

Original Article

Biodiversity of commercially important finfish species caught by mid-water and bottom trawls from two different coasts of Arabian Sea: Threats and conservation strategies

Biodiversidade de espécies de peixes comercialmente importantes capturadas por redes de arrasto de médio e fundo do Baluchistão e costas de Sindh do mar da Arábia no Paquistão: Ameaças e estratégias de conservação

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Abstract

This study was conducted to estimate the diversity and the occurrence of commercially important finfish species collected by twenty fish sampling site of Sindh and Baluchistan coasts of the Arabian Sea in Pakistan from January to December 2019. Additionally, physicochemical characteristics of seawater were analyzed from these selected sites and found to be within suitable ranges required for fish growth and survive. A total of 81287 fish individuals were collected and identified as 49 species belonging to 26 families in our study. The most diversified family was Sparidae (13 species) followed by Carangidae and Lutjanidae (4 species), Mullidae, Serranidae, Ariidae (3 species), and Sciaenidae (2 species). The remaining 20 families were represented by only one species. The values of Shannon diversity index calculated for the four selected habitats revealed that high fish diversity was reported at Sonmiani Coast ($H' = 1.81$), while less at Ormara Coast ($H' = 0.23$). Likewise, Evenness index (E) was high at Sonmiani Coast ($E = 0.50$) and less fish diversity was reported at Ormara Coast ($E = 0.06$). Reducing risks to threatened marine species in coastal habitats also requires conservation actions at multiple scales. Thus, it was concluded that our study could be valuable in providing the more information's regarding to the diversity of finfish species and their occurrence along the Pakistan Coast. Further, to better understand the effects, regular monitoring and conservation measures should be taken to mitigate the influence of anthropogenic activities and protect finfish diversity from further decline

Keywords: finfish diversity, relative abundance, occurrence, Ketī Bandar, Churna Coast, Sonmiani, Ormara Coast.

Resumo

Este estudo foi conduzido para estimar a diversidade e a ocorrência de espécies de peixes comercialmente importantes coletadas por vinte locais de amostragem de peixes nas costas de Sindh e Baluchistão do mar da Arábia, no Paquistão, de janeiro a dezembro de 2019. Além disso, as características físico-químicas da água do mar foram analisadas a partir desses peixes locais selecionados e considerados dentro dos intervalos adequados necessários para o crescimento e sobrevivência dos peixes. Um total de 8.1287 indivíduos de peixes foi coletado e identificado como 49 espécies pertencentes a 26 famílias em nosso estudo. A família mais diversificada foi Sparidae (13 espécies), seguida por Carangidae e Lutjanidae (4 espécies), Mullidae, Serranidae, Ariidae (3 espécies) e Sciaenidae (2 espécies). As 20 famílias restantes foram representadas por apenas uma espécie. Os valores do índice de diversidade de Shannon calculados para os quatro habitats selecionados revelaram que uma alta diversidade de peixes foi relatada na costa Sonmiani ($H' = 1,81$), enquanto menos na costa Ormara ($H' = 0,23$). Da mesma forma, o índice de regularidade (E) foi alto na costa de Sonmiani ($E = 0,50$) e menos diversidade de peixes foi relatada

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Received: February 2, 2021 – Accepted: April 04, 2021



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na costa de Ormara ($E = 0,06$). A redução dos riscos para as espécies marinhas ameaçadas em habitats costeiros também requer ações de conservação em várias escalas. Assim, concluiu-se que nosso estudo pode ser valioso para fornecer mais informações sobre a diversidade de espécies de peixes finos e sua ocorrência ao longo da costa do Paquistão. Além disso, para compreender melhor os efeitos, medidas regulares de monitoramento e conservação devem ser tomadas para mitigar a influência das atividades antropogênicas e proteger a diversidade de peixes finos de um declínio maior.

Palavras-chave: diversidade de peixes-barbatanas, abundância relativa, ocorrência, Keti Bandar, Costa Churna, Sonmiani, Costa Ormara.

1. Introduction

Fish is one of the chief sources of high-quality protein to consume one billion people globally (Ahmad et al., 2020; Khalid et al., 2021; Hassan et al., 2021a). Fish as the second trophic level in a food chain, also play a vital role in aquatic ecosystems. (Hassan et al., 2020a). The research of finfish gives an idea for providing a fruitful product to aquaculture and plays an important role in fisheries development (Hassan et al., 2021b). Fish diversity traits, abundance, and population are influenced by breeding grounds, food availability, geological and geographic factors, physiochemical parameters, size, depth, water current and topographic characteristics (Attaullah et al., 2021). Fish are susceptible to ecological modifications, and their diversity in a broad spectrum of differential tolerance reflects the health status of the ecosystem (Chowdhury et al., 2019; Sabbir et al., 2020). Changes in ecosystems of the food tropical level implanted remarkable effects on the abundance and distribution of fish. The relative abundance of any fish species is also a major component of fish biodiversity and it's also define how this species is common or rare in relative to the other species in a distinct location or community. Thus, the relative species abundance can be define as different fish species in a community exists in relative proportional. (Gladstone et al., 2013; Pratchett et al., 2014; Ali et al., 2020; Hasan et al., 2020). Vertebrate diversity is severely affected due to increased anthropogenic activities in aquatic ecosystem changes result in changes to the habitats of vertebrate species, parameters of water quality distinct biological and environmental variables (Hassan et al., 2020a). The potential impacts of ingested microplastics to aquatic organisms are driven by their physical and chemical effects, the latter being influenced by the presence of additives and adsorbed organic chemicals (Barboza et al., 2019). Microplastics is also affecting certain factors including habitat conditions, overall health implications, improper gill functioning early life, reduced feeding intensity, immuno-suppression, compromised reproducibility, fish fatness, season, development pattern, degree of stomach completeness, gonad middle age, sexual category, size range, physical condition, and common fish form and maintenance techniques (Tesch, 1971; Froese, 2006; Jisr et al., 2018; Hassan et al., 2020b).

The coastline of Pakistan about 1050 km. The coast is divided into two zones, i.e. the northwestern region or Makran coast with a generally rocky bottom and the shelf is uneven, and the southeastern region of Sindh coast with sandy or sandy-muddy bottom (Hassan et al., 2020a). Study area located in the northern part of the Arabian Sea the geographical location is $61^{\circ}30'$ E. $68^{\circ}10'$ E. The region is characterized by several bays such as, Sonmiani, Keti

Bandar, Churna coast and Ormara that represent a specific study area. The study area of this study, the Arabian Sea at the coast of Sindh and Baluchistan has rich fish deposits of commercial importance. Anthropogenic malpractices and destructive activities lead to enormous stress on fish and induce different toxicological effects/endpoints and even death at extreme levels, such as excessive use of pesticides, heavy metals, and discharge of untreated effluent to natural water bodies (Ullah and Zorriehzahra, 2015). As the anthropogenic activity in the sea its effective species allocation and great quantity could be distorted. Variations in chemical and physical characteristics of water can impact on sexual maturation and growth of fish. Such changes in water parameters can be partially produced by human activity in the sea as well as by season variations (Seiyaboh et al., 2016; Lelli et al., 2018). Many researchers conducted studies on the ecology and diversity of fishes on global (Pet-Soede et al., 2001; Graham and Nash, 2013; Marshall et al., 2003).

