INT. J. BIOL. BIOTECH., 17 (1): 97-107, 2020.

PELAGIC FAUNAL ASSEMBLAGE AT FISH HARBOUR, KARACHI, NORTHERN ARABIAN SEA

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ABSTRACT

The distribution and abundance patterns of marine animals were studied at Fish Harbour along Manora channel, Karachi on quarterly basis for a period of two years from March 2008 to December 2009. Fifty-three species were found belonging to following phyla: Coelenterates (2 species), Arthropods (Brachyuran crabs, 6 species; shrimps, 2 species), molluscs (3 species) and Chordate (finfishes; 40 species). The molluscs formed the major component in 7 out of 8 samples. The other animal groups, in order of abundance, were finfish and brachyuran crabs. Forty species of finfish belonging to 26 families were recorded during the study period. There are 8 families that were represented by 2 to 5 species whereas 18 families were represented just only one species. The largest family in terms of number of species is *Sciaenidae* that comprised of 5 species. Most abundant species were *Perna viridis*, *Penaeus semisulcatus*, *Metapenaeus monoceros*, *Charybdis cruciata*, *Scylla serrata*, *Portunas pelagicus*, *Thalmita pyrmna*, *Johnius elongates* and *J. belangeri*. The average values of species richness (2.09), Hill diversity N1 (3.96) and N2 (2.71) values were low. Species were, however, more evenly (Hill ratio, E5 = 0.721) distributed at Fish Harbour.

Key words: Marine animals, Fish Harbour, Finfishes, Molluscs, Crabs, Manora Channel, Karachi, Pakistan.

INTRODUCTION

The entrance of Manora channel is characterized as one of the most threatened aquatic lagoon systems of the Arabian Sea. The seawater entering and circulating in the channel through daily tidal flow becomes ineffective in flushing out the pollutants brought by the Lyari River (Fig. 1). The pollution load in the channel thus remains stagnant for some time (Haq, 1976; Ahmed, 1979; Beg *et al.*, 1984).

Information on the distribution and abundance of marine life in the Manora Channel is limited. Fragmentary knowledge exists on the benthic communities of some part of the lagoon. Jawed and Khan (1974) provided preliminary information on the intertidal communities of the Baba Island bordering the Manora Channel. Ahmed (1977, 1979) did some work on the intertidal animals of several beaches of the Sindh coast. He drew the conclusion that the diversity of macro-invertebrates increased with increasing distance from the Lyari outfall. The population dynamics and biomass of invertebrate fauna of Karachi beaches is comprehensively reviewed by Barkati and Rahman (2005) and Rahman and Barkati (2010).

The intertidal faunal assemblage of Kemari Seawall, one of the eight studied sites, is already documented (Ajazuddin and Barkati, 2013). Lack of knowledge regarding the effect of Lyari influx on the pelagic life of the channel animals prompted us to study in detail the population variety at different sites of the channel. The data gathered provides baseline information on the population structure, seasonal abundance and distribution of both, fin fish and some pelagic invertebrate species of Fish Harbor (Fig.1).

MATERIALS AND METHODS

Sampling of pelagic macro fauna was done from Fish Harbor of the Manora Channel on quarterly basis from March 2008 to December 2009.The water depth of sampling station ranged between 4.5 and 13.0 meters.

Sampling was conducted with the assistance of a large size commercial trawler. A trawl net of 16 mm mesh size operated mechanically was used through a pulley. A total of 32 hauls, based on 8 sampling trips, were made using a trawler named “Gulzar-e-Madina”. Trawling was undertaken during daytime (10.00 to 19.00 h) at a speed of 3 knots.

Each faunal group was categorized and placed into pre-weighed baskets to determine the weight to the nearest mg. Details of measurements and weights of animals were recorded. Each sample bag contained information about the haul number, station number, date and time of haul. These samples were kept in icebox for further studies in the laboratory. Total weight was obtained on an electronic balance (EB-3200 D, Shimadzoo, Asia Pacific Ltd). Fish, crabs and molluscs were identified with the help of publications of mentioned in Ajazuddin and Barkati (2013).

Measurements of sizes of only relatively large finfishes were taken on board the trawler. Total length of fish (T.L) was measured from the snout tip to the largest caudal fin tip. The total body length of shrimps was measured from the rostrum tip to the tail tip. Shrimp sexes including juveniles were determined with the help of their petasma and thelyca. The size of the crabs was obtained by measuring across the broadest part of the carapace with the help of a divider and a millimeter scale.

The following dimensions of the shells of all species of molluscs were measured with the help of a dial Vernier caliper to the nearest 0.01mm. In case of bivalves and amphineurans: Length as the maximum distance between anterior – posterior axis and Height as dorso-ventral axis; in case of gastropods: height from apex to the tip of the siphonal canal and width as dorso-ventral axis; in case of the cephalopods: maximum distance from the distant part of the mantle to the tip of the longest arm.

