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Feeding Diversity of Finfish in Different Wild Habitat

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Abstract

Sonmiani Bay has unique faunal diversity and distribution especially finfish as mangroves provides an imperative ecosystem which offer the shelter and protection to the associated organisms and care of their juveniles in bay limits. This study aimed to evaluate the diversity pattern according to physical and physiological responses and feeding habits (carnivorous and herbivorous) of finfish species in accordance with current habitat conditions in the Sonmiani Bay. A total of 4499, individuals of comprising 155 finfish species that represent 50 families were captured by these four (beach seines, purse seines, gill nets, and cast nets) nets during a twelve-month survey in a year. The distribution pattern of finfishes captured classified into four groups (tidal visitors, permanent residents, partial residents, and seasonal visitors) according to their patterns of distribution. Understanding of the true feeding behavior of organisms needs a more reliable and functional approach. The feeding ecology is not only functional for food and feeding behavior of fish as usually described by various tools and techniques of analytical research to take up more reliable details to explain the feeding biology in fish but also the indicator of habitat quality and status.

Keywords: food and feeding, finfish, lagoon water

1. Introduction

Ocean cover up the 99.8% of earth's livable space but its resources are finite and fisheries have increased greatly in local aptitude, regional reach, and mechanical capacity throughout the world during the past half-century [1, 2]. Therefore, it has been observed that around 30% of marine fishery resources in the worlds are overexploited, 60% brutally utilized, and only 10% moderately exploited [3]. Many fish and shellfish species used the surface and intertidal regions of estuaries as nursing ground and transferred to the lagoon area with the help of tidal currents [4, 5].

The estuaries are the water mixing sites of marine and rivers, therefore, have a diverse number of compounds that are deposited here from a various ecosystems. To estimate the ecological parameters of an estuary with the help of decapods and finfish

could be beneficial to assess the man-made impact on the ecosystem and their health risk on human health [6–8]. The estuaries can be divided into four categories as the natural estuaries, the lagoons, the tectonic estuaries, and the fjords [9–11]. Coastal lagoons, the permanent inland basins as connected to the nearby marine water (Sea or Ocean) by one or more inlets that remain open either continuously or periodically. The depth and size of lagoons usually depend on the adjacent sea level. The swampy coastal lagoons indicate the low sea level and when sea level is high, the water body appears as bays and coastal lakes. Only 13% of global coastline is comprised of lagoons [12] and thought to be distinct coastal area from estuaries [9].

The coastal lagoons are characterized as a sandy or muddy bottom, which are created and sustained by the deposition of sediments that carried by rivers, tides, currents, waves, and wind [13]. Mangrove finfish can be classified into four assemblages based on their distribution patterns: permanent residents, partial residents, tidal visitors, and seasonal visitors [14].

Mangrove canopy, an imperative feature of the Pakistan coastal areas and is most copious in the Indus Delta that constitutes about 97% of the total mangrove cover; whereas the 3% mangroves are found at three locations (Miani Hor, Jiwani at Gawatar, and Kalamat Hor) along the Balochistan coast. Mangrove habitats are highly productive and diversified areas as provide shelter to a number of invertebrates (crustaceans, polychaetes and mollusks) and also known as home of several commercial and non-commercial fishes [15]. The universal importance of this ecosystems is an essential habitat to maintain a variety of organisms and serve as feeding habitat, nurturing ground, and temporary and permanent residence to several finfish species and other invertebrate species [16–19]. Miani Hor is a protected mangrove environment and various authors explained Miani Hor as a highly variable place of commercial fauna as many fish, shrimp, and crabs are caught from mangroves which are carried out to the market and consumed by locals and the faunal diversity found in mangroves of Sonmiani [15, 20–22]. The studies on the significance of mangroves as feeding habitat for fish species and several commercially important macrobenthos have been provided by several authors worldwide [23–25].

Fishes are the important component of aquatic environment and have important contribution into the aquatic and terrestrial food chain. The analysis of fish feeding habits is essential for the functional role of those fishes which have not commercial importance and it's useful to understand the biological interaction, interspecies competition and to build trophic model by the diet composition [26, 27]. Food is a significant component of an organism for their survival and has major influence on the distribution, growth, reproduction migration rate, and behavior of an individual into the ecosystem [28, 29]. Food and feeding habits of an organism are important tool to understand the behavior of species, different aspect of energy flow, and relationship between predator and prey and consumer and widely address the trophic structure [30]. These can be analyzed by the morphological character of mouth shape, individual size, sex, age, locality of individual [31–33] and the composition and resources of the environment [34]. Availability of resources into an ecosystem often depends on the seasonal variation of climate, which lead to alter the nutrient levels and responsible to change the diversity and abundance of a community that influence the food habits of an individual [35].

The examination of food and determination of feeding habits for fish species is imperative to assess the place in the food web and biological role of any species in any ecosystems [36]. Information on the diet of any fish species can provide valuable

guidance for the practices of the species culture and water body management, as needed for aquaculture and conservation purposes. Different fish species feed on wide range of food materials and obtain their nourishment from plants as well as animals. Depending upon the number of different type of food items consumed by them, fishes have been divided into two groups:

1. Stenophagic: Feeding on few type of food.
2. Euryphagic: Feeding on variety of food.

Food and feeding pattern of different fish is considered very important feature to help the selection of fish type for culture and farming. Fishes are herbivorous, carnivorous or omnivorous in nature, some fish groups are firmly herbivorous or carnivorous in habit, however various species remarkably adaptable in their food selection and feeding habits, therefore make use of the available food.