In the last few years, the landing records of aquatic vertebrate fauna steadily declined in Pakistan, based on regular monitoring of local exporters and suppliers. The coastal area of Pakistan is composed of different regions such as Keti Bandar, Churna coast, Ormanra and Sonmiani. These regions are the homeland of varied groups of Fish fauna. Biodiversity, the variation of life on Earth, is a major factor in its resilience. It is regularly to be overlooked species that are the most important to healthy ecosystems. There are promising fisheries technologies which have been developed and are being practiced for improving fish biodiversity and nutrition. The stress on major ecosystems has resulted in erosion of biodiversity due to various anthropogenic activities. It has been concluded that changes in habitats and increased frequency of threats has caused a decline in the vertebrate diversity. This study was attempted to record diversity of commercially important finfish species caught by mid-water and bottom trawl from the twenty sites of Baluchistan and Sindh of Arabian Sea in Pakistan. Additionally, potential threats to finfish diversity and conservation strategies were also discussed.

2. Materials and Methods

2.1. Study area

The whole study area was divided into four major fishing stations, i.e., Keti Bandar and Churna coast of Sindh coast, Sonmiani and Ormara of Balochistan coast. Then, each

station was further sub-divided into five fish sampling sites as presented in Table 1 and Figure 1.

2.2. Water parameters analysis

Two liters of subsurface water samples were collected monthly during the study period extends from January to December 2019 by a polyvinyl chloride Van Dorn bottle at four selected fishing stations along the Sindh and Balochistan Coasts of Pakistan. Details of water sampling stations along with their longitude and latitude were presented in Table 1, respectively. Then all these water samples were kept in polyethylene bottles stored in ice boxes and their physio-chemical analyzed were done in the laboratory of Marine reference collection and resources center (MRCC) of the University of Karachi. Water parameters such as pH, salinity, temperature, and conductivity of four fishing stations were also calculated in situ by following the methods of Hassan et al. (2021a, b).

2.3. Collection of fish samples

Fishes were caught with different types of fishing gears e.g., gill nets, trammel nets, trawl nets, hooks, long lines,

traps, and hooks, as shown in Figure 2. Fishing was done on monthly basis from January to December 2019 (except in heavy monsoon season or rainy floods that extends from July to September). Fish samples were collected by a wooden ship from the twenty sites of 20 selected stations. Wooden ship registration number 18511-B was used for this study. About 40 meter long and 6 meter wide with a cork line at the top rope and metal line with the ground rope made locally of nylon and plastic net were used for fishing. Fishing was done late at night with the help of professional local crew members A total of 81287 specimens of different fish species were collected from landings at the Arabian Sea Pakistan monthly to check their biodiversity at study areas. The fish species identify by FAO species identification guide and fish stored in ship freezer by following the methodology (FAO, 2015; Hassan et al., 2020a).

2.4. Calculation of Relative abundance (R)

The relative abundance of fishes found at twenty sites was calculated by using the equation as; $RA = \frac{ni}{N} \times 100$, where "ni" is the number of specimens of the species, and $N = \sum ni$ (Odum, 1970).

Table 1. Study areas of the Arabian Sea at Sindh and Balochistan coast of Pakistan.

No	Stations	Fish Sampling Sites (S)	Depth (Meter)	Latitude	Longitude
1.	Keti Bandar	S1	150.0±50.0	23.514754°N	67.487464°E
		S2	150.0±15.0	23.333297°N	67.284217°E
		S3	100.0±50.0	23.871897°N	66.443763°E
		S4	50.0±20.0	24.117097°N	66.646995°E
		S5	150.0±80.0	23.754348°N	66.224021°E
2.	Churna coast	S6	50.0±40.0	24.949998°N	66.335830°E
		S7	40.0±30.0	24.926664°N	66.202562°E
		S8	20.0±5.0	24.904401°N	66.595795°E
		S9	30.0±5.0	24.688686°N	66.609226°E
		S10	46.0±14.0	24.78727°N	66.524082°E
3.	Sonmiani	S11	100.0±20.0	25.202357°N	66.424151°E
		S12	80.0±30.0	25.099709°N	66.351572°E
		S13	70.0±50.0	25.130349°N	65.969662°E
		S14	50.0±10.0	25.158942°N	66.032147°E
		S15	30.0±2.0	25.219834°N	66.225094°E
4.	Ormara	S16	140.0±100.0	24.926681°N	64.598947°E
		S17	130.0±50.0	24.458315°N	65.053439°E
		S18	110.0±50.0	24.449539°N	64.485150°E
		S19	90.0±50.0	24.336009°N	64.452877°E
		S20	38.0±5.0	24.086844°N	64.312649°E

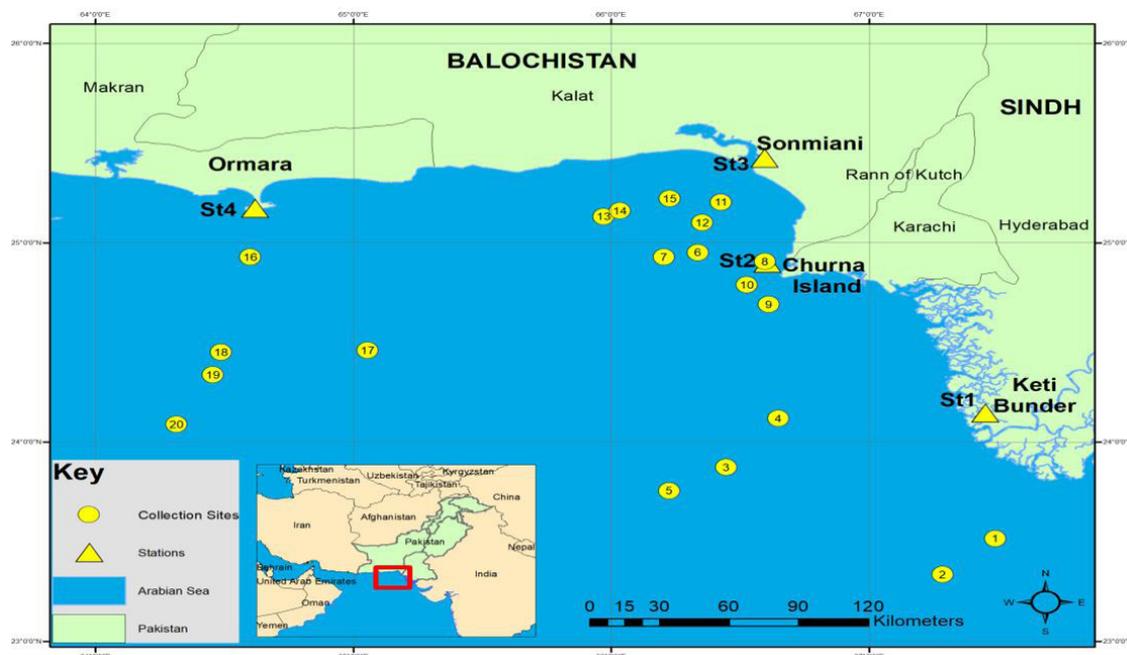


Figure 1. Map showing the collection localities of 49 fish species the Sindh and Balochistan coasts in the Arabian Sea, Pakistan, the sampling sites 8,9 and 11 indicate the contaminated site. Source: <https://www.google.com/arcmap/10.5>. 15th September 2020).

