Research Article

Studies on the Spatial Distribution and Abundance of Selected Estuarine Fish Species in the Indus Delta Creek System Sindh, Pakistan

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Abstract | This research was conducted in 13 Indus Delta creeks. A total of 583 samples were collected from study area and 246 species or groups of species have been identified. Significant variation was noted in the frequency of fish catch/kg/hr tow per month, particularly during pre-monsoon, post-monsoon. High abundance (74.95%) of estuarine fish species was found followed by marine fish species (23.27%) and freshwater fish species (1.78%). The estuarine fish species belonging to the family Clupeidae are most dominant (28.5%), followed by Carids shrimp (23.6%), Engraulidae (14.3%), Mugilidae (13.8%), Jellyfish (6.9%), Leiognathidae (6.5%), Sciaenidae (3.4%), Pristigasteridae (.0.9%), Penaeidae (0.8%), Ariidae (0.7%) and Carangidae (0.5%). In family Clupeidae; *Escualosa thoracata* was abundantly found and accounts for 95.4%, *Hilsa kelee* (2.7%). In Engraulidae; *Stolephorus indicus* (60.3%), *Thryssa hamiltonii* (13.6%). In Mugilidae; *Mugilidae* sp. (47.2%), *Mugil* sp. (36.0%). In Leiognathidae; *Nuchequula blochii* (92.7%), *Secutor insidiator* (4.5%). In Sciaenidae; *Johnius* sp. (58.85%), Sciaenidae (32.92%). In Pristigasteridae; *Ilisha* sp. (90.5%), *Ilisha elongata* (7.0%). In Penaeidae; *Penaeus indicus* (99.0%), *Penaeus merguiensis* (0.9%). In Ariidae; *Arius maculatus* (38%), *Plicofollis layardi* (36%) and in Carangidae; Carangidae (61.0%), *Carangoides* sp. (20.0%), and in Sergestidae; Carids shrimp (80.3%), *Sergestes* sp. (19.7%). Despite this, jellyfish make up 6.96% of all estuarine fish caught and are extensively dispersed throughout the survey region as well as marine waters. The distribution of fish stocks is greatly impacted by seasonal changes in the creeks, and the presence of these species aids in the management of fisheries resources in the stream system of the Indus delta.

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Introduction

There are four main categories of important fish species found in the Sindh Creek areas: permanent residents, partial residents, tidal visitors and seasonal visitors. About 400 aquatic species have been recorded, belonging to 21 orders, 9 suborders, and 118 families (Ahmad, 1988). Out of these, 40

species are commercially viable and actively exploited (Majid, 1988). Based on studies conducted by Khan (2004) and Noman *et al.* (2017) the marine fishery sector accounts for 1% of GDP and the total catch of marine fish is almost 400,000 tons, of which 20% is exported to different countries. Sindh is home to 71% of Pakistan's fish resources (Noshirwani, 2013). Sindh streams are directly associated with several maritime resources, both living and non-living (Khan, 2011).

The creeks are formed by the Indus River Delta, one of the largest deltas in the world, covering 600,000 hectares along the Pakistani coast (Snedaker, 1984; Harrison *et al.*, 1997; Shah *et al.*, 2007; Government of Sindh, 2008). The sixth-largest mangrove forest in the world dominates these streams (Khan, 2011). Many marine species spend their early life stages in the mangrove environment, which makes them good habitat for their larvae and juveniles (Ahmed, 1988). According to FAO (2009), Pakistan's mangroves cover an area of 100,000 to 500,000 hectares. Over the past 50 years, local authorities have observed significant loss of mangrove forests (Shah *et al.*, 2007). The decrease in fish catches in the Sindhi creeks is due to more than just the shrinkage of the mangrove area. The drop in fish captures can also be caused by other factors, such as contamination of the marine environment, the usage of illegal destructive fish nets, the capture of immature or juvenile fish, and climate change (Ilyas, 2014). The environments associated with mangroves include large mudflats, shallow canals, and creeks. Each of these environments serves as a spawning, feeding, and spawning ground for different kinds of fish and shellfish, and they all sustain distinct food webs (Psomadakis *et al.*, 2015).

Amir *et al.* (2016) conducted study on finfish diversity and seasonal abundance at Khober creek near Keti Bander. In this context, the Indus Delta creek survey was conducted in 13 creeks out of total 17 creeks. The study was conducted under the Fisheries Resource Appraisal Project (FRAPP). The survey design and the method have been discussed in Khan and Abbas (2021), the present study discusses the spatial distribution and abundance of selected estuarine fish species that were caught in the survey area of Indus Delta creek system.

