metals in sediments showed that the maximum concentration of Mn in all seasons in a way that among them the highest concentrations was measured in spring with an average of 594.4±97.5µg per kilogram dry weight, and lowest in autumn with 482.9±28.6µg./kg.dw (Figure 6B). There is not significant difference between heavy metals in sediments at different seasons (P>0.05). Mercury concentrations in different seasons showed that the highest was in autumn with an average of 0.086±0.043µg./kg.dw and lowest with an average of 0.039±0.033µg/kg.dw was in winter. Also the concentration of petroleum (Anthracene) in the sediments showed fluctuations and the results point out that the highest amount with an average of 7.79±0.00µg./kg.dw in spring. The Fluoranthene concentration in autumn and spring was 3.48±1.51µg./kg.dw and 2.44±1.31µg./kg.dw in mean, respectively. The results showed that in winter all petroleum groups have low levels of concentration (Figure. 6C).



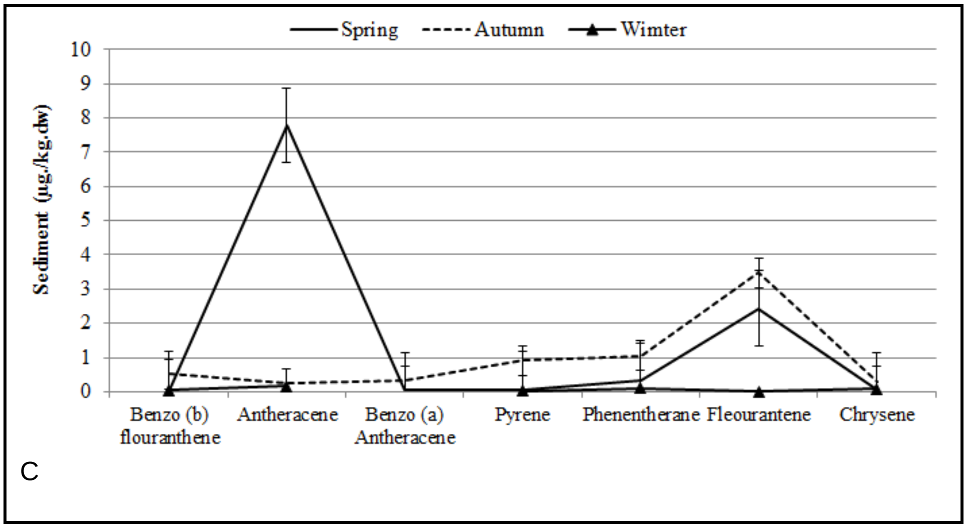


Figure 6: concentration of some heavy metals in water (A), sediment (B) and PAHs parameters (C) of the southern Caspian Sea (Mazandaran-Kelarabad)

DISSCUSION

Fish farming in cages play an important role in the development of aquaculture if so implemented without taking into account environmental considerations can be much damage to the Caspian Sea plankton in the food pyramid created the first chain [4]. Based on previous studies, in recent years major changes on the food chain in the southern of Caspian Sea coastal ecosystem has been created that can reduced to maintain their zooplankton biomass and abundance and change the composition of the dominant species, e.g. the disappeared of Copepod *Eurytemora grimmi* and *Eurytemora minor* and an increase from 50% to over 85% of *Acartia tonsa*, reduced of the 23 species of Cladocera, increased phytoplankton biomass and abundance and change their dominant species and an increase in cyanobacteria and Dinoflagellata [15, 27, 38, 40]. In the present study, 6 species of zooplankton identified that *Acartia tonsa* was dominant and cladoceran had only one species as well as correspond to previous studies [38]). In the inshore waters of the Caspian Sea more than 300 species of phytoplankton have been identified and 92 species in 1998 [16], 195 species in 1999 [27] and 183 species in 2010 [46] in which Bacillariophyta was dominant phytoplankton population [1]. At the present study, only 38 species were identified and Bacillariophyta had the highest abundance and species diversity as a dominant phylum, which was consistent with previous studies. Macrobenthos species composition showed decreasing trend in the southern Caspian Sea of 64 species in 1994 [37], 32 species in 2009 [44] to 28 species in 2011 [18]. Hence this information was resulted in a change mitigation of 56.3% in two decades after the 2001, exotic species *Streblospio gynobranschiata* showed most frequently by more than 60% [2]. In the present study, 6 species of macrobenthos identified such as this it would be because of the time and place of sampling, depth and other environmental parameters depend on in which *S. gynobranschiata* was dominant of macrobenthos population that correspond with previous studies. Phytoplankton and zooplankton abundance in different seasons showed an inverse relationship that could be due to feeding function of zooplankton. Zooplankton feed on phytoplankton, other zooplankton (sometimes cannibalistically), and even nektonic organisms [25].

The most dominant species of phytoplankton was *Thalassionema nitzschoides* that native and savory grazing by zooplankton [27] that corresponds with the results obtained in this study. In the present study, phytoplankton and zooplankton showed steady state in which could be due to the formation of thermocline layer, nutrients trapped in the substrate, and biological non-activity and algae non-bloom. In the southern Caspian Sea, water temperature was 7-10°c in winter and 25-29°c in summer showed seasonal thermocline at a depth of 20 to 30 M occurs during warm seasons [24].