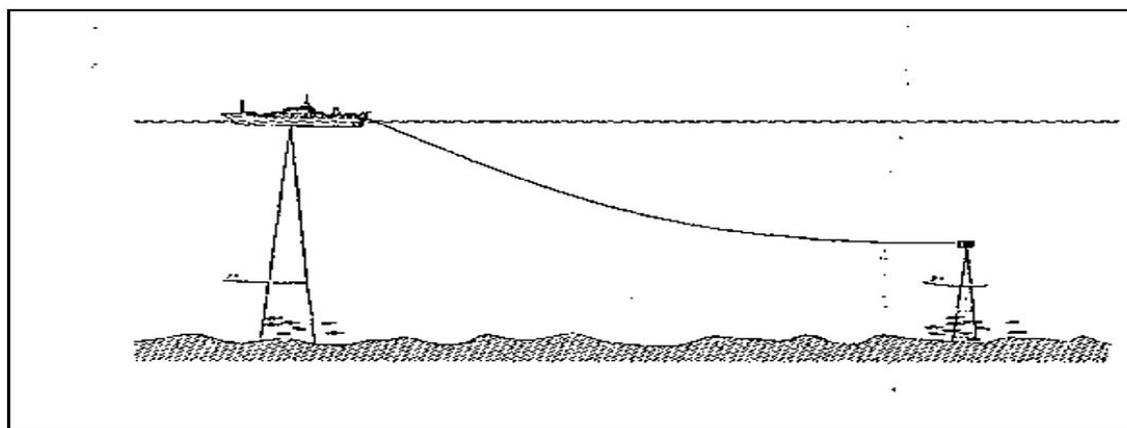


Figure 2. Voyage Of Arabian Sea Pakistan for fishing surveys mid-water and bottom trawls landing during study periods.

2.5. Calculation of fish diversity index

For calculating fish diversity, Simpson’s index (D), Shannon-Weiner diversity index (H’), Evenness (E), and dominance (D) of fish species were estimated using the formula, as follows:

i. Shannon-Weaver diversity index (H’) was calculated using the following equation of Shannon and Weaver (1949) as follows (Equation 1);

$$H' = - [\sum pi(lnpi)] \tag{1}$$

Where, H’ = Diversity Index; $pi = ni / N$; where “ni” is the number of individuals collected for a species, and ‘N’ is measured by $\sum ni$.

ii. Species richness (SR) was also calculated using the equation of Margalef (1951) as follows (Equation 2);

$$SR = (S - 1) / lnN \tag{2}$$

Where S= the total number of species and N = the total number of individuals present in the sample.

iii. **Species evenness (E)** was calculated by using the equation of Pielou (1966) as follows (Equation 3);

$$E = H' / \log nS \quad (3)$$

Where “S” was the total number of species and H’ is the Shannon-wiener diversity index.

All statistical analysis was performed using computer-based software such as MS Excel version 2013 and PAST version 2.17C by the methodology adopted from Hammert et al. (2001) and Mohamed et al. (2017).

2.6. Microplastics isolation

To each sample, a volume of 10% KOH (potassium hydroxide) solution (prepared with ultra-pure water) consistent to 3 folds of its volume was added. Dorsal muscle and gastrointestinal tract samples were incubated at 60 °C for 24 h (Dehaut et al., 2016), and gill samples were incubated at 40 °C for 72 h (Karami et al., 2017) to digest the organic material. Following the incubation time, the entire liquid was vacuum filtered through glass-microfiber filter membranes (pore size 1.2 µm, Munktell & Filtrak GmbH, Germany). Filters were covered in glass Petri dishes and oven-dried for 24 hours at 40 °C. (Drying oven EV50, Raypa, Spain). The filter membranes were then examined and photographed in a stereomicroscope equipped with a CMOS camera. (LEICA S9i, Leica Microsystems GmbH, Germany). Color and form (fragments – irregular pieces; pellets – circular and ovoid debris; fibres – thin and elongated pieces) were used to sort and quantify all of the plastic objects retrieved from the samples (Frias et al., 2018),

3. Results

3.1. Physicochemical parameters of water

Water samples collected from the four stations along with Sindh and Balochistan coast and their parameters i.e., temperature, pH, salinity, and electric conductivity were found in ranged from 21.22–31.86 °C, 7.85–8.05, 35.16–39.80 ppt and 62.8–71.4 µmhos/cm, which was

considered to be in suitable for these fish species as shown in Table 2 and Figure 3, respectively.

3.2. Species composition and abundance across twenty sampling sites

In this study, a total fish catch (N) contains 81287 fish samples collected from the four main stations along Sindh and Baluchistan coasts, which were identified and were reported as 26 families and 49 species by using their morphological approach. Table 3 shows the occurrence of species at twenty fish-sampling sites. The overall pattern of the species composition and abundance during the study period across the twenty sampling stations is reported in Table 4. Among 49 species, high fish catch (ni=74472) and relative abundance (R=91.6%), were reported for *Netuma thalassina* followed by *Arius arius* (ni=2555; R=3.14%), *Arius maculatus* (ni=592; R=0.73%), *Otolithes argenteus* (ni=340; R=0.42%), *Formioniger* (ni=286; R=0.35%), *Pampus argenteus* (ni=272; R=0.33%), *Lutjanus argentimaculatus* (ni=245; R=0.30%), *Acanthopagrus arabicus* (ni=241; R=0.30%), *Cynoglossus arel* (ni=234; R=0.29%), *Chanos chanos* (ni=212; R=0.26%), *Epinephelus coioides* (ni=204; R=0.25%), *Sillago sihama* (ni=181; R=0.22%), *Lutjanus malabaricus* (ni=169; R=0.21%), *Acanthopagrus berda* (ni=145; R=0.18%), *Acanthopagrus catenula* (ni=139; R=0.17%), *Pomadasys kaakan* (ni=124; R=0.15%), *Muraenesox cinereus* (ni=118; R=0.15%), *Platycephalus fuscus* (ni=102; R=0.13%), *Caranx malabaricus* (ni=78; R=0.10%), *Lutjanus rivulatus* (ni=56; R=0.1%), *Rastrelliger kanagurta* (ni=51; R=0.1%), *Coryphaena hippurus* (ni=47; R=0.1%), *Lutjanus fulvus* (ni=42; R=0.1%), *Acanthopagrus bifasciatus* (ni=37; R=0.1%). While remaining species such as *Nemipterus japonica*, *Mullus barbatus*, *Epinephelus tauvina*, *Sparidentex hasta*, *Epinephelus diacanthus*, *Scomberoides commersonianus*, *Cheimerius nufar*, *Crenidens indicus*, *Panulirus polyphagus*, *Carangoides malabaricus*, *Argyrops spinifer*, *Terapon jarbua*, *Panulirus polyphagus*, *Lates calcarifer*, *Parexocoetus brachypterus*, *Aluterus monoceros*, *Psettodes erumei*, *Acanthopagrus shim*, *Pagellus affinis*, *Sparidentex hasta*, *Diplodus capensis*, *Rhabdosargus haffara*, *Isurus oxyrinchus*, *Rhabdosargus sarba*, *Lepturacanthus savala*, *Sphyrnaena putnamae*, and

Table 2. Physicochemical parameters of water samples collected from four locations of the Arabian Sea in Pakistan.