Environmental variables (Temperature, salinity, pH, etc.) of the study site were obtained. The salinity was recorded by Atago hand-held refractometer, pH by Expandable ion analyzer and temperature using centigrade thermometer.

Data analysis

Diversity is considered as one of the major characteristics of a community. Species richness is calculated **by**

Margalef's index d =(S-1) / log N.
Where S = total number of species, N = total number of individuals observed.
Species diversity was calculated by Hill Diversity numbers 1 & 2 (Ludwig and Reynolds, 1988). The Hill Diversity numbers N1 = eH'
Where H'= Shannon-Wiener index.
The Hill Diversity number N2=1/Y
Where Y=Simpson's index.
Species Evenness (E5) was calculated by Modified Hill's Ratio E5=N2-1/N1-1
Diversity indices were calculated using the statistical software **PRIMER v. 6** (Clarke and Gorley, 2006) from the Plymouth Marine Laboratory, UK.

RESULTS

Study Area

The study site, Fish Harbor, is situated in the north of Manora channel, a lagoon environment located on the coast of Karachi, Sindh, northern Arabian Sea (Fig. 1). The channel is approximately 8 km long and 850 to 1000-meter-wide, a semi-enclosed body of water connected to open sea through a narrow inlet on the eastern side. Being a navigational channel, it is an overcrowded ship berthing port.

Untreated domestic and industrial sewage from Karachi city reaches this lagoon through Lyari River bringing various types of effluvia from the SITE area of Karachi. About 34 tons of suspended solids are carried by the Lyari River daily (Beg *et al*., 1975).

Wave action at Fish Harbor is not severe. The Lyari River discharges into the Manora Channel at this point and lowered down the salinity. The wastes from the Sindh Industrial Trade Estate (SITE) also use the route of Lyari River and dump into the Manora Channel very near to this station. About 34 tons of suspended solids are carried by the Lyari river daily (Beg *et al*., 1975).

The water at this station turns black and is local called as "Kala Pani": This particular site also become polluted from the wastes of Fish Harbor.

Environmental variables

The seasonal variation in temperature, salinity and pH values of the study site i.e. Fish Harbour is shown in Fig. 2. The water temperature values ranged from 20 to 32 °C with a mean of 25.13 °C. The salinity values ranged from 28 to 36 with mean of 32.56 ‰. The pH values ranged from 7.72 to 7.80 with a mean of 7.73. The depth of the area ranged from 6.42 to 7.50 meters with an average of 7.00 meters.

Macro Fauna

It consists of coelenterates, brachyuran crabs, shrimps, molluscs and finfish species. The molluscs formed the major component in 7 out of the total of 8 samples (Figure 3 & Table 1). More than 50 per cent of the 6 samples consisted of molluscan species. The other animal groups, in order of abundance, are finfish and brachyuran crabs.

Coelenterate individuals were found in 3 samples only viz. September 2008 (*Rhizostoma* pulmo; 100 %), December 2008 (*Aurelia aurita*; 100.00 %) and December 2009 (*Rhizostoma pulmo*; 100%).

Molluscan species were represented by 1 species of bivalve (*Perna viridis*) and 2 species of cephalopods (*Loligo duvaucelli* and *Sepiella inermis*). The mussels were available in 7 of the 8 samples constituting almost 100 per cent in 6 and 97.15 per cent in 1 sample. Few individuals of two species of cephalopods namely *Loligo duvaucelli* and *Sepiella inermis* were also collected (Table 1).

Table 1. Species of Invertebrate collected from Fish Harbour Trawl station of Manora Channel, Northern Arabian Sea and Karachi Coast from March 2008 to December 2009.

S. No	Family	Species	Common Name
1	Portunidae	*Charybdis cruciatea* (Linnaeus, 1758)	Coral crab
2		*Charybdis lucifera* (Fabricius, 1798)	Box crab
3		*Portunus pelagicus* (Linnaeus, 1758)	Blue swimming crab
4		*Portunus sanguinolentus* (Herbst, 1795)	Red spot swimming crab
5		*Scylla serrate* (Forsskaol, 1775)	Mud crab
6		*Thalamita pyrmna* (Herbst)	Crab
7	Penadeidae	*Metapenaeus monoceros* (Fabricius, 1798)	Speckled Shrimp
8		*Penaeus semisulcatus (*Dettaan, 1844)	Green Tiger Prawn
9	Rhizostomidae	*Rhizostoma pulmo*	Barrel Jellyfish
10	Ulmaridae	*Aurelia aurita* (Linnaeus, 1758)	Moon jellyfish
11	Mytilidae	*Perna viridis* (Linnaeus)	Green Mussel
12	Loliginidae	*Loligo duvauceli* (Orbigny,1848)	Indian Squid
13	Sepiidae	*Sepiella inermis* (Orbigny, 1848)	Spineless cuttlefish