Materials and Methods

The fish sampling was done through bottom trawl and pelagic trawl. Fish stock analyses were performed from the field data collected during the creek survey of Fisheries Resource Appraisal Project (UTF/Pak/108/Pak). The data was further treated under the GIS environment to map spatial and temporal distribution of fish species and identify the creeks with the abundance of pelagic and demersal fish species. For fish, all the measurements of lengths were taken as Fork Length (FL) and Total Length (TL) while for shrimps it was Total Length (TL) and Carapace Length (CL) in centimeters. The unit of weight measurements for all the species was kilograms. Species were identified according to Tirmizi and Bashir (1973) and Fischer and Bianchi (1984). The latest scientific name accepted is verified from Integrated Taxonomic Information System (ITIS), World Register of Marine Species (WORMS) and Froese and Pauly (2021).

In order to conduct a fish capture study, 583 sampling stations for trawl tow were chosen in the creeks survey. These sampling stations depend on seasonal change, high and low tides, and vegetation mainly mangroves in the creeks. Because creeks are extremely susceptible to local seasonal variations, accessing them can occasionally be challenging. Almost all the sampling stations covered those areas within the creeks where fishing is possible. Creeks are the small inlets of water where access is only possible via small boats. Local fishermen mainly fish through small wooden boats with traditional fishing methods; they hardly go to the open ocean for fishing. For this creek survey, a small boat named 'dolphin' was used in the creeks. The sampling method has been described in Khan and Abbas (2021).

Results and Discussion

The weight of the species that were taken in creeks has been estimated by looking at the spatial distribution of marine and estuarine species. Total 246 species or groups of species have been identified from the 583 samples that were collected from the Indus Delta study area. These selected species, however, come from major families that account for about 60% of the stock in creeks. Therefore, distribution of these species gives an idea of overall weight statistics of these fish species in different creeks.

The total numbers of individuals captured were categorized according to the habitat which includes

estuarine, marine and freshwater as mentioned in Table 1. The total estuarine fish catch was 136,233, i.e., 74.95%, marine fish catch was 42,299, i.e., 23.27% and freshwater fish catch was 3,233, i.e., 1.78% during the survey period.

Table 1: *Total number of fish catch by main fish groups at study area of Indus Delta under FRAP project.*

Groups	No. of Fish Catch	Percentage
Estuarine	136,233	74.95%
Marine	42,299	23.27%
Fresh Water	3,233	1.78%
Total	181,765	100%

The main families of fish species found in estuarine category are: Clupeidae, Engraulidae, Mugilidae, Jellyfish, Leiognathidae, Sciaenidae, Pristigasteridae, Ariidae and Carangidae for fish, while Caridea and Penaeidae for shrimps. The family Clupeidae (28.5%) has highest fish catch followed by Caridea (23.6%), Engrulidae (14.3%), Mugilidae (13.8%) Jellyfish (6.9%), Leiognathidae (6.5%), Sciaenidae (3.4%), Pristigasteridae (0.9%), Penaeidae (0.8%), Arridae (0.7% and Carangidae (0.5%) as shown in **Figure 1**.

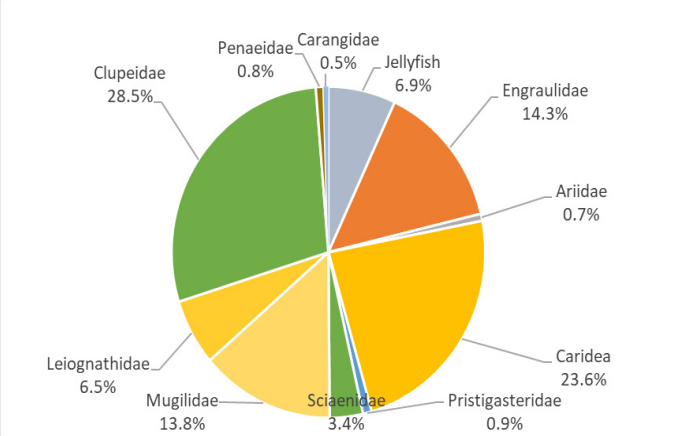

Figure 1: *Percentage composition of groups in estuarine species recorded from the study area of Indus Delta, Pakistan.*

The total number and species composition of the family Clupeidae consists of *Escualosa thoracata* (95.4%), *Hilsa kelee* (2.7%), Clupeidae (1.2%), *Anodontostoma chacunda* (0.7%), as shown in Figure 2. The *Escualosa thoracata* is widely distributed in all the creeks and the most dominant species in Clupeidae family, and the spatial distribution is shown in Table 2. It appears that maximum catch of 1.52 kg/hr tow was recorded at Hajamro creek, and the minimum catch of 0.08 kg/hr tow was recorded at Khar creek. The maximum catch of *Hilsa kelee* 1.62 kg/hr tow was recorded at Jhang River and the minimum catch of 0.01 kg/hr tow was recorded at Issaro, Waddi-Khudi, Patiani, Dabbo and Hajamro creeks. It was not recorded at Chhan, Chani, Khar, Khajar and Wari creeks. The spatial distribution of *Anodontostoma chacunda* recorded maximum catch of 0.56 kg/hr tow from Wari creek, and the minimum catch of 0.01 kg/hr tow was recorded at Jhang River. It was not recorded at Waddi-khudi, Patiani, Mal, Chhan, Khar,and Khajar creeks.