In aquatic ecosystem, among other nektons, fishes are a key consumer or top predator to occupy an obvious position in the trophic food web. The review of recent practice in feeding ecology of fish recognizes the need of directional efforts toward the assessment of descriptive ecology directly with the primary productivity in accordance with abundance of herbivore and carnivores finfish as primarily based on the diet information as mostly perceive directly through gut analysis or indirectly by computing some diet-based indices.

The widely used term feeding ecology explains the whole study about the feeding habit and acquired food of any particular species in relation with the habitat and tactics as animal adopts in specific environment to get its most enviable food through feeding or predation. In general, the tracing and occurrence of undigested food particles are recorded through stomach dissection [37, 38] for the qualitative and quantitative analyses. The examination of stomach contents along with various descriptive numerical techniques is used for estimation of diet and habits in aquatic animals [39]. There exists a different measure as described by various authors [37, 40–45] used as a handful tool to estimate stomach content and feeding habits of fish and likely used as an indicator of habitat status for any fish species.

An information of food components as ingested by the fish in natural habitat, quantitative analyses of gut content, the relevancy of morphological modification in the mouth or presence of any other supplementary body structure in relation with the food as intake by any particular fish are the most relevant areas to study the feeding ecology. However, the organic environment in the gut, sensational response for rejection and acceptance of food and responsive molecular signaling (**Figure 1**) are also important in feeding biology. The changes in position and structure of fish mouth are accountable for the food and feeding habits shown in **Figure 1**. Except mouth location and shape, further detailed study of various other factors like presence or absence of teeth, structure and number of teeth, mouth size, and presence of supplementary structure (spines, barbels), their location and modification can be helpful to determine the nature of food and habits of feeding in finfish species.

In previous studies, for the estimation of the fish stomach content different measures were adopted and used e.g. Index of Relative Importance [40]; Relation of total gut content weight with fish weight [41]; Feeding index [42]; Vacuity coefficient [44]; Visual assessment [40]; and Frequency of occurrences and volumetric

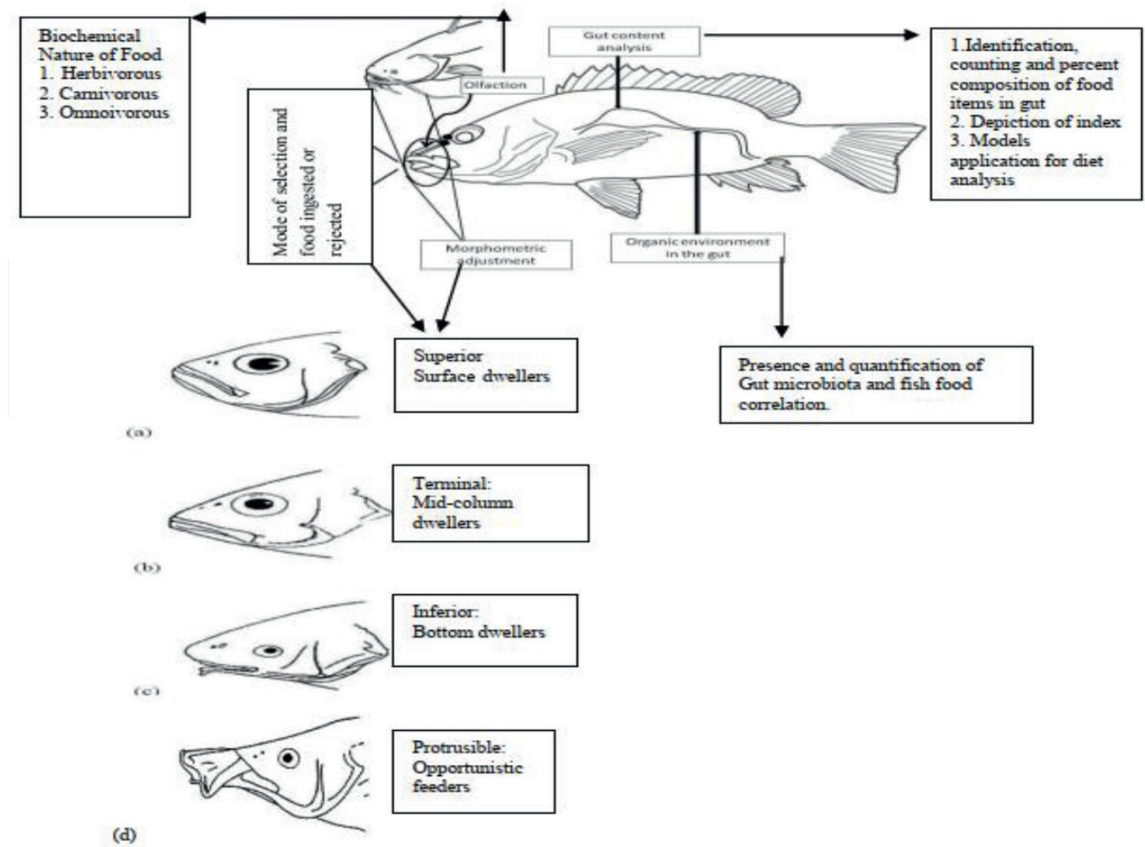


Figure 1.
A general description of areas needed to determine the feeding ecology in fish.

contribution [43]. There are also different measures for the analyses of stomach content except the mentioned methods. The different statistical and mathematical models are also present in the literature as usually applied for the description of food and feeding analyses; Electivity index [46]; Pianka's overlap index [47]; Hurlbert's diet breadth [48]; Levin's standardized index and Moritia's index [49]; Shannon index [50]; Repletion index [44]; Pelicice feeding activity index [51] and Saikia's diet breadth index [52].