Stations	Salinity (ppt)	Temperature (°C)	pH	Conductivity (mS/cm)
	Mean±S.E	Mean±S.E	Mean±S.E	Mean±S.E
Keti Bandar	35.87±1.41	21.22±6.89	7.85±0.39	62.8±6.43
Churna coast	39.80±1.21	28.03±3.65	8.86±1.68	70.95±2.33
Sonmiani	36.16±1.10	29.92±1.86	8.05±0.24	69.7±2.91
Ormara	35.16±0.95	27.65±4.45	8.08±0.35	71.4±5.31
Range	35.16–39.80	21.22–31.86	7.85–8.05	62.8–71.4
Permissible range for fishes (Kane et al., 2015)	32.0–37.0	20.0–30.0	7.0–8.5	46.0–72.0

S.E = Standard Error of the mean.

Argyrosomus heinii were reported in less relative frequency of occurrence as shown in Figure 4 and Figure 5.

3.3. Abundance of fishes along the four sampling stations (S)

Relative abundance (R) of the fish samples along with the four stations i.e., Sonmiani coast shows highest fish catch (N=51170) and relative abundance (R)=62.95% followed by

Keti Bandar (N=17236; R=21.2%), Churna coast (N=8115; R=9.98%), while Ormara shows low fish catch (N=4677) and low relative abundance (R)=5.86%.

3.4. Abundance of fishes along with twenty sub-stations

The relative abundance (R) of the fish samples along the twenty sampling sites of four stations. The overall results revealed that the highest fish catch (N=18661) and relative

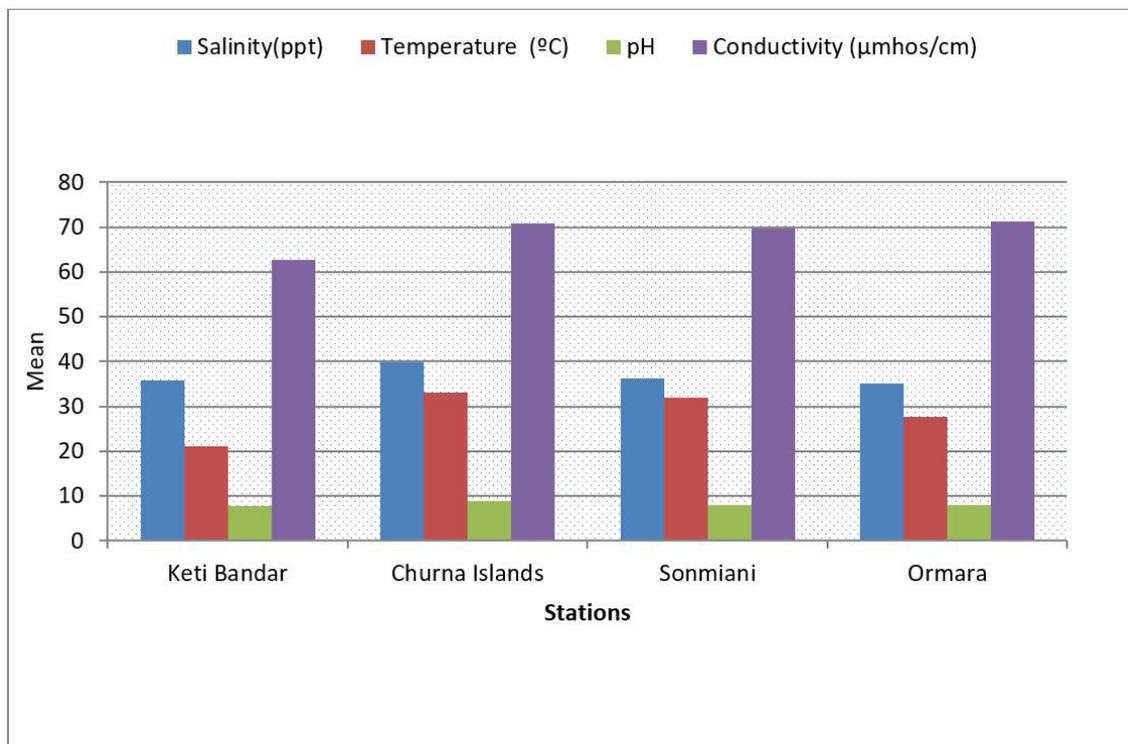


Figure 3. Physicochemical parameters of water samples collected from the study areas.

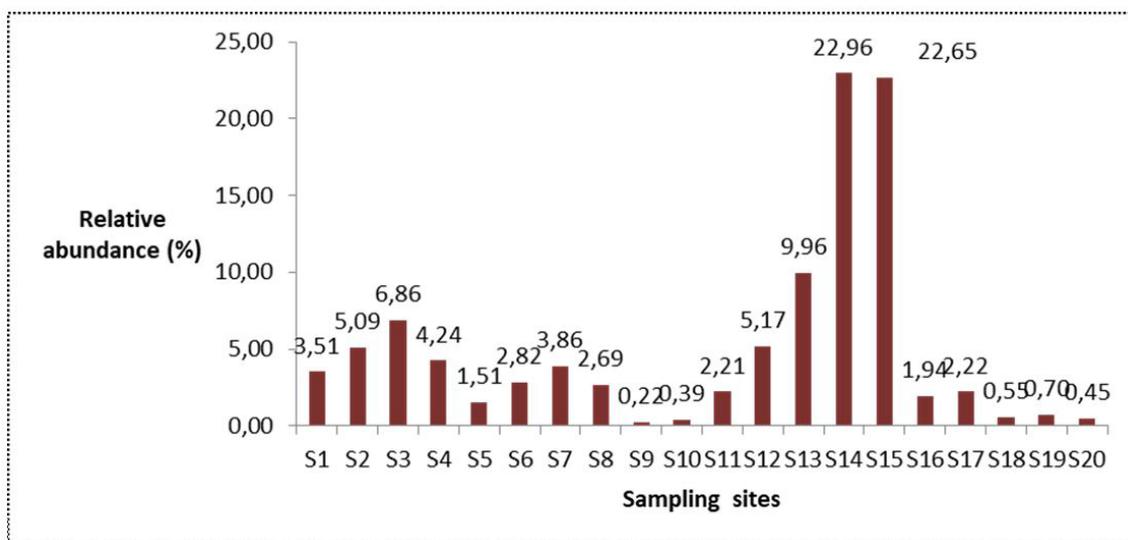


Figure 4. Relative abundance (R) of fish samples collected from twenty sites during study period.(N:81287).

Table 3. Occurrence of the 49 species landing at twenty sampling sites of Sindh and Balochistan Coast during the study period.