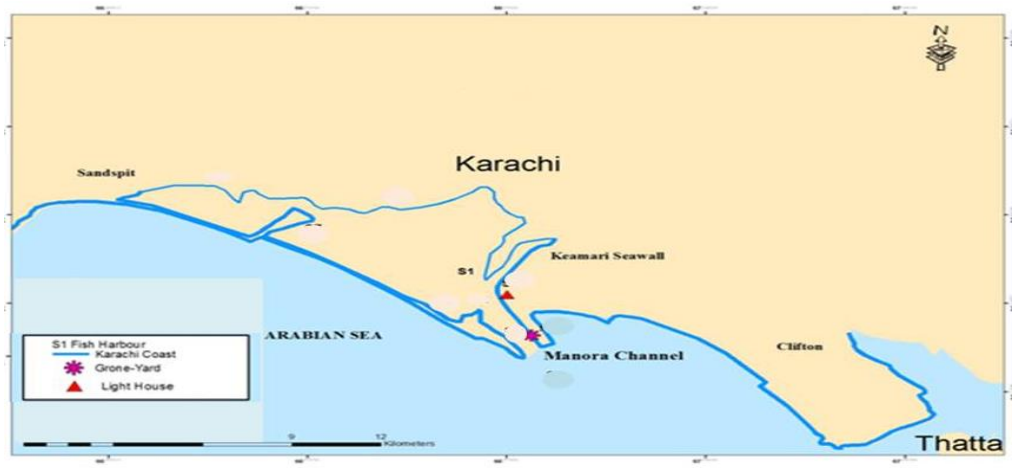


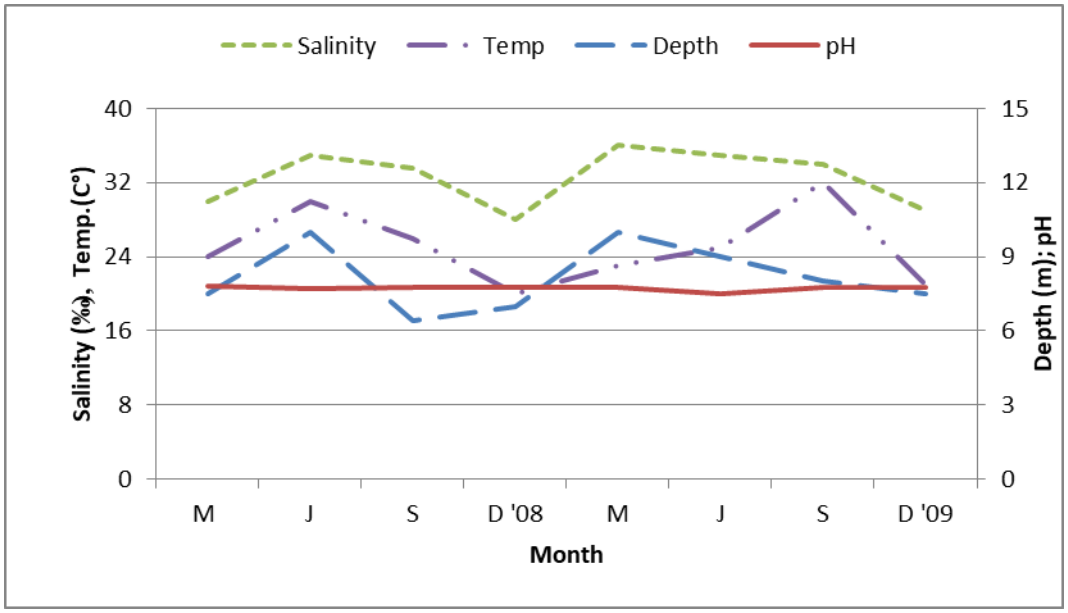
Fig. 1. Map showing the location of Fish Harbour (sampling station 1) in Manora Channel.

Included in shrimps are 2 species of family *Penaeidae* (*Metapenaeus monoceros* (Photograph 16) and *Penaeus semisulcatus); Metapenaeus monoceros* was found in just one sample (September 2008); *Penaeus semisulcatus* was relatively more abundant than *M. monoceros*.

Brachyuran crabs constitute the third most abundant portion of the trawl samples. Six species of crabs were found namely, *Charybdis cruciata*, *C. lucifera*, *Portunas pelagicus*, *P. sanguinolentus*, *Scylla serrata* and *Thalmita pyrmna*. Not a single species was seen consistently in all 8 samples. Only two species (*C. lucifera*) and (*S. serrata*) was caught in 6 out of 8 samples. The species constituted 33.07 to 96.72 per cent of the crab species. In September 2008 *Scylla serrata* constitute 17.86 per cent of crab species whereas in December 2009 *S. serrata* contribute 9.45 per cent of crab species. Moreover, *S. serrata* was altogether absent in March and December 2009 (Fig. 4). The next

abundant species were *Portunas pelagicus* and *Thalmita pyrmna*. Both species were present in 5 samples. In September 2009, *P. pelagicus* constituted 68.42 per cent of crab species whereas in June 2008, it contributed 58.60 per cent of crab species. Moreover, *P. pelagicus* was altogether absent in December 2008, 2009 and March 2009.