The different finfish species like to live different type of habitats for their survivals and throughout their life stage including sand and mud substrates, oyster beds, water column, and sea grass. These species have wide range of feeding habits, and mostly depend on Crustaceans, Fishes, Bivalves, polychaetes as a diet which depend on the availability of prey, life stage locality, and species [53, 54]. There are enormous studies on the assessment of food and feeding habitat of different species of fishes [41, 55–58] in wild environment. The overview of feeding habits of mostly Finfish families is presented in **Table 1**.

In addition some particular and detailed information on the food and feeding habits of most commercial species are available [44, 111–127] in different region of the world show that there nature of consumers and feed on shrimp, Crab, other small fishes, polychaete and bivalve, that likely vary according to the size and age of the fishes [128, 129].

The present study determines the permanent and seasonal finfish diversity of lagoon waters and categorization of the fish feeding habit according to the available literature based on experimentation and food study in wild finfish species as collected throughout the year (each month) from lagoon waters of Sonmiani Bay.

Family	Distribution area	Feeding habit	References
Batrachoididae	Greater Caribbean (Florida to Belize), Mochima Bay.	Piscivorous	[59–61]
Gobiidae	Nigeria, Indo-West Pacific region, Persian gulf, Oman, Pakistan, India and Bay of Bengal, West Atlantic (Chesapeake Bay to Brazil and Georgia)	Juvenile- Herbivorous; Adult- Carnivorous	[59, 62–65]
	Greater Caribbean (Florida to South Caribbean to Gulf of Mexico and Bermuda) Northern West Atlantic (Virginia to Suriname).		
	Baltic Basin	Carnivorous	[66]
	Norway	Carnivorous	[67]
	Pakistan	Cannibalistic and Carnivorous	[68]
	India	Cannibalistic	[69]
	Vietnam	Omnivore	[70]
Bothidae	Slovakia	Carnivorous	[71]
	Northern Sicilian coast, between Capo d’Orlando and Capo Calavà	Carnivorous	[72]
Soleidae	Izmir bay	Carnivorous	[73]
	Pakistan	Carnivorous	[74]
	Iran	Carnivorous	[75]
Callionymidae	Indo-West Pacific: Thailand to southern Japan, Borneo, Philippines, and Indonesia.	Invertivorous	[76]
	Indo-West Pacific: Persian Gulf to China, Indonesia, New Guinea, Borneo, Philippines and Southern part of southeast Asia, Western Central Pacific: Mediterranean Sea: Gulf of Genoa to the western Aegean Sea. Northwestern Australia and Papua New Guinea, Southern and eastern Black Sea.	Invertivorous	[77]; Fishbase.com
Cynoglossidae	Indo-West Pacific: Persian Gulf, Iran, Pakistan, India, Bangladesh, Myanmar, Sri Lanka, Philippines, Indonesia, Japan, and the north and east coasts of Australia.	Carnivorous	[75, 76]
Platycephalidae	Persian Gulf, India, Indo-West Pacific: Red Sea and East Africa to the Philippines, Eastern Mediterranean coast (Lebanon), North to Southern Japan and Korea, South to Northern Australia. Sicily, and strait of Messina.	Piscivorous and Invertivorous	[78–81]
Hemiscylliidae	Eastern Papua New Guinea; Arabian Sea to India, Pakistan, Sri Lanka, Singapore, Thailand, Vietnam, Indonesia, Taiwan, and Solomon Islands. Probably occurring in Korea and Japan.	Invertivorous	[82]
Synodontidae	Eastern Atlantic: Canary Islands, São Tomé Island, Morocco to Cape Verde, including the Mediterranean, and St. Helena Island, Western Atlantic: Florida, USA, Gulf of Mexico, Canada Indo-West Pacific: Northwest Atlantic: Somalia to Papua New Guinea, Japan and south to Indonesia.	Piscivorous	[83–87]
Dasyatidae	Indo-Pacific, India to New Guinea, Japan, Atlantic and Caribbean, Northern South America, and West Africa.	Invertivorous	[76, 88, 89]
Lactariidae	Indo-West Pacific: East Africa to Southeast Asia, North to Japan, Queensland, Australia, Fiji.	Invertivorous	[90, 91]