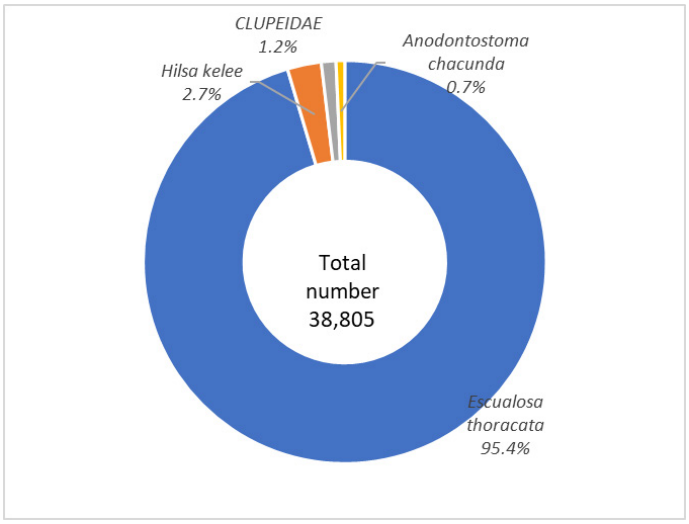

Figure 2: *Species composition in family Clupeidae.*

Sergestes sp. belonging to the family Sergitidae are small planktonic nearly transparent shrimps are found in shallow offshore waters, and they were widely distributed in the survey area except Khar and Khajar creeks**.** The maximum catch of 0.05 kg/hr tow was caught at Wari creek and the minimum catch of 0.01 kg/hr tow was recorded at Patiani, Dabbo, Richhal, Chhan, and Hajamro creeks.

The Carid shrimps are belong to true shrimp and they account to 19.7% of the total Carideans. The spatial distribution of Caridea shrimp shows that the maximum catch of 1.76 kg/hr tow was recorded at Jhang-River creek and the minimum catch of 0.01 kg/hr tow was recorded at Waddi-Khudi, Dabbo, Chhan, Chani, Hajamro and Wari creeks.

The Family Engraulidae includes *Indian anchovy, Anchovy, Hamilton's thryssa, Moustached thryssa, Anchovies-thryssa*, and *Orangemouth anchovy*. The group Engrulidae and *Thryssa dussumieri* was also recorded but in few numbers (Figure 3). The *Thryssa vitrirostris* account 2.0% of the total catch and the spatial distribution shows that maximum catch of 4.4 kg/hr tow was recorded at Richhal creek and it was not recorded at Waddikhudi, Patiani, Dabbo,

Table 2: *Special distributions of estuarine and marine species were recorded from different creeks under FRAP project.*