The individuals of *Thalmita pyrmna* ranged in percentage from 3.28 to 28.57. The carapace size varied from 41 to 77 mm. More than 28 per cent of crab species belong to *Thalmita pyrmna* in one sample (September 2008).
The remaining 2 species i.e. *Charybdis cruciata* and *Portunas sanguinolentus* were relatively large size edible species, though these were found in only 4 and 2 samples, respectively. Individuals of *C. cruciata* contributed 0.80 to 15.79 per cent of crab species. Individuals of *P. sanguinolentus* were present in just 2 samples (March 2008 and September 2009) contributing 1.01 and 15.79 %, respectively.



Fig, 2. Variation in values of temperature, salinity, depth and pH of the Fish Harbour (station 1).

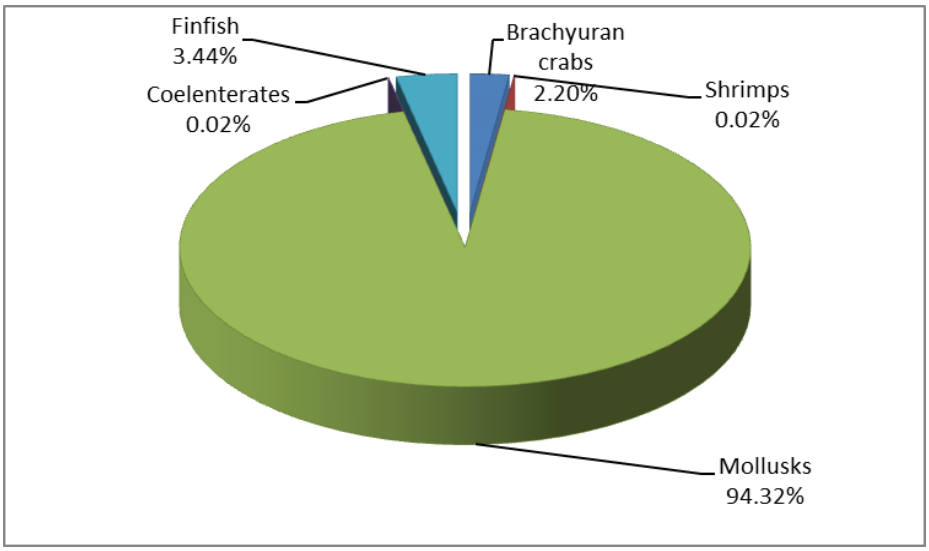


Fig. 3. Pie-chart showing Catch composition of animal groups sampled using trawl net at station No. 1 (Fish Harbour) from March 2008 to December 2008.

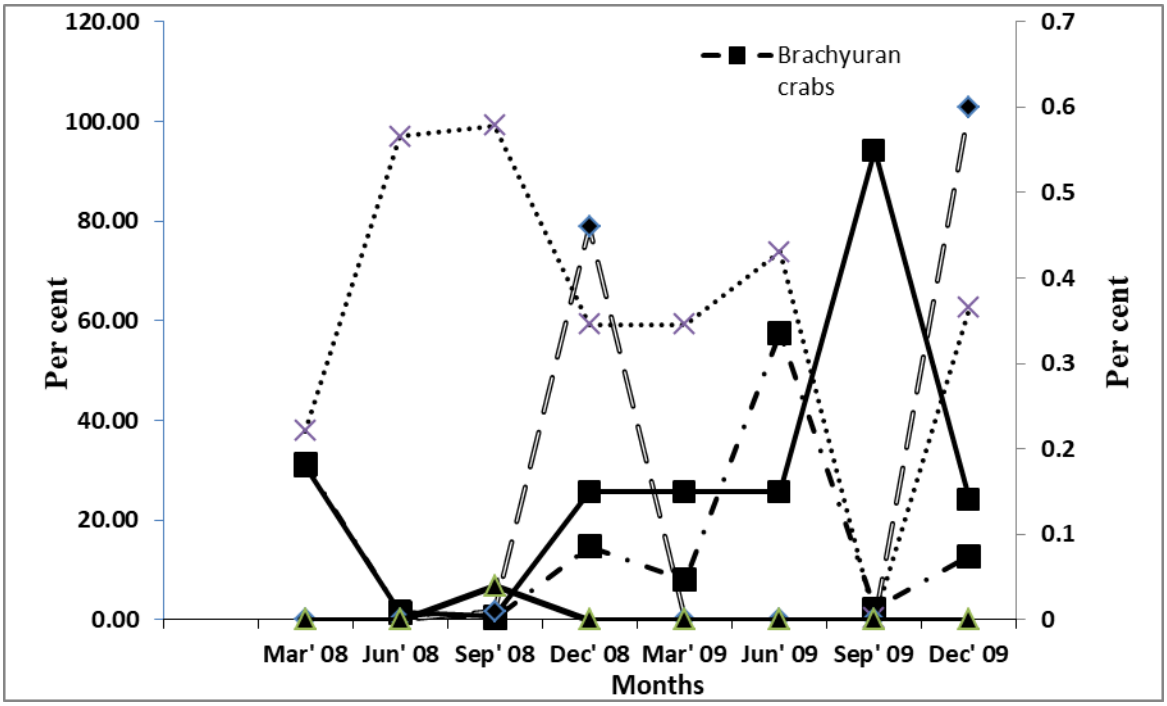


Fig. 4. Monthly variation in Percent (%) of Coelenterate species, Molluscan species, Shrimps, crabs and finfish species using trawl net at station No. 1(Fish Harbour) from March 2008 to December 2009.