Family	Distribution area	Feeding habit	References
Mugilidae	Cosmopolitan, Indo-Pacific: Pakistan, India, Japan, Red Sea to Samoa Eastern Pacific: California, USA to Chile, Japan to Australia, Western Indian Ocean: Western Pacific: South Africa, Nova Scotia, Canada to Brazil, Western Atlantic: Cape Cod to southern Gulf of Mexico; Eastern Atlantic: Bay of Biscay, Greater Caribbean Mediterranean Sea and Black Sea.	Planktivorous, Invertivorous and Detritivorous	[59, 79, 92]
Polynemidae	Indo-West Pacific: Pakistan, India, including Sri Lanka to Malay Peninsula, Persian Gulf to Papua New Guinea, Australia, West Atlantic (North Carolina to Brazil).	Piscivorous and Invertivorous	[59, 93]
Ariidae	Southeast Asia, Pakistan, India, West Indian Ocean (Polynesia and Japan), South New Guinea and Australia, Greater Caribbean and Gulf of Mexico	Omnivorous	[59, 79, 94]
Plotosidae	Indo-West Pacific: Red Sea, India, South Korea, East Africa, Samoa, Japan, Ogasawara Islands, Australia, Palau and Yap in Micronesia, Madagascar.	Invertivorous and Detritivorous	[79]
Clupeidae	Indo-West Pacific, Pakistan, India, Persian Gulf, Andaman Sea, Thailand, Indonesia, Vietnam, and Philippines Australia, the Caroline Islands, New Caledonia, Greater Caribbean, West Atlantic.	Planktivorous, Invertivorous	[59, 79, 95, 96]
Lutjanidae	Indo-West Pacific: Pakistan, India, Sri Lanka, Samoa, East Africa, and Australia. Ryukyu Islands, Solomon Islands, New Guinea, Indonesia, the Philippines, and China.	Invertivorous and Carnivores	[96]
Leiognathidae	Indo-West Pacific: India, Pakistan, New Guinea; Northern Japan; Southern Australia, Sri Lanka, Indonesia and Philippines, Red sea	Planktivorous, Invertivorous	[79, 96]
Sillaginidae	Western Indian Ocean: Arabian Sea, Pakistan, India, Indo-West Pacific, Eastern Africa and northward to Korea.	Invertivorous	[79, 91, 97]
Terapontidae	East Africa to Samoa, Red Sea, Japan, Australia, and Lord Howe Island.	Omnivorous and Invertivorous	[98]
Harpadontidae	Indo-West Pacific: Somalia, New Guinea, Japan, and Indonesia.	Carnivorous	[99]
Carangidae	South Africa, North to Red sea, Persian Gulf, India, Pakistan, Sri Lanka, Thailand, Japan, Indonesia to Fiji, New Zealand, Australia, Gulf of Papua.	Piscivorous and Invertivorous	[100]
Haemulidae	Indo-West Pacific: Pakistan to Sri Lanka, Western Pacific, China, Australia. Greater Caribbean (Gulf of Mexico-Guyana) and West Atlantic, Gulf of Suez Mozambique and South Africa.	Invertivorous (Nocturnal) and Carnivores	[59, 94, 96, 101]
Sparidae	South Africa, Mozambique, India, Red Sea, Persian Gulf, Malaysia (Penang Island and Langkawi Island, near Singapore). Northern Arabian Sea, Pakistan, Persian Gulf, Oman.	Carnivores, Invertivorous	[102, 103]
Sciaenidae	Indo-West Pacific, west to India and Sri Lanka, east to New Guinea, Pakistan, China and Australia, Greater Caribbean and Northern Western Atlantic (New York, Gulf of Mexico, Massachusetts, Argentina, Maine, Chesapeake Bay and Brazil).	Carnivores and Invertivorous	[59]

Family	Distribution area	Feeding habit	References
Serranidae	Portugal, Angola, including the Mediterranean, Pakistan, Indian Ocean: Northern India, Gulf of Aden to Sri Lanka, Persian Gulf, Red Sea. Greater Caribbean (North Carolina to Suriname and Gulf of Mexico).	Carnivores, Piscivorous, and Invertivorous	[59, 96]
Ophichthidae	Northern India, Pakistan, Gulf of Aden to Sri Lanka, Persian Gulf, Red Sea.	Carnivores, Piscivorous, and Invertivorous	[59, 79]
Terapontidae	India, Pakistan, Red Sea and East Africa, Japan, Taiwan, New Guinea, Indonesia, Malaysia, and Australia.	Carnivores	[104]
Gerreidae	Indo-Pacific: East Coast of India, Pakistan and Sri Lanka, Bangladesh, Myanmar, and Thailand. Bermuda and Florida, USA; Bahamas, northern Gulf of Mexico, South American coast to Rio de Janeiro, Brazil.	Invertivorous	[91]
Narcinidae	Pakistan, Western Indian Ocean, Gulf of Oman, Gulf of Aden.	Invertivorous	[101]
Mullidae	Indo-West Pacific: Red Sea to New Caledonia, Japan, Mozambique, Indo-Malayan region, Northern Australia, Fiji, east Mediterranean, Suez Canal.	Invertivorous	[105];
Scatophagidae	Indo-West Pacific; Fiji, Indonesia, Philippines.	Invertivorous and Detritivorous	[76]
Ambassidae	Pakistan; India, East Africa, South Africa, Western Pacific: Thailand, Indonesia and Philippines, New Guinea, Ryukyu Islands.	Planktivorous	[76, 101]
Gymnuridae	Indian Ocean and Central Pacific: India Pakistan Sri Lanka, Indonesia, Singapore and Thailand, West Atlantic: USA, Gulf of Mexico, extended to the Caribbean Sea, Central Pacific: Gulf of California and Panama.	Invertivorous	[106]
Belonidae	Pakistan, India, Persian Gulf, and Sri Lanka, Southern China, Northern Australia, and Philippines.	Piscivorous and Invertivorous	[107]
Chirocentridae	Pakistan	Carnivorous	[94]
Engraulidae	Gulf of Aden, Persian Gulf, Pakistan, India, Bay of Bengal Andaman Islands, Indonesia, Thailand, Taiwan Island, South to Northern Australia; Fiji and Tonga.	Planktivorous and Invertivorous	[79, 91, 94]
Hemiramphidae	India, Pakistan, Philippines, New Guinea, New Caledonia, and northern Australia; Peninsula of Japan, Indonesia, New Guinea Gulf of Thailand, and western Polynesia.	Omnivorous	[79, 91]
Sphyracnidae	India, Pakistan, Red Sea, East coast of Africa to Hawaii; Marquesas and Tuamotu islands, USA to Uruguay, New Jersey, Persian Gulf, Red Sea, East Africa; Japan to New Caledonia, Hawaii and Tahiti. California, USA to Ecuador and Peru.	Carnivorous	[96]
Lethrinidae	Red Sea, East Africa, Seychelles, Maldives, Sri Lanka, Andaman, Indonesia, Philippines, South Japan, Northeast Australia, New Guinea, Fiji, Vanuatu.	Invertivorous and Carnivorous	[108]
Nemipteridae	Indo-West Pacific: India and Pakistan, Bay of Bengal, southern Japan to Indonesia and northwestern Australia.	Planktivores and Invertivorous	[91, 94]