Fish families	Scientific name	Sindh coast										Baluchistan coast										
		Keti Bandar					Churna coast					Sonmiani					Ormanra					
		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20	
Sparidae	<i>Acanthopagrus catenula</i>	+	+	+	+	+	+	+	+	+	-	-	+	+	-	-	-	-	-	-	-	
	<i>Acanthopagrus sheim</i>	+	+	+	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
	<i>Sparidentex hasta</i>	-	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Crenidens indicus</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Diplodu scapensis</i>	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Acanthopagrus bifasciatus</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-
	<i>Acanthopagrus arabicus</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-
	<i>Acanthopagrus berda</i>	+	+	+	+	-	-	+	+	-	-	-	+	+	+	+	+	+	+	+	+	+
	<i>Argyrops spinifer</i>	+	+	-	-	-	+	-	-	-	-	-	-	-	-	-	+	+	-	+	+	-
	<i>Rhabdosargus sarba</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Carangidae	<i>Rhabdosargus haffara</i>	-	-	-	-	-	-	+	+	-	-	-	-	+	+	-	-	-	-	-	-	
	<i>Pageillus affinis</i>	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	<i>Cheimentus nufar</i>	-	-	+	-	+	+	-	-	-	-	-	-	+	+	+	+	+	+	+	+	-
	<i>Scomberoides commersonianus</i>	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	<i>Carangoides malabaricus</i>	+	+	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-
	<i>Formio niger</i>	+	+	+	+	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	-
	<i>Caranx malabaricus</i>	+	+	+	+	-	-	-	-	+	-	-	-	-	-	-	-	-	+	+	+	+

+ shows occurrence of the species; - shows absence of species.

Table 4. Relative abundance of the 49 species with their 26 families landed at four stations at Sindh and Balochistan Coasts.

Fish families	Fish Species	Fish Species		Sampling stations (S)		Number of samples/species	Relative abundance
		Sindh Coast		Balochistan Coast			
		Keti Bandar	Churna coast	Sonmiani	Ormara	ni	R (%)
Sparidae	<i>Acanthopagrus catenula</i>	0.27	1.05	0.02	0.00 _d	139.0	0.17
	<i>Acanthopagrus sheim</i>	0.03	0.00 _d	0.00 _d	0.00 _d	7.0	0.01
	<i>Sparidentex hasta</i>	0.02	0.02	0.00 _d	0.00 _d	6.0	0.01
	<i>Crenidens indicus</i>	0.01	0.06	0.01	0.08	15.0	0.02
	<i>Diplodus capensis</i>	0.03	0.00 _d	0.00 _d	0.00 _d	6.0	0.01
	<i>Acanthopagrus bifasciatus</i>	0.06	0.14	0.02	0.06	37.0	0.05
	<i>Acanthopagrus arabicus</i>	0.66	1.22	0.02	0.36	241.0	0.30
	<i>Acanthopagrus berda</i>	0.28	0.22	0.09	0.69	145.0	0.18
	<i>Argyrops spinifer</i>	0.02	0.02	0.00 _d	0.10	12.0	0.01
	<i>Rhabdosargus sarba</i>	0.01	0.00 _d	0.01	0.00 _d	5.0	0.01
	<i>Rhabdosargush affara</i>	0.00 _d	0.05	0.00 _d	0.00 _d	6.0	0.01
	<i>Pagellus affinis</i>	0.01	0.01	0.00 _d	0.08	7.0	0.01
	<i>Cheimerius nufar</i>	0.02	0.01	0.01	0.15	17.0	0.02
Carangidae	<i>Scomberoides commersonnianus</i>	0.01	0.05	0.02	0.04	18.0	0.02
	<i>Carangoides malabaricus</i>	0.04	0.00 _d	0.00 _d	0.08	13.0	0.02
	<i>Formio niger</i>	0.58	0.00 _d	0.23	1.43	286.0	0.35
	<i>Caranx malabaricus</i>	0.29	0.00 _d	0.00 _d	0.59	78.0	0.10
Lutjanidae	<i>Lutjanus argentimaculatus</i>	0.08	0.00 _d	0.22	2.48	245.0	0.30
	<i>Lutjanus malabaricus</i>	0.17	0.42	0.06	1.57	169.0	0.21
	<i>Lutjanus rivulatus</i>	0.08	0.02	0.00	0.86	56.0	0.07
	<i>Lutjanus fulvus</i>	0.01	0.02	0.02	0.59	42.0	0.05
Ariidae	<i>Netuma thalassina</i>	88.91 _a	91.53 _a	96.03 _a	54.13 _{ab}	74472.0	91.6
	<i>Arius arius</i>	2.29	1.49	2.51	15.88 _r	2595.0	3.14
	<i>Arius maculatus</i>	1.07	0.90	0.18	5.04 _r	592.0	0.73
Serranidae	<i>Epinephelus coioides</i>	0.67	0.30	0.06	0.63	202.0	0.25
	<i>Epinephelus tauvina</i>	0.04	0.10	0.02	0.08	28.0	0.03

Superscripts a, b, c, d shows highest to lowest percentage composition of fish samples; Subscripts a= high frequency of occurrence of species with R>70%, ab= low frequency of occurrence when R<60%, r= rare species when R<50%, d= absence of species when R=0.0%.

Table 4. Continued...

Fish families	Fish Species	Sindh Coast		Balochistan Coast		Number of samples/species ni	Relative abundance R (%)
		Keti Bandar	Churna coast	Sonmiani	Ormara		
	<i>Epinephelus diacanthus</i>	0.01	0.00 _d	0.02	0.25	25.0	0.03
Sciaenidae	<i>Argyrosomus heinii</i>	0.00 _d	0.00 _d	0.00 _d	0.02	1.0	0.00
	<i>Otolithes argenteus</i>	0.34	0.32	0.15	3.69	340.0	0.42
Haemulidae	<i>Pomadasys kaakan</i>	0.14	0.16	0.08	0.94	124.0	0.15
Nemipteridae	<i>Nemipterus japonicus</i>	0.12	0.04	0.00 _d	0.17	31.0	0.04
Terapontidae	<i>Terapon jarbua</i>	0.03	0.00 _d	0.01	0.06	12.0	0.01
Scombridae	<i>Rastrelliger kanagurta</i>	0.24	0.00 _d	0.02	0.00 _d	51.0	0.06
Monacanthidae	<i>Aluterus monoceros</i>	0.01	0.00 _d	0.01	0.08	10.0	0.01
Sillaginidae	<i>Sillago sihama</i>	0.95	0.16	0.01	0.00 _d	181.0	0.22
Sphyraenidae	<i>Sphyraena putnamae</i>	0.02	0.00 _d	0.00 _d	0.00 _d	4.0	0.00
Coryphaenidae	<i>Coryphaena hippurus</i>	0.06	0.02	0.01	0.65	47.0	0.06
Cynoglossidae	<i>Cynoglossus arel</i>	0.63	0.12	0.00 _d	2.39	234.0	0.29
Muraenesocidae	<i>Muraenes oxcinereus</i>	0.48	0.12	0.03	0.25	118.0	0.15
Psettodidae	<i>Psettodes erumei</i>	0.01	0.00 _d	0.01	0.04	8.0	0.01
Stromateidae	<i>Pampus argenteus</i>	0.18	0.07	0.05	4.39	272.0	0.33
Trichiuridae	<i>Lepturacanthus savala</i>	0.02	0.00 _d	0.00 _d	0.00 _d	5.0	0.01
Palinuridae	<i>Panulirus polyphagus</i>	0.07	0.00 _d	0.00 _d	0.00 _d	12.0	0.01
Mullidae	<i>Mullus barbatus</i>	0.06	0.02	0.01	0.27	29.0	0.04
Platycephalidae	<i>Platycephalus fuscus</i>	0.06	0.00 _d	0.03	1.64	102.0	0.13
Centropomidae	<i>Lates calcarifer</i>	0.06	0.02	0.00 _d	0.00 _d	12.0	0.01
Chanidae	<i>Chanos chanos</i>	0.71	1.00	0.02	0.00 _d	212.0	0.26
Exocoetidae	<i>Parexocoetus brachypterus</i>	0.01	0.05	0.00 _d	0.13	12.0	0.01
Lamnidae	<i>Isurus oxyrinchus</i>	0.03	0.00 _d	0.00 _d	0.00 _d	6.0	0.01
Number of Fish samples/station (SN)		17236	8115	51170	4677	Total fish samples (N) =81287	
Relative abundance/Station (%)		21.20 ^b	9.98 ^c	62.95 ^a	5.86 ^d		

Superscripts a, b, c, d shows highest to lowest percentage composition of fish samples; Subscripts a= high frequency of occurrence of species with R>70%, ab= low frequency of occurrence when R<60%, r= rare species when R<50%, d= absence of species when R=0.0%.