	Creeks												
Species name	**Issaro**	**Waddi khudi**	**Patiani**	**Mal**	**Dabbo**	**Rich-hal**	**Chann**	**Chani**	**Hajamro**	**Khar**	**Khajar**	**Jhang river**	**Wari**
Clupeidae													
Escualosa thoracata	0.28	0.12	1.17	0.54	0.18	0.43	0.12	0.51	1.52	0.08	0.2	0.36	0.36
Hilsa kelee	0.01	0.01	0.01	0.32	0.01	0.56	0	0	0.01	0	0	1.62	0
Anodontostoma chacunda	0.21	0	0	0	0.02	0.14	0	0.2	0.08	0	0	0.01	0.56
Engraulidae													
Stolephorus indicus	0.07	0.05	0.09	0.24	0.03	0.23	0.06	0.09	0.11	0	0	0.1	0.03
Thryssa hamiltonii	0.18	0.06	0.08	0.44	0.06	0.13	0.1	0.12	0.08	0	0.02	0.04	0.21
Stolephorus sp.	0.14	0.05	0.04	0	0.15	0.06	0.05	0.03	0.04	0	0	0.01	0.07
Thryssa mystax	0.14	0.15	0.01	0	0	0.07	0.08	0.21	0.57	0.78	0	0.14	0.18
Thryssa sp.	0.01	0.04	0	0	0.01	0.01	0	0.1	0.01	0	0	0.03	0.02
Thryssa vitrirostris	0.15	0	0	0.3	0	4.4	0	0.08	0	0	0	0	0
Coilia dussumieri	0	0	0	0	0	0	0	0	0	0	0.1	0.46	0.03
Mugilidae													
Mugil sp1	1.37	0.11	0.57	0.32	0.16	0.01	0.33	0.13	0.62	0	0	0.06	0.1
Mugil sp2	0.08	0.19	0.09	0.7	0.07	0.1	0.01	0.01	0.09	0	0	2.79	0.18
Liza sp.	0.44	0.09	0.59	0.09	0.1	0.15	0.29	0.18	0.27	0.05	0	0.12	0.66
Ellochelon vaigiensis	0	0	0.07	0	0.04	0	0.02	0.24	0.31	0.09	0.11	0.09	1.4
Leiognathidae													
Nuchequula blochii	0.34	0.03	0.44	0.55	0.03	1.33	0.11	0.11	0.25	0	0	0.03	0.02
Secutor insidiator	0.09	0	0.04	0.04	0.08	0.04	0.25	0.04	0.18	0	0	0	0
Leiognathus spp.	0.08	0.03	0.02	0.01	0	0.3	0	0	0	0	0	0	0
Sciaenidae													
Johnius sp.	0.1	0.8	0.42	1.68	0.32	0.09	0.14	0.1	0.08	0	0	0.16	0.82
Johnius carouna	0.3	0.45	0	0.26	0	0	0	0.56	0	0	0.71	0	0.33
Pristigasteridae													
Ilisha sp.	0.06	0.02	0.17	0.17	0.02	0.65	0.03	0.1	0.23	0	0	0	0.07
Ilisha elongata	0.09	0.03	0	0.01	0.07	0.13	0	0	0.09	0	0	0.01	0.04
Ariidae													
Arius maculatus	0.19	0.81	0.02	0.07	0.03	0	1.83	0	0	0	0	0.13	0.46
Arius tenuispinis	0.21	0.31	0.24	0.58	0.14	0.06	0	0.05	0.01	0	0	0.04	0.05
Arius sp.	0	0	0	0.63	0	0.15	0	0.16	0	0.01	0	0.14	0.36
Arius thalassinus	0	0.29	0	0.15	0	0.07	0	0.1	0.05	0	0	0	0.27
Carangidae													
Carangoides sp1	0.01	0	0.09	0.01	0.01	0.02	0.01	0.01	0.05	0	0	0	0.01
Carangoides sp2	0	0.01	0.01	0.02	0.01	0.03	0.03	0.01	0.02	0	0	0	0
Parastromateus niger	0	0.08	0	0	0	0	0	0	0	0	0	0.01	0.07
Caranx sp.	0.01	0	0.02	0.03	0	0	0	0	0	0	0	0	0
Penaeidae													
Penaeus indicus	0.09	0.07	0.06	0.06	0.04	0.07	0.06	0.02	0.02	0.01	0	0.02	0.05
Penaeus merguiensis	0	0.07	0	0	0	0	0	0.03	0	0	0	0	0.03
Sergestidae													
Sergestes sp.	0.02	0.03	0.01	0.03	0.01	0.01	0.01	0.03	0.01	0	0	0.03	0.05
Caridea													
Caridea shrimp	0.02	0.01	0.05	0.06	0.01	0.02	0.01	0.01	0.01	0	0	1.76	0.01
Scyphozoa													
Jellyfish	4.91	9.32	52.32	62.5	10.53	16.11	22.03	2.78	7.32	0	0	0	0.46

**Data are presented as average fish catch (kg/hr tow).*

Chhan, Hajamro, Khar, Khajar, Jhang River and Wari creeks. The *Stolephorus indicus* is widely distributed and accounts 60.3% of the total catch and it appears that maximum catch of 0.24 kg/hr tow was caught at Mal creek while the minimum catch of 0.03 kg/hr tow were caught at Dabbo and Wari creeks. It was not recorded from Khar and Khajar creeks.