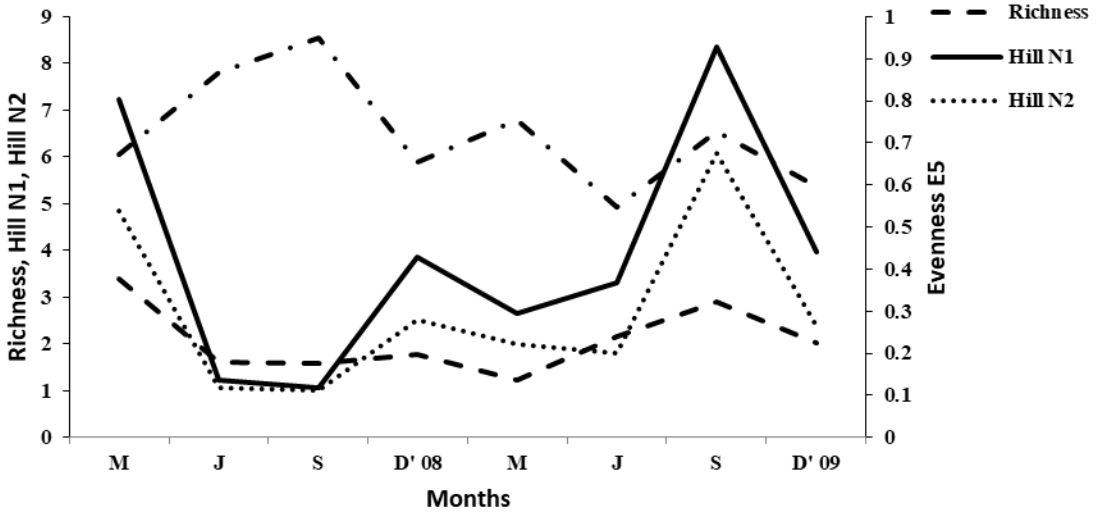


Fig. 5. Seasonal variation in values of richness, Hill Diversity N1, Hill Diversity N2 and evenness E5 of marine fauna at station No.1: Fish Harbour

Fish Species

Forty species of finfish (26 families) were recorded during the study period from March 2008 to December 2009 (Table 2). There are 8 families that were represented by 2 to 5 species whereas 18 families were represented by just one species (Tables 2; Fig. 3 & 4).

The largest family in terms of number of species is *Sciaenidae* that comprised of 5 species: *Johnius elongates*, *J. belangeri*, *J. carruta*, *Otolithes cuvieri* and *Protnibea dicanthus.* Only two of these species (*J. elongates* and *J. belangeri*) appeared in 4 and the other (*Protnibea dicanthus*) in 2 samples whereas the 2 species of this remaining family were found just once. *Protnibea dicanthus* was the largest of all in body length Table 2).

Table 2. Species of vertebrate (finfish) collected from Fish Harbour Trawl station of Manora Channel, Northern Arabian Sea and Karachi Coast from March 2008 to December 2009.