In the present study, the highest abundance and biomass of macrobenthos was found in autumn with frequency 63.3% ind./m^2 coincided to *S. gynobranchiata* and the maximum biomass was 3.44g./m^2 belong to the species *C. glaucum*, which can be due to its large size. In this study, evaluation of organic nitrogen and total inorganic nitrogen showed in winter with the highest amount which showed a positive correlation between phytoplankton and nutrients. Total dissolve solids (TDS) showed increased from surface to depth of increases in turbidity, which can affect the density and biomass of phytoplankton. In the present study, the different forms of phosphorus (P) and nitrogen (N) in the sediments showed that the transfer of inorganic phosphorus and nitrogen from the sediment to the water column was used more frequently because it had a high concentration in the sediment. So with the beginning of breeding fish in cages and the use of antibiotics to enhance food safety authority fish, increasing the amount of phosphorus and nitrogen in water and sediment. The consequently risk of algae blooms because of high levels of phosphorus and nitrogen release into the water column through fish farms cage culture will increase [32] that correspond with the results obtained in this study. Survey on different forms of phosphorus in various layer of water showed that ratio of inorganic phosphorus in summer and winter and organic phosphorus in spring and fall was the highest in the surface layer which can be a positive correlation between algae bloom water with nutrients. Based on the results it is approved that the two phenomena downwelling occurs in the spring and upwelling in the fall and the results of nitrite and nitrate amounts in different seasons and layers can contribute to the algae bloom. Shiea Ali and Ali Akbari [42] reported that upwelling occurred in deep of less than 40m of surface water in the center and eastern coastal of the Caspian Sea that called topographically associated upwelling. The ecological relation between environmental parameters showed that 5 to 20 m deep fisheries are considered as sensitive areas and a depth of 5m and 20-10m in two classes were divided into groups that represent relationships between biotic and abiotic groups on each other's activities. In this study, the concentrations of heavy metals in water and sediments were below the limit based on WHO, but some of them was higher compared to international standards. The results showed that the highest amount of Cd concentration was detected in autumn with an average of 77.83±38.4µg./l. In this study, concentrations of heavy metals in sediments showed fluctuations trend that the concentrations of copper, zinc, chromium, lead, cadmium and mercury in sediments was less than in Australia waters but the amount of nickel was higher (Table 5). This could be due to topographic conditions, time and place of sampling, sea currents, industrial wastewater, agricultural, urban and rural, ship traffic and oil pollution and other natural and geochemical factors.

Table 5: Comparison limit of some heavy metals (µg./kg.dw) in marine sediments at the different countries with present study

Hg	Cd	Pb	Ni	Cr	Cu	Zn	Area (Country)	References
0.15	1.2	46.7	20.9	81	31	159	USA	Pittenger *et al.*, 2007
0.3	0.8	85	35	100	36	140	Canada	Johannessen *et al.*, 2007
0.15	1.5	50	21	80	65	200	Australia	Cole, 2002
-	-	33.3	133.5	-	-	104.4	Anzali Wetland	Karbassi *et al.*, 2011
-	-	-	32	-	-	85.2	Gorgan Bay (Iran)	VesaliNaseh, *et al.*, 2012
-	-	25.37	34.2			127.2	Agh Gel Wetland	Sobhanardakani, 2016
0.06	0.18	14.6	27.4	41.03	24.76	93.53	Present study	

Nash and Waknitz [30] reported that in fish farming cage culture the amount of heavy metals, especially zinc and copper may enter the ecosystem through food and cage structures become more and can cause adverse effects on organisms. Comparison of polycyclic aromatic hydrocarbons groups (PAHs) in various seasons showed that the highest amount was measured in spring and autumn with Anthracene and Fluoranthene, respectively. There is not significant differences between petroleum concentration in different seasons ($P>0.05$) but this difference was seen only in the concentration of Anthracene ($P<0.05$). Hellou *et al.* [19] reported that in fish meal, fish oil and marine sediments nearby the fish cages, organic compounds such as PAHs in sediments around the cage in Canada ranged 0.09-10.23µg/g.dw as compared to the reference site WHO (0.004µg/g.dw). The results showed that the petroleum pollutant was less than the limit. In general, it seems that the distribution of the petroleum amount in the southern Caspian Sea is less compare to the amounts of the arrival of the materials from coastal rivers such as Sefidrood, Tajan, Gorgan rivers and washing the shores of the seasonal rainfall, traffic boats, ships, rotate the body of water from Baku to the Iranian coast and large cyclone moving from north to south of the Caspian Sea [22, 32, 39]. There is also increased refinery in the western region of the Caspian Sea which can affect compounds 16PAHs in the coastal area [21, 23]. Various studies in the sediments of the southern Caspian Sea especially Kelarabad (Mazandaran) showed that polyaromatic hydrocarbons compounds and ecological risk (HQ) for each of the 16PAHs compounds showed that HQs was the highest limited in which these compounds can adverse effect on the different organisms [32, 43]. In the present study, the results showed that the amount of pollutants in the

Caspian Sea was less than the standard limited. Generally, the concentration of petroleum in winter was the lowest which would be due to sea storms, sea currents and increased turbulence. The results showed that the changes in abundance and biomass of biotic and the concentration of abiotic parameters have been significant and it seems that if it is willing to development the fish farming in cages, environmental risk assessments should be into accounted because it is possible to face irreparable damage to the fauna and flora communities of the Caspian Sea. So it is needed the "detailed pilot plan fish cage culture in the southern Caspian Sea" before any exploitation is suggested.

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