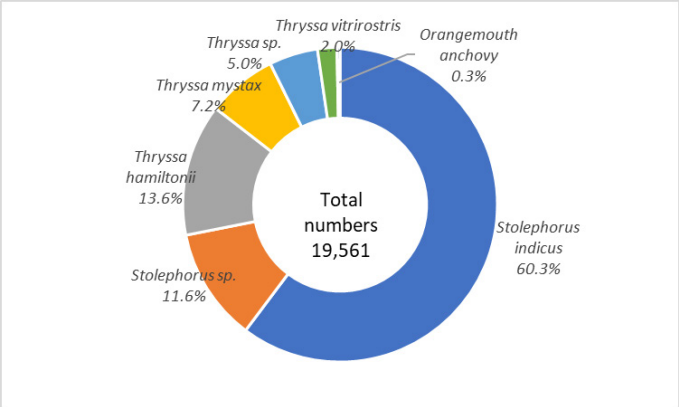

Figure 3: *Species composition in family Engraulidae.*

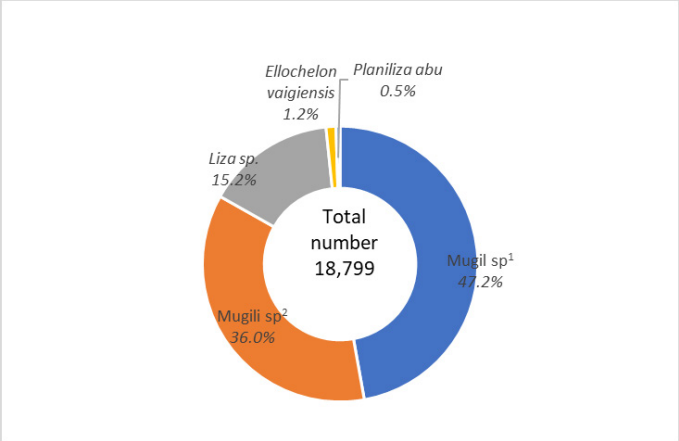

Figure 4: *Species composition in Family Mugilidae.*

The Family Mugilidae is accounts for 13.8% of the total brackish or estuarine fish catch. The species composition is shown in Figure 4. It appears that, *Mugil* sp¹. (47.1%), *Mugil* sp². (35.9%), *Liza* sp. (15.2%), *Ellochelon vaigiensis* (1.2%), *Planiliza abu* (0.5%). All these five species groups contribute 99.9% of the total Mugilidae. The Mugil sp¹ is widely distributed in the survey area (47.2%) and its spatial distribution shows the maximum catch 1.37 kg/hr tow was recorded at Issaro creek, while the minimum catch of 0.01 kg/hr tow was found at Richhal creek. No record was found from Khar and Khajar creeks.

The family Leiognathidae accounts 6.5% of the total catch from the survey area. It appears that five species which includes *Nuchequula blochii* (92.7%), *Secutor insidiator* (4.5%), *Leiognathus* sp. (1.8%), *Leiognathus brevirostris* (0.6%) and *Photopectoralis bindus* (0.5) as shown in Figure 5. The *Nuchequula blochii* also known as *Leiognathus blochii* is the dominant species. The maximum catch 1.33 kg/hr tow was recorded at Richhal creek, while the minimum catch of 0.02 kg/hr tow was recorded at Wari creek. It was not recorded at Khar and Khajar creeks.

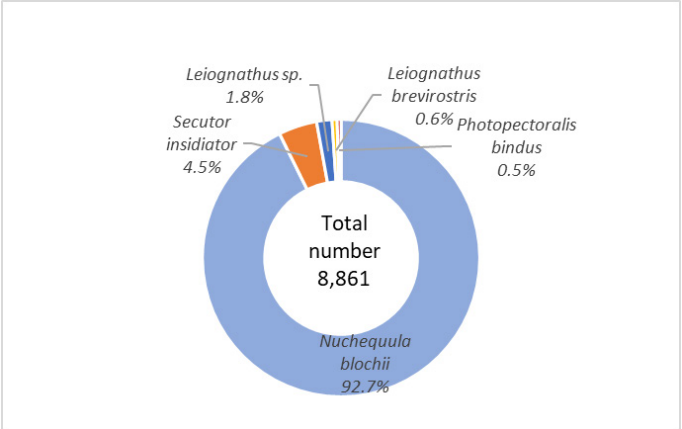

Figure 5: *Species composition in family Leiognathidae.*

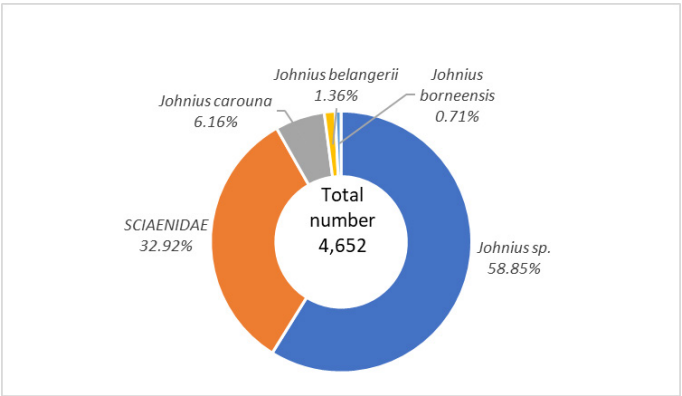

Figure 6: *Species composition in family Sciaenidae.*

The species composition of family Sciaenidae is given in Figure 6 and the following three species consist of 97.3% of the total Sciaenidae species during the survey, which includes *Johnius* sp. is the most dominant (58.85%), followed by Sciaenidae (32.92%), *Johnius carouna* (6.16%), while the other species were found in less quantity (Figure 6). The spatial distribution of *Johnius* sp. and *Johnius carouna* are shown in table under reference. Recorded maximum catch of 1.68 hg/hr tow at Mal creek while 0.71 kg/hr tow at Khajar creek, respectively. No record was found from Patiani, Dabbo, Richhal, Chhan, Hajamro, Khar and Jhang River creeks.