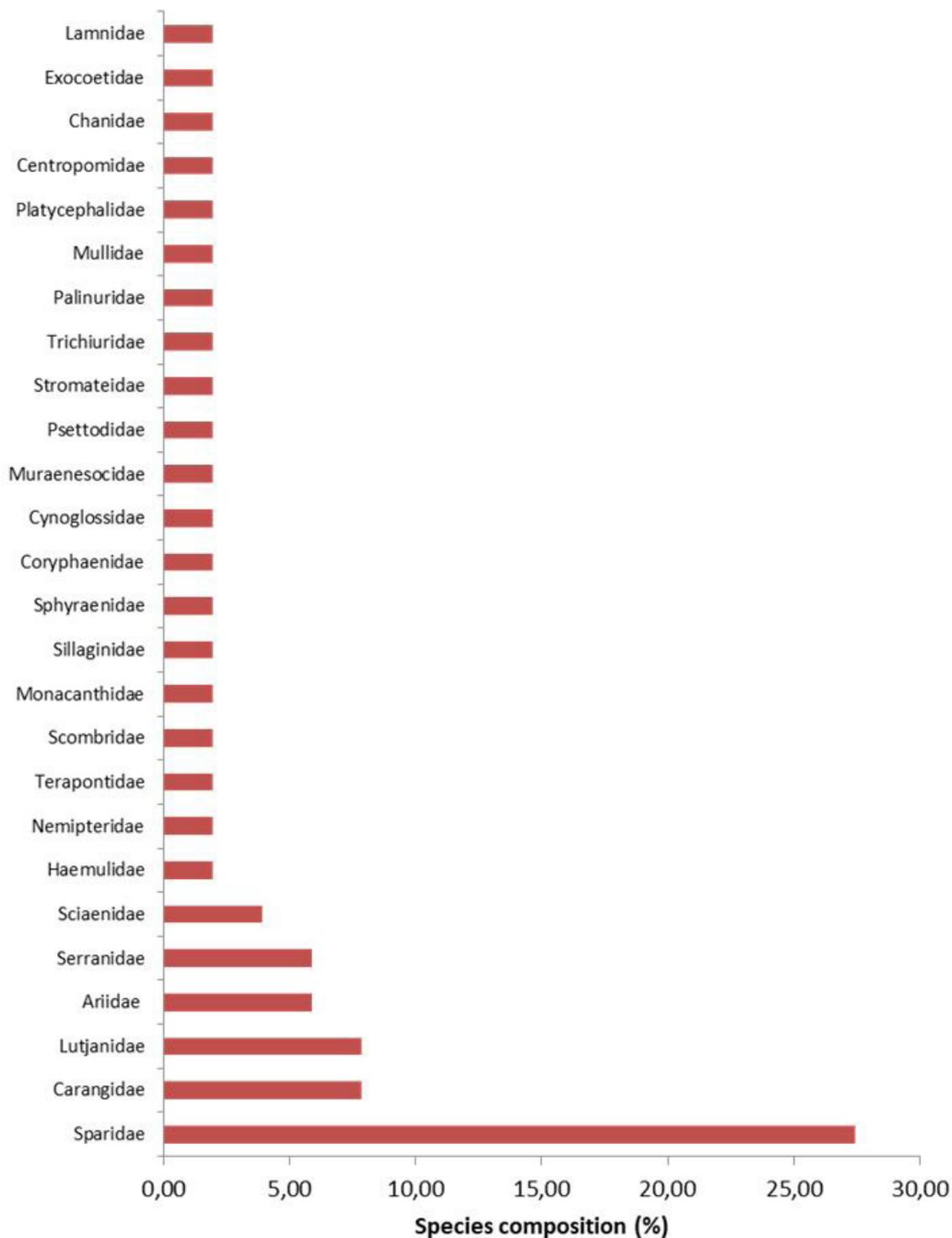


Figure 5. Species composition of 26 fish families collected from study areas. (N:81287).

abundance (R) =22.9% were reported on sampling sites S14 of Sonmiani coast, whereas low fish catch (N=182) and low relative abundance (R) =0.2% were reported on Sampling sites S9 of Churna coast.

3.5. Abundance of fish families across the twenty sub-stations

The overall results revealed that the frequency of occurrence of twenty-six fish families along the selected

sampling sites was reported high for family Ariidae and followed by family Sparidae, Lutjanidae, Carangidae, Scienidae, Stromateidae, Serranidae, Cynoglossidae, Chanidae, Sillaginidae, Haemulidae, Muraenesocidae, Platycephalidae, Scombridae, Coryphaenidae, Nemipteridae, Mullidae, Rhinidae, Terapontidae, Palinuridae, Centropomidae, Exocoetidae, Monacanthidae, Psettodidae, Lamnidae, Trichiuridae, and found to be least for family Sphyraenidae.

3.6. Variation in species composition among the different families across the sampling stations

In this study, family Sparidae contain the highest number of species (n) = 13 and relative abundance (R)=27.5% among the other fish families (total number of fish families (N)=51) in the total fish catch ($N=81287$) of twenty sampling sites followed by Carangidae ($n=4$; R=7.84%), Lutjanidae ($n=4$; R=7.84%), Ariidae ($n=3$; R=5.88%), Serranidae ($n=3$; R=5.88%), and Sciaenidae ($n=2$; R=3.92%). Moreover, few families also contain relatively less number of species ($n=1$) and relative frequency (R=1.96%), which includes i.e., Haemulidae, Nemipteridae, Terapontidae, Scombridae, Monacanthidae, Sillaginidae, Sphyraenidae, Coryphaenidae, Cynoglossidae, Muraenesocidae, Psettodidae, Stromateidae, Trichiuridae, Palinuridae, Rhinidae, Mullidae, Platycephalidae, Centropomidae, Chanidae, Exocoetidae, and Lamnidae.

3.7. Variation in the occurrence of fish species along with the sampling stations

The frequency of occurrence and abundance of species. Total fish catch ($n=81287$) of this study contains forty-nine fish species found at Sindh and Balochistan Coasts. However, variations were found in the occurrence of species among the four sampling stations i.e., Keti Bandar, Churna coast, Sonmiani, and Ormara coasts. In this study, about forty-seven fish species were reported on Keti Bandar and thirty-one from Churna coast of Sindh coast. Whereas, about thirty-five fish species were reported from Ormara coast and thirty-fish species from the Sonmiani Coast of Balochistan. Moreover, fish species like *Rhabdosargus haffara* was reported only at Churna coast, while *Argyrosomus heinii* was reported only at Ormara coast of this study.