Family	Distribution area	Feeding habit	References
Trichiuridae	Cosmopolitan, Pakistan (Sindh and Balochistan), Indo-Pacific (Arabian Sea-North eastern, Indian ocean-northwest and central east) and Atlantic areas.	Carnivorous	[109]
Scombridae	Pakistan, Atlantic and Mediterranean, Tropical and Subtropical seas.	Carnivorous	[96]
Stromateidae	West Atlantic (Chesapeake Bay to Argentina).	Juvenile-Planktivorous Adult-Invertivorous	[59, 110]
Tetraodontidae	Red Sea, Pakistan, India, Persian Gulf to South Africa, Japan to Australia. South coast of South Africa, Indonesia, Papua New Guinea, Caribbean Greater.	Carnivorous	[59, 96]
Triacanthidae	Indo-West Pacific: Gulf of Oman, Arabian Sea, Persian Gulf, Bay of Bengal, and Japan China, South China Sea including Gulf of Thailand, Indonesia, Philippines, northern Australia.	Invertivorous	[76]

Table 1.
A detailed review of literature on the feeding habits of various finfish families.

2. Materials and methods

The lagoon area of Sonmiani Bay (Miani Hor) is located at the east coast of Balochistan and 90 km far from Karachi city [21, 130]. It is an estuary system having various islands, intertidal mudflats, and an extensive mangrove swamp. It extends up to 60 km and is widespread up to 7 km. The twisted and complicated water bodies



Figure 2.
The coastal area of Sonmiani bay showing the sampling area with location (stars) of the net activities performed (yellow stars = gill net, green stars = cast net, violet star = commercial beach seine, and red stars = purse seine).

connect it to the Arabian sea [131]. It is known as the largest bay in Pakistan. It spreads up to 363.3 square kilometers and about 80 km wide shelf area [132]. The rainwater runoff here from Porali and Windor rivers during the rainy season. This bay is extending up to 60 km in length and 7 km wide, twisted, and contorted body of water (**Figure 2**). Churna and Kiou islands are two islands present offshore and connected with intertidal mudflats, muddy beaches, mangrove forests, sandy beaches, and Hub River [131] characterizes Miani Hor. Three mangrove species have been reported from Pakistan (i.e. *R. mucronata*; *C. tagal* and *A. marina*). Miani Hor is the only region in Pakistan, where all these species are present together in a natural environment [133].

2.1 Field sampling

For the sampling of Finfish species, four sites were selected for a period from December 2001 to November 2002. Plate 1, shows the sampling area of this study which was comprised of the mouth of the bay, the front area of sand dune, mangrove creeks off Damb, and mangrove creeks of Bhaira village. The sampling site was muddy with some patches of sandy bottom. This helps to operate all types of nets in this area.

2.2 Fishing methods

The fishing methods/ nets adopted by local fishermen in *Miani Hor* (**Figure 3**), were also used for this study described as follows:

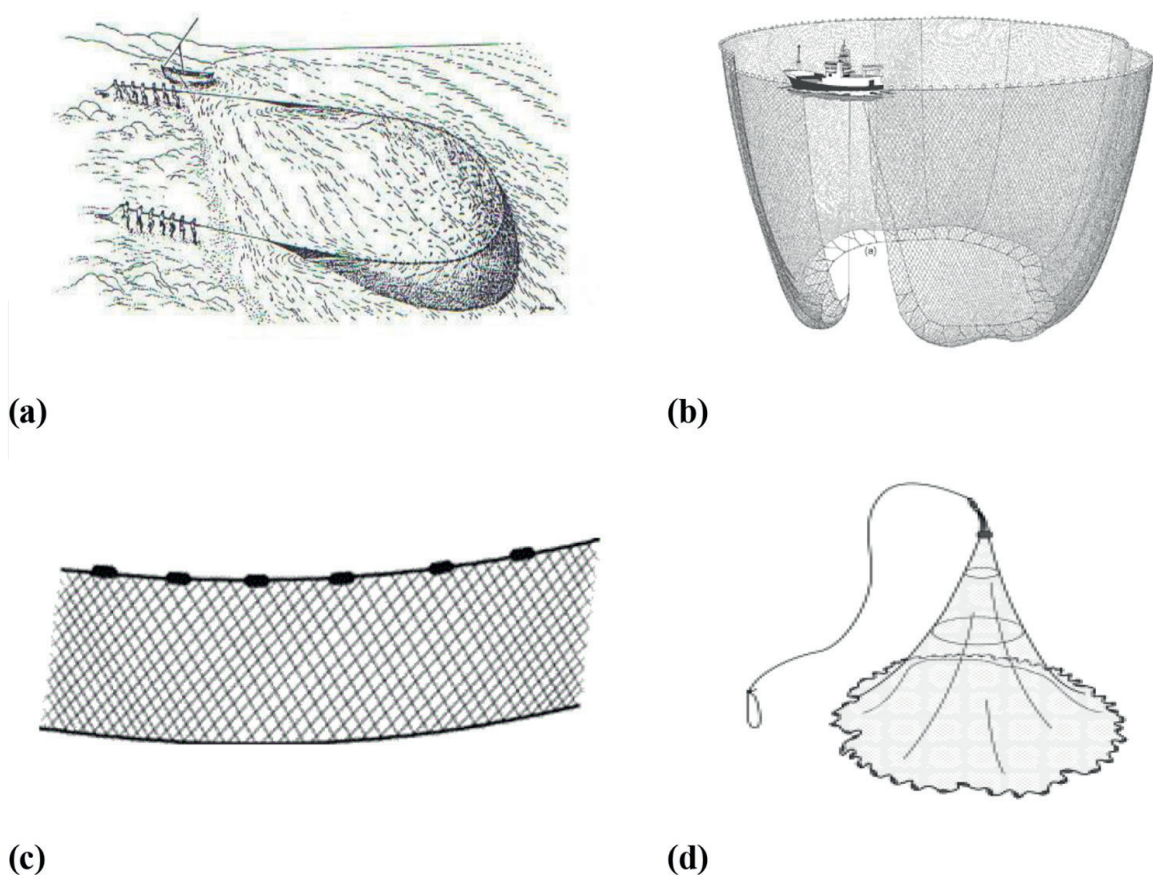


Figure 3.
The diagrammatic view showing four different types of gears used for study purposes (a) beach seine (b) purse seine (c) gill net (d) cast net.