S. No	Family	Species	Common Name
1	Clupeidae	*Ilisha megatoptera* (Swairison, 1839)	Bigeye ilisha
2		*Pellona ditchella* (Valenciennes, 1847)	Indian pellona
3	Engraulidae	*Thryssa mystax* (Schneider, 1801)	Moustached thryssa
4	Ariidae	*Arius maculatus* (Thunberg,1792)	Spotted carfish
5	Platycephalidae	*Cociella crocodile (Tilesius, 1812)*	Crocodile flathead
6		*Grammopolites suppositus (Troschel, 1840)*	Spotfin flathead
7		*Platycephalus indicus (*Linnaeus, 1758*)*	Bartail flathead
8	Serranidae	*Epinephelus diacanthus* (Valenciennes, 1828)	Thornycheek grouper
9	Teraponidae	*Terapon jarbua(Forsskaol, 1775)*	Jarbua terapon
10		*Terapon puta (Cuvior, 1829)*	Small scaled terapon
11	Sillaginidae	*Sillago sihama (Forsskaol,1775)*	Silver sillago
12	Lactariidae	*Lactarius lactarius (Bloch & Schneider, 1801)*	False trevally
13	Carangidae	*Decapterus russeli (Ruppell, 1830)*	Indian scad
14	Lutjanida	*Lutjanus johnii* (Bloch,1787)	John's snapper
15	Lophotidae	*Lophiomus setigerus*	Black mouth angler
16	Haemulidae	*Pomadaysys maculatum (Bloch, 1797)*	Saddle grunt
17	(Pomadasyidae)	*Pomadasys stridens* (Forsskail,1775)	Striped piggy
18		*Pomadaysys hasta*	Silver grunt
19		*Pomadaysys furcatus*	Branded grunter
20	Sparidae	*Acanthopagrus berda* (Forsskail, 1775)	Picnic seabream
21		*Acanthopagrus bifasiatus* (Forsskail,1775)	Twobar Seabream
22	Sciaenidae	*Johnius elongates* (Mohan)	Croakers
23		*Johnius belangerii* (Cuvier, 1830)	Belanger's croaker
24		*Johnius carutta* (Bloch, 1793)	Karut croaker
25		*Otolithes biauritus (*Cantor,1850)	Bronze Croaker
26		*Protonibea diacanthus* (Lacepede,1802)	Spotted croaker
27	Scatophagidae	*Scatophagus argus* (Bloch,1788)	Spotted scat
28	Mugilidae	*Liza carnita* (Valenciennes,1836)	Keeled mullot
29		*Liza subvirdis*	Green back mullet
30	Polynemidae	*Polynemus heptadactylus*	Seven thread fin
31	Trichiuridae	*Lepturacanthus savala* (Cuvier,1829)	Savalai hairtail
32	Callionymidae	*Callionymus marleyi* (Regan)	Sand dragonet
33	Bothidae	*Pseudorhombus arsius* (Hamilton, 1822)	Large tooth flounder
34		*Pseudorhombus elevates* (Ogibby,1912)	Deep flounder
35	Soleidae	*Solea elongate* (Day,1827)	Elongate sole
36	Cynoglossidae	*Cynoglossus bilineatus* (Lacepede, 1802)	Four lined tongue sole
37		*Cynoglossus arel* (Schnieder,1801)	Largescale tongue sole
38	Tetraodontidae	*Mene maculata* (Bloch & Schneider, 1801)	Moonfish
39	Batrachoidadae	*Batrachus grunniens*	Toadfish
40	Scombridae	*Rastrelliger kanagurta* (Curvier,1817)	Indian mackerel

There are 4 species in the family *Haemulidae*, namely, *Pomadasys maculatum*, *P. stridens*, *P. hasta* and *P. furcatus*, and these are moderately large size fishes. They are represented in 1 to 7 samples. Only one of these species (*P. stridens*) appeared in 7 and the other (*P. maculatum*) in 3 samples whereas the remaining two species of this family were found just once. The maximum number of individuals obtained was those of *P. stridens*, (360) and *P. maculatum* (207).

The family *Platycephalidae* was represented by 3 species: *Platycephalus indicus*, *Cociella crocodile* and *Grammoplites suppositus.* The first mentioned species was seen in 2 and the last 2 species in just one sample each. Individuals of these 3 species were found in small number.

There are 5 families being represented by two species each viz. *Clupidae, Teraponidae, Sparidae, Mugilidae* and *Cynoglossidae.* The species included in the family *Clupidae* are *Ilishia megaloptera* and *Pellona ditchella*. Individuals of both species were found in just one out of 8 samples. *Ilishia megaloptera* was represented only in the sample of March 2008. It is a medium size species. *Pellona ditchella* was obtained in one sample (March 2009) only.

The family *Teraponidae* is represented by two species: *Terapon jarbua* and *T. puta*. The later was found in six out of eight samples whereas the *T. jarbua* was present in 7 out of eight samples. It was never found more than 11.29 per cent of the total fishes in the sample. *T. puta* was found in 6 samples and contributed 2.70 to 28.89 per cent of the fish species in the sample (Fig. 4). The family *Sparidae* was represented by 2 species: *Acanthopagrus bifasiatus* and *A. berda.* The first mentioned species was seen in 3 and the second species in four out of eight samples. Individuals of *A. berda* were found in small number (17 individuals) in 4 samples whereas 73 individuals *A. bifasiatus* were captured in 3 samples which were of larger size and weight as compared to *A. berda*.

Family *Mugilidae* tis represented by *Liza carnita* and *L. subvirdis*. Individuals of both species were present in good numbers. *L. subvirdis* was, however, caught only twice (June 2008 & 2009). The fish species were mainly represented by *Liza carinata* while other species contributed very few. *L. carnita* was found in 7 samples and contributed 0.21 to 84.25 per cent of the fish species in the sample. *L. subvirdis* was represented to a maximum of 5.63 per cent of total fish species in June 2009.

The family *Cynoglossidae* was also represented by 2 species; *Cynoglossus arel* and *C. bilineata*. These were captured only twice during the 8 sampling trips. The *C. bilineata* was comparatively larger in size than *C. arel*. Both of these species were poorly represented 0.31 to 12.59 per cent of total fish.