The Family Pristigasteridae is represented by *Ilisha* sp. (90.5%), *Ilisha elongata* (7.0%), *Pellona ditchela* (2.6%) as shown in Figure 7. The spatial distribution of *Ilisha* sp. and *Ilisha elongata* appears that maximum catch of

0.65 kg/hr tow and 0.13 kg/hr tow was recorded at Richhal creek, respectively.

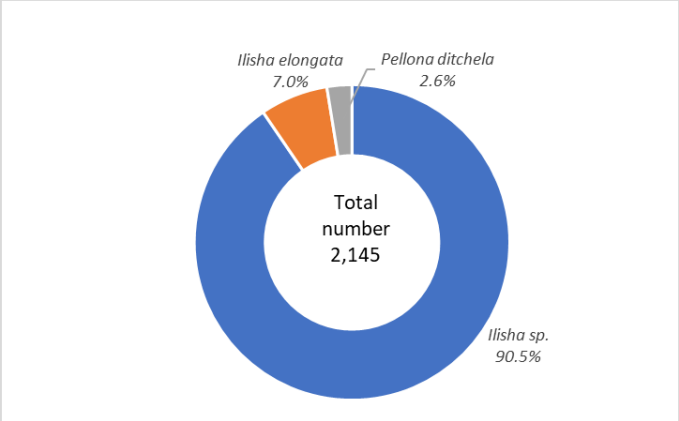

Figure 7: *Species composition of families Pristigasteridae.*

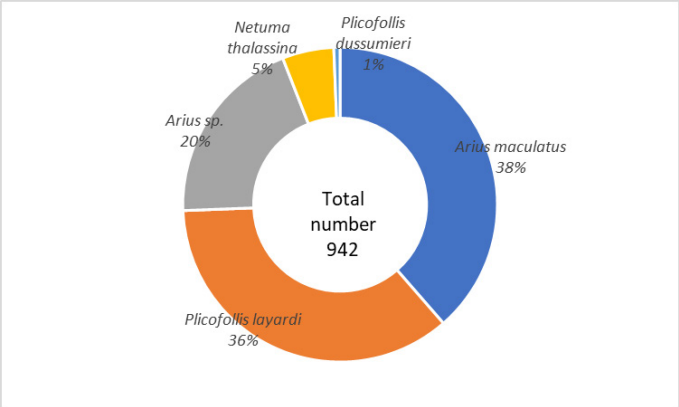

Figure 8: *Species composition in Family Ariidae.*

The species composition of Family Ariidae is shown in Figure 8. The dominant species was found *Arius maculatus* (38.6%) and *Plicofollis layardi* also known as *Arius tenspinis* (36%) among others. The maximum catch of *Arius maculatus, Arius tenspinis*, *Arius* sp. and *Arius thalassinus* i.e., 1.83, 0.58, 0.63, and 0.29 kg/hr tow was recorded at Chhan creek, Mal creek and Waddi-khudi creek, respectively.

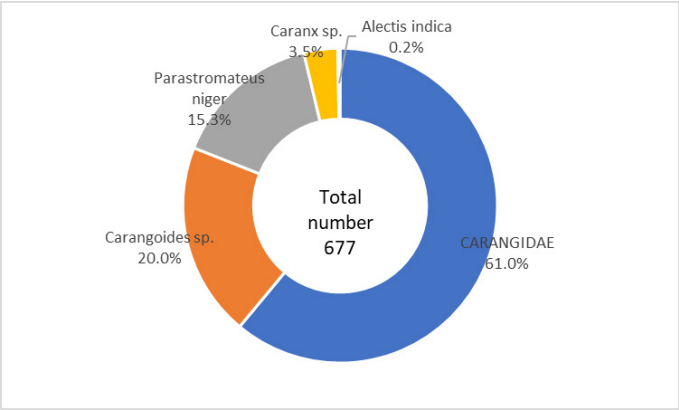

Figure 9: *Species composition in Family Carangidae.*

The species composition of family Carangidae is represented in Figure 9, and the spatial distribution of Carangidae group is shown in table under reference. The maximum catch of *Carangoides* sp[1] and *Carangoides* sp[2] was recorded 0.09 and 0.03 kg/hr tow from Patiani creek, Richhal and Chhan creeks.

There are 20 species of Penaeid shrimp that were caught from the study area, but they were caught in small numbers and half of them were caught even less than fifty numbers. The *Penaeus indicus* and *Penaeus merguiensis* are recorded and the *Penaeus indicus* is widely distributed in the survey area, except in Khajar creek. The maximum catch of 0.09 kg/hr tow was recorded at Issaro creek, while the minimum catch 0.01 kg/hr tow was recorded at Khar creek. Although, *Penaeus merguiensis* was recorded only from Waddi-khudi (0.07 kg/hr tow), Chani and Wari creek (0.03 kg/hr tow each). The jellyfish is widely distributed in the study area and the maximum catch 62.50 kg/hr tow was recorded at Mal creek, whereas, the minimum catch 0.46 kg/hr tow was found at Wari creek. No record was found from Khar, Khajar and Jhang river creeks.