2.2.1 Beach seine (Cada)

The beach seine is a well known commercial net used in Sonmiani Bay creeks. The net was used about 55.5 meters long and 9.2 meters wide at the center and at the corners it was about 7.4 meters wide curtains with 1 cm² mesh size. This methodology was used to operate by approximately 6–8 persons. This type of net is commonly used to catch small-sized pelagic and demersal fishes at high tide.

2.2.2 Purse seine (Katra)

The major commercial tool used to catch the sardine fisheries along the Sonmiani Bay (**Table 2**). It is about 250x100 meters curtain operating with two boats and with approximately 1 centimeter square mesh size. To capture a dense and mobile school of pelagic fish, the purse seine is effective.

2.2.3 Gill net (Tukri)

A type of commercial net provides major support for the shrimp fisheries of the Sonmiani bay (**Table 2**). Total size of Gill net used in the collection was 30.48 long and 3.65 meter wide with 1 square inch in mesh size. The gillnet is consisting of a web and a rectangular frame. It hangs into the water like a wall with the help of a head rope and foot rope.

2.2.4 Cast net (Goal-jal)

This is the type of non-commercial fisheries used by a fisherman in the coastal villages of the Sonmiani bay and support the domestic livelihood of the local people (**Table 2**). The cast net is a technical netting process and was used by only one person who was hired during collection time.

2.3 Laboratory analyses

2.3.1 Taxonomic identification

In the laboratory, the catch brought into the laboratory, washed, sorted according to the fish group and kept in marked polyethylene bags in deep freezer for subsequent study. The all collected finfish were identified up to the lowest taxonomic level. The fish species were identified with the help of field guide provided by Bianchi [91] and FAO Fish identification sheets by Psomadakis et al. [94].

No.	Sites	Nets	Status
1	Off Damb mangrove creeks	Beach seine, Gill net	Commercial
2	Bhaira village mangrove creeks	Gill net	Commercial
3	Mouth of the bay	Purse seine	Commercial
4	Damb Jetty Area	Cast net	Non-commercial
5	Sand dunes front	Cast net	Non-commercial

Table 2.
The status of different net types used to catch the marine fauna from the selected research sites of Sonmiani Bay.

3. Results

3.1 Finfishes diversity and habitat found in the Sonmiani Bay Area

During the current research total 155 finfish species from 49 families were collected and identified. Different type of fishing gears was used for the collecting of fishes “beach seine, purse seine, gill net, and cast net” in various habitat like shore line, pelagic and benthos pelagic area and mangrove area of Sonmiani Bay.

Because various finfish acquire varied behavior with habitat, all collected species were subjected to ecological factors such as habit and manner of feeding with reference to their habitat, morphological modifications and habitat adaptation. Mangrove finfish can be classified into four assemblages based on their distribution patterns: permanent residents, partial residents, tidal visitors, and seasonal visitors [14]. These variances are related to food and shelter. Bottom-dwelling fish with limited visibility live in the muddy mangroves. Following are four types of finfishes of the Sonmiani Bay area:

3.1.1 Permanent finfishes of Sonmiani Bay

Allenbatrachus grunniens of the Batrachoididae family and *Oligolepis acutipennis* of the Gobiidae family are examples of permanent finfish fauna (Table 3). Mudskippers are mostly found on the soft mud flat due to their typical adaptation such as pectoral

Permanent Finfishes of Sonmiani Bay		
Family	Species	Common name
Batrachoididae	<i>Allenbatrachus grunniens</i>	Grunting toadfish
Gobiidae	<i>Oligolepis acutipennis</i>	Sharptail goby
	<i>Oplopomus oplopomus</i>	Spinecheek goby
	<i>Oxyurichthys microlepis</i>	Maned goby
	<i>Oxyurichthys papuensis</i>	Frogface goby
	<i>Trypauchen vagina</i>	Burrowing goby
	<i>Bolephthalmus sp.</i>	Goby
Seasonal finfishes of Sonmiani Bay		
Family	Species	Common name
Bothidae	<i>Pseudorhombus elevatus</i>	Deep flounder
Soleidae	<i>Euryglossa orientalis</i>	Oriental sole
	<i>Solea elongata</i>	Elongate sole
Cynoglossidae	<i>Cynoglossus bilineatus</i>	Roundhead tongue sole
	<i>Cynoglossus dispar</i>	Carrot tongue sole
	<i>Cynoglossus dubius</i>	Carrot tongue sole
	<i>Cynoglossus puncticeps</i>	Speckled tongue sole
	<i>Paraplagusia bilineata</i>	Double lined tongue sole
	<i>Cynoglossus sp.</i>	Tongue sole
Platycephalidae	<i>Cociella crocodila</i>	Crocodile flathead
	<i>Platycephalus indicus</i>	Bartail flathead