3.8. Seasonal variation

The seasonal variations in finfish species were recorded during the study period. The highest finfish diversity recorded in spring and summer season and the lowest finfish recorded in autumn and winter. The variation in biodiversity might be correlated with seasons or warm sea waters shows high species diversity index than in colder regions, the temperature was raised in spring and summer season and reduced in autumn and winter. The temperature is directly affected on fish diversity.

3.9. Associated threats to fish biodiversity

This study found out major threats to biodiversity. The annual leaks in our seas eight million tons of polyethylene bags. A lot of plastic escapes from the

fish port. Each boat utilizes more than 3000 bags of polyethylene usually finished on a 30-day basis, in fishing for one thousand vessels. Fishermen in the boat, after separating fish, use polyethylene bags to preserve all (fish) from the same polyethylene bag discard. It is not easy to decompose a polyethylene bag that was necessary for decay a year, and the significant threats to aquatic fauna that damaged fish have been reported. Plastic pollutes the water bodies and the oceans by storm-water overflow, flowing into or directly through the sources of water. It was released into coastal areas. The plastics have the chemical composition from which they are made. High incidences of environmental pollution and polymerization processes causes contamination reaches the food chain, dangerous long-term carcinogenicity. Impact on fish, animals and humans due to the release of chlorofluorocarbons (cfc), formaldehyde, lead, mercury and cadmium. Oceans are typically polluted by micro plastic. The accumulation of polyethylene bags affected on survival and growth of fishes, like habitat conditions, development pattern, early life, feeding, fish fatness, degree of stomach completeness, gonad middle age, sexual category, size range, physical condition, overall health, gastrointestinal tract, dorsal muscle, lipid oxidative damage in the brain gills and increased brain AChE activity in fish containing microplastics were found shown in Figure 6.

The bioaccumulation and bio magnification process in aquatic fauna effected on food tropical levels and indirectly effects on human health. The mismanagement of the landing scheme by human activities creates serious threats to aquatic diversity. Poisonous pollutant suspended solid sewage and organic pollutants thermal pollution over fishing oil leakage, petroleum hydrocarbon, pesticide, antifouling agent and heavy metal respectively, shown in Figure 7.

These particles are non-biodegradable and very slow rate of elimination ship repairing oil leakage strongly affected aquatic life. During the study some area has low biodiversity because affected of life by some major threats. These stations coordinate represent by some contaminated position N: 24°80'9626 E: 66°969844 we conduct 20 sites for caught of fishing. Some pollution reported in this station N: 24°89'0605 E: 66°98'8818; N: 24 ° 89 0605E: 66 ° 98 8818 in this sites observed low biodiversity.

3.9.1. Micoplastics in fish

In this study, a total of 500 fish individuals belonging to 16 species collected from the contaminated sites, (8,9,11) during the study periods. Microplastics were found in a considerable percentage of 16 commercially important fish species in from Pakistan coastal waters (Arabian Sea). A total of 290 microplastic items were recovered from the 500 individuals: 74 microplastics from the gastrointestinal tract (55%), 130 items from the gills (25%) and 86 from the muscle (20%). Based on microplastic size, all the species had more fibers in the size range 400–1400 μ m in the gastrointestinal tract and 132–496 μ m in gills. In the dorsal muscle, in the size range 480–1430 μ m.

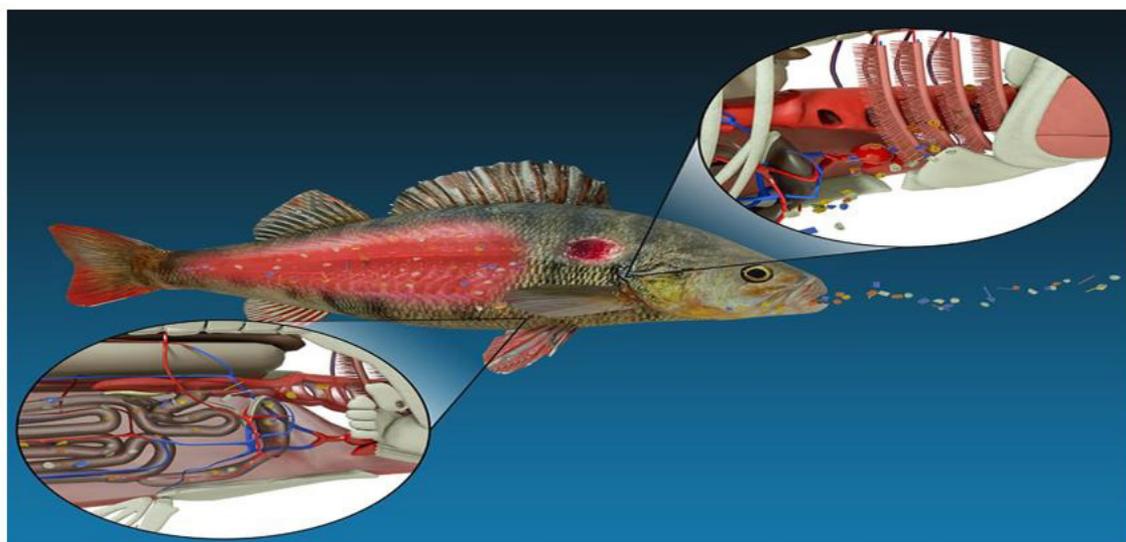


Figure 6. Notional model illustrating capture, retention and internalization of microplastics by fish species.



Figure 7. A lot of microplastics, polyethylene bags) escapes from the fish landing site, canal and river to the ocean.

3.10. Diversity analysis

Data for diversity analyses are recorded in Table 5 which shows a highly significant level of species diversity at the Sominani coast of Balochistan ($H' = 1.81$) compared to Keti Bandar ($H' = 0.67$), Churna coast ($H' = 0.51$), and less species diversity was reported at Ormara Coast ($H' = 0.23$) as shown in Figure 8.

4. Discussion

4.1. Physicochemical parameters of seawater

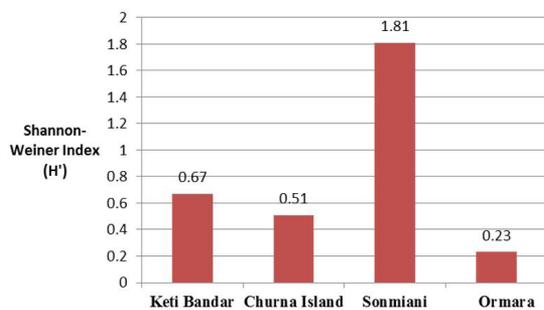
No significant variations were recorded in seawater physical parameters according to Kane et al. (2015), as most metabolic activities of aquatic organisms, particularly fishes are pH-dependent because their normal pH value is

7.4. A pH level less than 4.0 or greater than 11.0 may cause the death of most marine fishes; hence, the level of pH of any aquatic system mostly represents not only its water quality but also the level of toxic metals or pollutants found in it. In this study, the pH values of water samples analyzed from the four stations were lies in a suitable range and are favorable for fish productivity. The optimal range of seawater temperatures, that is lies between 28 - 30 °C, which is ideal for growth and survival as reported by Bhatnagar and Devi (2013). The electrical conductivity of seawater recorded for the 20 stations of this study was ranged between 62.8–71.4mS/cm hence shows a suitable range . Therefore, any change in the electric conductivity of seawater depends on the other water parameter such as salinity (Boyd, 1981). In seawater, salinity is the most important water quality parameter varies based on the mixing of inland fresh inland rivers or rain waters with

Table 5. Fish diversity index of four selected habitats of Sindh and Baluchistan Arabian Sea Pakistan.