It is well known that climate change has substantial impacts on many environmental variables that are related to fish production (Khan and Abbas, 2020). The seasonal variations of biophysical parameters indicated variations in temperature and salinity not only in different seasons but also within the creeks. Bell (1986), Clark (1995), and Agbesi (2002) studied the oxygen status, which is an important factor in the distribution of fish stock and confirmed the correlation between the physical and biophysical environment for habitat of fish species. Studies by Tsuchiya (1981), Blanke and Raynaud (1997) and Agbesi (2002) showed that changes in water temperature can lead to the formation of high oxygen underwater currents, which are responsible for dissolved oxygen and nutrients that ultimately affect distribution of fish species. Temperature of our study area ranged between 14.5°C to 31.1°C throughout a year and correlated with the study of Khan and Abbas (2020), which slightly higher than the temperature as reported by ADB and IUCN (2002).

The Khar, Khajar and Wari creeks on east of Jhang River were ranked as moderately productive zones because they were difficult to access due to strong currents and due to this reason, there is no, or little human activity was observed in those creeks resulting

in average high frequency of fish species. However, if fish resources are overexploited, they cannot cope or withstand the climatic and ecological changes in the area (Blanchard *et al*., 2012). It is found that high salinity at shallow depths at west of the Jang River increased in the Issaro, Waddi Khuddi, Patiani, Mal and Dubbo creeks. This condition has affected estuarine fish stocks more than marine fish species, as marine fish are highly migratory and tend to change habitat or adapt to any environmental change faster than estuarine species (Khan and Abbas, 2021). In addition, it was observed that when salinity increases with increasing temperature at shallow depths, it causes a deficiency of dissolved oxygen for creek species. Consequently, salinity tends to decrease with increasing depth in the Chan, Chani, Hajamro and Jang rivers, although the temperature has changed little at shallow depths in these creeks (Khan and Abbas, 2020). The significantly low salinity in the Hajamro creek and the Jang River is due to the presence of fresh water (Khan and Abbas, 2020).

In this article, the spatial distribution of some selected estuarine species has been examined. These species were caught in large numbers or in weight in the study area of the Indus Delta creek system. A total of 583 specimens were collected and 246 species were recorded in the Indus Delta survey area. Psomadakis *et al*. (2015) has reported more than 800 fish and shrimp species from Pakistan waters, of which 256 species were recorded in the Indus Delta study area, whereas 127 species of freshwater fish species were recorded from the mangroves of Indus delta (IUCN, 2003).

The species belonging to the Clupeidae family are the most dominant and widely distributed in the tropical waters, mainly coastal waters and form schools (Whitehead, 1985). The Caridea, commonly known as caridean shrimp, these are second largest group in the estuarine category and well-known from Pakistan coast (Moazzam *et al*., 2020) and inhabiting all types of aquatic habitats from high altitude streams to coastal marine waters (Kazmi and Kazmi, 2010). All these carid shrimps are different from Penaeid shrimp in morphology and biology. Many species are a widely distributed because of their life history traits (Hughes, 2015), have narrow range of salinity and temperature tolerance compared within the Carid shrimp's species (Yasser *et al*., 2018). The family Engraulidae makes up 17.7% of the total estuarine fish species. These fishes tolerate a wide range of salinity virtually from fresh to hypersaline waters (Whitehead *et al*., 1988). The low catches of this family in Jhang River, Hajamro and Dabbo creeks might be due to the low temperature due to rains in monsoon season in May to September (Khan and Abbas, 2020). We identified seven species in our study as compared to Amir *et al*. (2016), they reported four species of Engraulidae from Khober creek which includes *Coilia dussumieri, Thryssa setirostris, Thryssa mystax, Thryssa hamiltonii*. The Family Mugilidae consists of mullets are ecologically, recreationally, and commercially important fishes (Dianne *et al*., 2021). Mullets in general tolerate a wide range of salinity (Thomson, 1966). Influence of abiotic factors on the distribution of young mugilids has been described by several authors (Perlmutter *et al*., 1957; Lasserre and Gallis, 1975; Brusle, 1981; Cardona, 2006). They pointed out that salinity is the key factor that determines the distribution pattern of young mugilids. Migratory periods of this species are varied from 2 to 7 months (Mićković *et al*., 2010). Amir *et al*. (2016) has found 8 species of family Mugilidae at Khober creek of Indus delta, whereas we only found four species in our study area. The family Leiognathidae accounts for 6.5% in our study and are widespread throughout tropical waters of the Indo-West Pacific where they live on soft bottoms in coastal marine and estuarine waters (Dianne *et al*., 2021), a few ranging up into fresh water (Woodland *et al*., 2001; Sparks *et al*., 2005). Three species of Leiognathidae is reported at Khober creek near Keti Bander (Amir *et al*., 2016). This is similar to our study from different creeks. The fishes of the Family Sciaenidae are commonly known as drums or croakers are primarily coastal marine fishes, some are confined to fresh water rivers. Many croakers use estuarine environments seasonally as nursery grounds during their juvenile phase (young-of-the-year), and as feeding grounds during young adult phase, others are year-round inhabitants of estuaries and coastal lagoons. Croakers are mostly demersal fishes (Chao, 1995). Amir *et al*. (2016) has found 8 species of family Sciaenidae at Khober creek, near Keti bander, while we found only two species from our study areas. Fish of the family Pristigasteridae is distinguished from other sardines (Clupeidae) by their long anal fin (Berra, 2001), mostly fish that are marine, coastal, or schooling in tropical and subtropical waters (Munroe *et al*., 1995). The Ariidae are a family of catfish that mainly live-in marine waters with many freshwater and brackish water species. These estuarine bentho-