Permanent Finfishes of Sonmiani Bay		
Family	Species	Common name
Callionymidae	<i>Callionymus marleyi</i>	Sand dragonet
Synodontidae	<i>Saurida undosquamis</i>	Brushtooth lizardfish
Dasyatidae	<i>Himantura gerrardi</i>	Stingray
Demersal waters dweller finfishes of Sonmiani Bay		
Family	Species	Common name
Mugillidae	<i>Liza carinata</i>	Keeled mullet
	<i>Liza subviridis</i>	Greenback mullet
	<i>Liza tada</i>	Tade gray mullet
	<i>Valamugil cunnesius</i>	Longarm mullet
	<i>Valamugil seheli</i>	Blue spot mullet
	<i>Valamugil speigleri</i>	Speigler's mullet
	<i>Liza sp.</i>	Liza Juvenile
Polynemidae	<i>Eleutheronema tetradactylum</i>	Fourfinger threadfin
	<i>Polynemus heptadactylus</i>	Seven thread tassel fish
	<i>Polynemus indicus</i>	Indian threadfin
Ariidae	<i>Arius arius</i>	Threadfin sea catfish
	<i>Arius caelatus</i>	Engraved catfish
	<i>Arius crossocheilus</i>	Roughback sea catfish
	<i>Arius dussumieri</i>	Blacktip sea catfish
	<i>Arius maculatus</i>	Spotted catfish
	<i>Arius platystomus</i>	Flatmouth sea catfish
	<i>Arius sagor</i>	Sagor sea catfish
	<i>Arius sona</i>	Sona sea catfish
	<i>Arius subrostratus</i>	Shovelnose sea catfish
	<i>Arius tenuispinis</i>	Thinspine catfish
	<i>Arius thalassinus</i>	Giant catfish
Plotosidae	<i>Plotosus lineatus</i>	Striped eel catfish
Clupeidae	<i>Anodontostoma chacunda</i>	Chacunda gizzard shad
	<i>Nematolosa nasus</i>	Bloch's gizzard shad
Lutjanidae	<i>Lutjanus russellii</i>	Russell's snapper
	<i>Lutjanus lunulatus</i>	Lunartail snapper
Leiognathidae	<i>Gazza minuta</i>	Toothpony
	<i>Leiognathus berbis</i>	Berber ponyfish
	<i>Leiognathus blochi</i>	Tow-blotch ponyfish
	<i>Leiognathus daura</i>	Goldstripe ponyfish
	<i>Leiognathus equulus</i>	Common ponyfish
	<i>Leiognathus fasciatus</i>	Striped ponyfish

Permanent Finfishes of Sonmiani Bay		
Family	Species	Common name
Gerreidae	<i>Leiognathus splendens</i>	Splendid ponyfish
	<i>Secutor insidiator</i>	Pugnose ponyfish
	<i>Gerres filamentosus</i>	Whipfin silver biddy
	<i>Gerres poietii</i>	Strongspine silver biddy
Mullidae	<i>Upeneus vittatus</i>	Striped goatfish
Sillaginidae	<i>Sillago sihama</i>	Silver sillago
Terapontidae	<i>Terapon jarbua</i>	Jarbua terapon
Scatophagidae	<i>Scatophagus argus</i>	Spotted scat
Harpadontidae	<i>Harpadon nehereus</i>	Bombay duck
Carangidae	<i>Alectis indicus</i>	Indian threadfish
	<i>Alepes djedaba</i>	Shrimp scad
	<i>Alepes melanoptera</i>	Blackfin scad
	<i>Atule mate</i>	Yellowtail scad
	<i>Carangoides caeruleopinnatus</i>	Coastal trevally
	<i>Carangoides malabaricus</i>	Malabar trevally
	<i>Carangoides oblongus</i>	Coach whip trevally
	<i>Caranx ignobilis</i>	Giant trevally
	<i>Caranx para</i>	Banded scad
	<i>Caranx sexfasciatus</i>	Bigeye trevally
	<i>Decapterus russelli</i>	Indian scad
	<i>Scomberoides commersonnianus</i>	Talang queenfish
	<i>Scomberoides toli</i>	Needle scaled queenfish
	<i>Selaroides leptolepis</i>	Yellowstripe scad
	<i>Carangid sp.</i>	<i>Carangid sp.</i>
Haemulidae	<i>Plectorhinchus pictus</i>	Trout sweet lips
	<i>Pomadasys argyreus</i>	Bluecheek silver grunt
	<i>Pomadasys commersonni</i>	Spotted Grunter
	<i>Pomadasys kaakan</i>	Javelin grunter
	<i>Pomadasys maculatum</i>	Saddle grant
	<i>Pomadasys olivaceum</i>	Olive grant
	<i>Pomadasys stridens</i>	Stripped grunter
Sparidae	<i>Acanthopagrus berda</i>	Picnic seabream
	<i>Acanthopagrus latus</i>	Yellowfin seabream
	<i>Argyrops spinifer</i>	King soldier bream
	<i>Cheimerus nufar</i>	Santer seabream
	<i>Crenidens crenidens</i>	Karanteen seabream
	<i>Rhabdosargus sarba</i>	Goldlined seabream