Diversity indices	Sampling stations			
	Keti Bandar	Churna coast	Sonmiani	Ormara
Dominance (D)	21.20 ^d	9.98 ^a	62.95 ^b	5.86 ^c
Evenness (E)	0.17 ^b	0.15 ^c	0.5 ^a	0.06 ^d
Species Richness (R)	49 ^a	33 ^c	37 ^b	37 ^b
Shannon-Weiner Diversity Index(H')	0.67 ^b	0.51 ^c	1.81 ^a	0.23 ^d
Simpson's index (D)	0.21 ^b	0.16 ^c	0.67 ^d	0.07 ^d
Species diversity index (S)	4.92 ^a	3.55 ^c	4.25 ^b	3.32 ^d
Fish populations/Total fish catch (N)	17236 ^b	8115 ^c	4766 ^d	51170 ^a

Superscripts a, b, c, d shows highest to lowest values.

**Figure 8.** Shannon –wiener diversity index (H) of four stations.

marine waters on deltas (Twomeu et al., 2014); hence, it can affect the density, growth, and migrations of aquatic fauna. Moreover, In Ocean, salinity largely depends on the balance between evaporation and precipitation (Jamabo, 2008; Hassan et al., 2021c), therefore, water samples collected from the 20 stations in this study show a narrow range between 35.2-39.8ppt, which is the indications of low precipitation in these areas and also found in permissible range, that is 32.0-37.0 suitable for fish survival, as previously reported by Kane et al. (2015).

4.2. Analysis of fish biodiversity, occurrence and associated threats

In this study, 26 families and forty-nine species were reported. As biodiversity is widely regarded to be important to maintain genetic richness, ecological functioning and the resilience of the ecosystem (Gondal et al., 2012). The biological diversity of each ecosystem depends on the ecological services. The Sea of Pakistan is made up of various zoogeographic and environmental combinations. Various flora and fauna classes are available that support diverse environments from the Arabian Sea to coastal areas and Creek's natural ecosystems. The coastal site of Pakistan represents a valuable ecosystem that includes mangrove forests, tidal creeks, mudflats, salt pans, rocky shores, and pure sandy beaches Twenty-seven family and fifty-one species

of fishes recorded Sindh and Baluchistan coast and observed associated threats of fish fauna similar finding (Santos et al., 2002; Gondal et al., 2012; Afsar et al., 2013; Chowdhury et al., 2019; Hassan et al., 2020a). The variation in biodiversity might be correlated with seasons or warm sea waters shows high species diversity index than in colder regions as reported by Ahmed et al. (2013). Moreover, a recent study showed that low diversity was recorded in the polluted area. Ali et al. (2020) had also reported that human activities transform the habitats and species finally transfer from their native habitats (Korai et al., 2008; Hassan et al., 2020a). According to Bassem (2020), seawater pollution is now a growing problem worldwide, because the existence of all aquatic biota as well as its biodiversity is affecting negatively due to water pollutants. Most aquatic biodiversity is affected by human activity in addition to other environmental threats like climate change, toxic pollutants, overexploitation of fish species, habitat degradation, and exotic species invasion.(Abro et al., 2020; Hassan et al., 2020a). Hence, nowadays, our ultimate challenge is the protection of most marine fish biodiversity on the Pakistan coast. The climate of Pakistan is continental compared with other countries of the subcontinent as it lies at the western margin of the monsoon region. Warm temperatures stretch from the Indus plains to Baluchistan, while the rising elevation of the northern mountains creates moderate climatic conditions. At higher latitudes, the temperature stays below the freezing point with snowfall for much of the year. Winter, summer, monsoon, and post-monsoon seasons are the four main seasons in Pakistan. The highest fishes were recorded in monsoon and summer compared to other seasons. The lowest fishes were recorded in winter and post-monsoon similar finding Ahmed et al. (2013). Annual leaks in our seas eight million tons of polyethylene bags. Each boat uses more than 3,000 bags of Polyethylene usually finished on a 24-day basis, in fishing for one thousand vessels. Crew members of the boat, after separating fish, use polyethylene bags to preserve all (fish) from the same polyethylene bag discord. It is not easy to decompose a polyethylene bag that was necessary to decay a year, and significant threats to aquatic fauna that damaged fish have been reported. Microplastics may have been uptaken by fish directly

from the seawater passively (e.g. gill water filtration) and actively (i.e. ingested by confusion with prey), and through the ingestion of contaminated prey, as suggested in previous studies with fish (Lusher et al., 2013; Ory et al., 2018). Plastic pollutes the water bodies and the oceans by storm-water overflow, flowing into or directly through the sources of water. It was released into coastal areas similar finding (Hassan et al., 2020a). The presence of microplastics in the gastrointestinal tract, gills and muscle of commercial important fish species from coastal waters is in agreement with the presence of microplastics in the gastrointestinal tract (Jabeen et al., 2017).

The anthropogenic activity are increasing day by day in the coastal area of Sindh and Baluchistan Pakistan. Anthropogenic malpractices and destructive activities lead to enormous stress on fish and induce different toxicological effects/endpoints and even death at extreme levels, such as excessive use of pesticides, heavy metals, and discharge of untreated effluent to natural water bodies, etc. (Ullah and Zorriehzahra, 2015). The declined trend in the abundance of fish species is being alarming due to overfishing, siltation, industrial water discharge, use of illegal fishing gear, lack of sanctuary management, wastage of municipals. According to the Hassan et al. 2020a, the coastal area of Baluchistan and Sindh contaminated some sites to declined biodiversity the contaminated sites represented in map by red color. The mismanagement of the landing scheme by human activities creates serious threats to aquatic diversity. Poisonous pollutants suspended solid sewage and organic pollutants overfishing oil leakage, petroleum hydrocarbon, pesticide, antifouling agent, and heavy metal, respectively. (Hester and Harrison, 2011; Chowdhury et al., 2019; Hassan et al., 2020a, b).

5. Conclusion

The declined trend in the diversity of fish species is being alarming due to overfishing, wastewater discharge, Usage of illegal fishing gear, lack of conservation regulation, Waste of the municipalities. Also, political and industrial control is disrespectful of the fishery resources and intimidating the local small-scale crew members. Conservation steps should be taken as a top priority to protect and conserve the marine environment and natural heritage from further loss, extinction and stop or minimize losses incurred through irresponsible fishery practices. It is recommended that conservation measures should be adopted on top priority to protect biodiversity from further decline and extinction. Policy makers and implementing agencies will also be informed about the relevance of biodiversity to our environment. Local human resources are needed to support the rational development and management of fishery resources.

Acknowledgements

We are very much thankful to my family and FDB, MNFS & R for the financial support to complete this research. The authors are grateful for the support received from

Department of Zoology University of Karachi, explicitly gratitude for Dr Qadeer Mohammad Ali and Mustafa Kamal for providing necessary technical guidance. The authors (SM, KAG and FAM) express their sincere appreciation to the Research Supporting RSP Project No. (2021/93), the King Saud University, Riyadh, Saudi Arabia.

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