There are 18 families which were represented by just one species. Details of these species are given below:

1. Engrulidae (*Thryssa dussameri*). Found in just one sample i.e. September 2009 constituting 16.41 per cent of the total fishes caught.
2. Arriidae (*Arius maculates*) caught in large number constituting 8.59 per cent of the total fishes in June 2009.
3. Batrachoididae (*Batrachus grunniens*) found in 4 samples. It constituted from 0.79 to 19.17 per cent of the total fish species in the sample.
4. Serranidae (*Epinephelus diacanthus*).
5. Sillaginidae (*Sillago sihama*) present in four samples only. It constitutes 0.26 to 3.75 per cent of the fish species in the four samples.
6. Lactarridae (*Lactarius lactarius*) represented by 1 individual in March 2008.
7. Carangidae (*Decapterus russelli*) found in March 2008.
8. Lutjanidae (*Lutjanus johni*) found in March 2008.
9. Lophiidae (*Lophiomus setigerus*) found in the sample of September 2008.
10. Scatophagidae (*Scatophagus argus*) was represented in 2 samples, June 2008 and June 2009 representing 4.28 to 4.69 per cent of the sample.
11. Polynemidae (*Polynemus heptadactylus*) found in just one sample of March 2008 constituting 1.03 per cent of the total fishes were caught.
12. Scombridae (*Rastelliger kanagurta*) were caught only once (March 2008).
13. Trichiuridae (*Lepturacanthus savala*).
14. Callionymidae (*Callionymus marelyi*) was obtained in one sample March 2008.
15. Bothidae (*Pseudorhombus arsius*) contributing 0.21 per cent of total fish caught in March 2009.
16. Soleidae (*Solea elongate*) captured in 2 samples only. It seems to be an abundant species as is evident from the number of individuals. It constituted 18.8 per cent of the fish species in June 2008 and September 2009 samples.
17. Tricanthidae (*Pseudotricanthus strigilifer*) caught just once (March 2008) constituting 12.99 % of the fishes present.
18. Meneidae (*Mene maculate*) was obtained in one sample (September 2009). It is a small size species.

Species Richness

High variation in values of species richness was observed for first year as compared to second year of study. Values of richness ranged from a minimum of 1.23 in March 2009 to a maximum of 3.40 in March 2008 with an average of 2.09 (Fig. 5).

Values of richness fluctuated seasonally from a maximum in spring (3.40) to a minimum in autumn (1.59) during first year (2008) but reversed was the case during second year of study (2009) i.e. the value was low in spring

(1.23) and high in autumn (2.91). The values vary considerably during both years, but no seasonal trend was observed.

Hill Diversity Index N1

Values of Hill Diversity Index N1 decreases, when number of species is less. High variation in the values of index among the samples of different months was observed at Fish harbour. The values of N1 was lowest (1.07) in September 2008 and highest (8.35) in September 2009 with an average of 3.96 (Fig. 5).

The values of N1 index varied from a maximum in spring (7.22) to a minimum in autumn (1.07) during first year of study i.e. 2008. However, the value was lowest in spring (2.65) and highest in autumn (8.35) during second year of study period i.e.2009.

Hill Diversity Index N2

High variation in values of Hill diversity N2 was observed during second year of study i.e. 2009. The diversity is low (1.02) in September 2008 and high (6.08) in September 2009 with a mean value of 2.71 (Fig. 5).

Diversity fluctuated from highest in spring (4.85) to a lowest in autumn (1.02) during first year of study period. However, N2 values were low in summer (1.81) and high in autumn (6.08) during second year of observation. No seasonal trend was during the study period.

Modified Hill Ratio (E5)

When all species of a sample are equally abundant, evenness is maximum i.e. 1 (Ludwig and Reynolds, 1988). The values of E5 were minimum (0.547) in June 2009 and maximum (0.949) in September 2008 with an average 0.721 (Fig. 5). The values of Evenness E5 followed almost the same pattern as that of species richness. High variation in evenness values was observed for first year (2008) as compared to second year of study (2009). Moreover, more species are evenly distributed during first year of study period. The values of E5 were high in autumn (0.949) and low in winter (0.653) during 2008, whereas, high E5 value was observed in spring (0.755) and low in June (0.547) during 2009. The values vary considerably but no seasonal trend is observed.

DISCUSSION

In the present study, 53 marine species were recorded from Fish Harbour along Manora Channel- Karachi, Pakistan. The coastal area of Sindh and Baluchistan presents a variety of coasts (muddy, sandy, rocky). Earlier studies on marine faunal species were mainly undertaken on the coastal areas of Sindh as well as on Baluchistan (Ahmed *et al*., 1982; Ahmed, 1987; Barkati and Burney, 1995; Hameed and Ahmed, 1999; Ayub and Ahmed; 2001; Ajazuddin and Ahmed, 2002; Barkati and Rahman, 2005; Niazi *et al*., 2007; Atiqullah *et al*., 1997; Ajazuddin and Moazzam, 2007; Baluch and Kazmi, 2007).

There is paucity of information on the faunal composition of pelagic community of Pakistani waters. A perusal of literature, however, shows that considerable attention is given on such aspects elsewhere in the world. The results of the present study documented the presence of 53 species of pelagic animals. Only few (13) of these belong to invertebrate and rest (40 species) to finfishes.