phagous species are well adapted to live in different habitats of estuaries of the tropical and subtropical world (Barletta and Blaber, 2007). Seven species of family Ariidae were reported from the Khober creek (Amir *et al*., 2016), however, we found only four species from different creeks. The Carangidae are a family of ray-finned fish which includes the jacks, pompanos, jack mackerels, and scads, mainly living in marine waters but some of them also found in brackish or estuarine areas as well. These fishes caught commercially and for recreational (Nelson, 1984). Only three species of family Carangidae was reported from the Khober creek which includes *Scomberoides commersonnianus, Carangoides, praeustus* and *Caranx sexfasciatus* (Amir *et al*., 2016). However, we identified four species from different creeks of study area. Except in a few cases, penaeid prawns are a marine species. Some marine shrimp spend part of their life cycle in brackish water estuaries. A total of 20 Penaeid species were caught in the study area, but they were caught in small numbers. The *Penaeus indicus* and *Penaeus merguiensis* are considered as estuarine species. It is already reported by the Van Zalinge *et al*. (1986, 1987) that shrimp species are heavily overexploited, and the fleet size of the shrimp trawlers are more than the double to get the maximum sustainable yield (MSY). The creeks were most affected by the use of banned or prohibited nets, including encircling net (locally known as "Katra") and estuarine set bag net (locally known as "Bullo") commonly used in Indus creeks of Pakistan (MINFAL, 2006; Pitcher and Pramod, 2006; FAO, 2009; Psomadakis *et al*., 2015). Jellyfish are free-swimming and belonging to the class Scyphozoa. The jellyfish is widely distributed in our study area. The jellyfish fishery began in Pakistan in 2003. Prior to this, a large bloom of *Crambionella orsini* in 2002 affected the shrimp fishery with trawlers and gillnets but helped to establish jellyfish processing in Pakistan. Many species of jellyfish are found in Pakistan, only *Catostylus perezi* and *Rhizostoma pulmo* are commercially harvested using trawls or gillnets (Psomadakis *et al*., 2015). The rich presence of jellyfish further suggests a heavily disturbed resource system; these are important predator of juvenile fishes and shrimp and, once established in dominant abundance, may interfere with rebuilding abundant fish stocks of commercially valuable species (Fanning *et al*., 2016).

Conclusions and Recommendations

From the above discussion, it can be interpreted that the fisheries sector in Sindh, especially in Indus delta creeks, requires strengthening institutions to implement fisheries legislation, to prohibit the use of destructive fishing gears and Illegal, Unregulated and Unreported (IUU) fishing. The Sustainable Development Goal (SDG) 14 related to Conserve and sustainably use the oceans, seas and marine resources for sustainable development. Target 14.4 requires an effective regulation of fishing by 2020 and to stop overfishing, and destructive fishing practices and to restore fish stocks at Sustainable level because overexploitation of fish resources leads to the loss of fish biodiversity, which will not only affect the ecosystems, but also affect the fishing community and the future of Pakistan's fishery industry.

Novelty Statement

The fisheries sector in Sindh, especially in Indus delta creeks, requires strengthening institutions to implement fisheries legislation, to prohibit the use of destructive fishing gears and illegal, unregulated and unreported (IUU) fishing to conserve the fisheries resources for future generation.

Author's Contribution

Muhammad Wasim Khan: Conceptualized and designed the study, performed the experiments and wrote the manuscript.
Ghulam Abbas: Reviewed the manuscript and supervised this research.
Asma Fatima and Shahnaz Rashid: Helped in data analysis.

Conflict of interest
The authors have declared no conflict of interest.

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