Included among studies on faunal composition of various lagoons are those at Puerto Rico (Stoner, 1986), the. Teacapán-Agua Brava lagoon-estuarine system, Pacific coast of Mexico, inshore habitats along California central coast, Elkhorn Slough, California (Yoklavich *et al*., 1991), Ria de Aveiro, an estuarine coastal lagoon in Portugal (Rebelo, 1992).), Phangnga Bay, the Andaman Sea, Thailand (Janekarn 1993). inshore habitats of Baby, Queensland Williamson *et al.* (1994) from Goa, India (Ansari *et al.*, 1995), Terminos Lagoon (Ramos-Miranda *et al.*, 2005), Campech, Mexico. Among them 105 were fishes, 5 shrimps, 4 crabs and one squid. Islam *et al.* (2006) investigated the fish assemblage, distribution and diversity along Chikugo estuarine gradient in the Ariaka Bay, Japan. A total of 27 species of fish larvae and juvenile were recorded.

Similar studies on estuarine macro fauna were also described from Belgium (Maes *et al.*, 1998), Tasmania (Edgar, 1999), Delaware Bay, USA (Able, *et al*., 2001), southern Taiwan (Kuo *et al*., 2001), Doto near shore water, Japan (Yamamura, 2003), the diversity of fin fish juvenile in Vellar Estuary, Southeast Coast of India (Brinda *et al.* 2010), seasonal distribution and richness of fish species in the Badagry Lagoon in south west Nigeria (Olufemi *et al.*, 2010).

Seasonal Variation in Abundance

Abundance of marine organisms on the rocky shores varies with time (Saifullah, 1973; Horn *et al*., 1983; Qari and Qasim, 1986; 1994; Barkati and Burney, 1995; Rahman and Barkati, 2012). Likewise, the richness of marine pelagic organisms (fauna and flora) was related to the monsoon season (Barkati and Burney, 1995; Nasreen *et al*., 2000; Saifullah, 1973; Qari and Qasim, 1986, 1988). In May and August, the number of macro-invertebrate

individuals was higher than in other months of the year. Horn *et al.* (1983), working on a central California rocky intertidal habitat near Piedrs Blanca related the overall macrophyte population greatest during summer and autumn and least during winter

The number of pelagic individuals in the present study were highest in autumn (45,090) followed by summer (37, 418), spring (1575) and lowest in winter (867) during 2008. However, relatively high values were noticed in summer (4,349) followed by spring (1,523), winter (998) and lowest in autumn (343) in 2009.

Abundance of fin-fishes changes with season in various estuaries and lagoons has been documented by a number of authors i.e. Rebelo, 1992 (Portugal); Ribeiro *et al*., 2006 (Portugal); Brinda *et al*., 2010 (India); Soyinka *et al*., 2010 (Nigeria); Ansari *et al*., 1995 (Goa, India); Janekarn, 1993 (Thailand); Monteiro-Neto *et al*., 2003 (Brazil); Kuo *et al*., 2001 (Chiku lagoon, Taiwan); Fujita *et al*., 2002 (Shimanto estuary, Japan); Maci and Basset, 2009 (Acquatina lagoon, Italy); Shou *et al*., 2009 (Zhoushan).

Diversity indices are used to describe species richness relationship in the communities. Various indices are used in marine ecology for describing these relationships. According to Littler (1980) the richness indices for macrobiota closely parallel the counts of total taxa on the rocky shores of Southern California Bight. Values of various diversity indices were also used for the assessment of disturbance due to pollution and other reasons. Littler and Murray (1975) pointed out that the control areas revealed greater species diversity than the sewage outfall near San Clemente Island, California. Unpolluted sites showed more diversity as compared to disturbed and polluted sites of Bermuda Harbour (Warwick *et al.*, 1990). Gray *et al.* (1990) documented that a reduction in number of species and diversity and increase in dominance of opportunistic species in response to oil as a stress factor from the Ekofisk and Eldfisk oilfield, North Sea.

Moreover, working on exploited and non-exploited rocky infratidal macrofaunal assemblages along Transkei coast, South Africa, Lasiak and Field (1995) pointed out that exploitation had no significant effect on species richness or on diversity. The results of the present study conform to the observations of Warwick and Clarke (1993) and Lasiak and Field (1995).

The present study showed that all four types of diversity indices (richness, Hill diversity N1 & N2, Modified Hill Ratio E5) showed almost the same pattern i.e. maximum in spring and minimum in autumn in 2008 but the reverse was true in 2009 i.e. lowest in spring and highest in autumn. This is indicative of the fact that seasonal trend in not consistent.

ACKNOWLEDGEMENTS

Special thanks are due to Mr. Mushtaq Ahmad, Deputy Director- Karachi Fish Harbour Authority for special permission of collection trip and help in taking photographs of study sites and marine animals.

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(*Accepted for publication December 2019*)