Permanent Finfishes of Sonmiani Bay		
Family	Species	Common name
Sciaenidae	<i>Johnieops sina</i>	Sin croaker
	<i>Johnius aneus</i>	Greyfin croaker
	<i>Johnius belangerii</i>	Belanger's croaker
	<i>Johnius carutta</i>	Karut croaker
	<i>Johnius dussumieri</i>	Bearded croaker
	<i>Johnius glaucus</i>	Pale spotfin croaker
	<i>Otolithes cuvieri</i>	Lesser tiger tooth croaker
	<i>Otolithes ruber</i>	Tiger tooth croaker
	<i>Paranibea semiluctuosa</i>	Half mourning croaker
	<i>Umbrina canariensis</i>	Canary drum
Lethrinidae	<i>Lethrinus microdon</i>	Smalltooth emperor
	<i>Lethrinus ramak</i>	Yellow banded emperor
Serranidae	<i>Epinephelus fuscoguttatus</i>	Brown-marbled grouper
Muraenesocidae	<i>Muraenesox bogio</i>	Common pike conger
Ophichthidae	<i>Cirrhimuraena playfairii</i>	Fringe lip snake eel
Hemiscylliidae	<i>Chiloscyllium griseum</i>	Gray bamboo shark
Narcinidae	<i>Narcine indica</i>	Large spotted numbfish
Narcinidae	<i>Narcine timlei</i>	Black spotted electric ray
Gymnuridae	<i>Gymnura poecilura</i>	Butterfly-ray
Pelagic waters dweller finfishes of Sonmiani Bay		
Family	Species	Common name
Ambassidae	<i>Ambasis gymnocephalus</i>	Bald Glassy Perchlet
	<i>Ambassis ambassis</i>	Commerson's glassy
Belonidae	<i>Strongylura strongylura</i>	Spottail needlefish
	<i>Tylosurus crocodiles crocodilus</i>	Crocodile needlefish
Chirocentridae	<i>Chirocentrus nudus</i>	Whitefin wolf-herring
Clupeidae	<i>Dussumieria acuta</i>	Rainbow sardine
	<i>Escualosa thoracata</i>	White sardine
	<i>Hilsa kelee</i>	Kelee shad
	<i>Ilisha megaloptera</i>	Bigeye ilisha
	<i>Ilisha melastoma</i>	Indian ilisha
	<i>Opisthopterus tardoore</i>	Tardoore
	<i>Sardinella albella</i>	White sardinella
	<i>Sardinella gibbosa</i>	Gold stripe sardinella
	<i>Sardinella longiceps</i>	Oil sardine
	<i>Sardinella melanura</i>	Blacktip sardinella
	<i>Sardinella sindensis</i>	Sind sardinella
	<i>Tenuالosa toli</i>	Toli shad
	<i>Ilisha sp.</i>	<i>Ilisha sp.</i>

Permanent Finfishes of Sonmiani Bay		
Family	Species	Common name
Engraulidae	<i>Coilia dussumieri</i>	Gold spotted grenadier anchovy
	<i>Stolephorus commersonii</i>	Commerson's anchovy
	<i>Stolephorus indicus</i>	Indian anchovy
	<i>Thryssa hamiltonii</i>	Hamilton's thryssa
	<i>Thryssa malabarica</i>	Malabar thryssa
	<i>Thryssa mystax</i>	Mustached thryssa
	<i>Thryssa setirostris</i>	Long jaw thryssa
	<i>Thryssa vitrirostris</i>	Orange mouth anchovy
	<i>Thryssa sp.</i>	<i>Thryssa sp.</i>
Hemiramphidae	<i>Hyporhamphus dussumieri</i>	Dussumier's halfbeak
	<i>Hyporhamphus limbatus</i>	Congaturi halfbeak
Sphyraenidae	<i>Sphyraena obtusata</i>	Obtuse barracuda
Lactariidae	<i>Lactarius lactarius</i>	False trevally
Carangidae	<i>Megalaspis cordyla</i>	Torpedo scad
	<i>Parastromateus niger</i>	Black pomphret
Drepanidae	<i>Drepane punctata</i>	Spotted sickle fish
Nemipteridae	<i>Nemipterus bipunctatus</i>	Delagoa threadfin bream
Trichiuridae	<i>Lepturacanthus savala</i>	Savalai hairtail
	<i>Trichiurus lepturus</i>	Largehead hairtail
Scombridae	<i>Auxis thazard</i>	Frigate tuna
	<i>Rastrelliger kanagurta</i>	Indian mackerel
Stromateidae	<i>Pampus argenteus</i>	Silver pomfret
	<i>Pampus chinensis</i>	Chinese silver pomfret
Aluteridae	<i>Alutera monoceros</i>	Yellow finned leather jacket
Tetraodontidae	<i>Arothron lepoardus</i>	Banded leopard blowfish
	<i>Lagocephalus laevigatus</i>	Smooth puffer
	<i>Lagocephalus lunaris</i>	Green rough backed blowfish
Triacanthidae	<i>Pseudotriacanthus strigilifer</i>	Long-spined tripod fish

Table 3.
Permanent and seasonal diversity of Finfishes in two habitat of the Sonmiani Bay, during the study period, December 2001 to November 2002.

fins and moist outer coat. The pectoral fins have bases to help them creep through the mud with more vigor and moist outer coat acts as a breathing organ respectively.

3.1.2 Seasonal finfishes of Sonmiani Bay

Seasonal finfishes in the area include the family Bothidae, which includes the species *Pseudorhombus elevates*, and the Soleidae, which includes the species *Solea elongate*, as revealed in our findings (Table 3).

3.1.3 Demersal waters dweller finfishes of Sonmiani Bay

Ariidae and Lutjanidae [134] are mostly demersal finfishes which usually found on the soft benthopelagic area and mostly travel toward the high tidal zone. (Table 3). Flatfish, flathead, rays, and demersal finfishes are buried in the mud of mangrove creeks, and while giant fish may live in deep waters, lesser species access the Sonmiani bay’s tidal channels.

3.1.4 Pelagic waters dweller finfishes of Sonmiani Bay

Pelagic water dweller finfishes are those that only stay for a short time during tidal intervals, leaving at low tide and returning at high tide (Table 3). The family Engraulidae and clupeids are belonging to this group which are plankton feeder such as sardine, shad, and herring fishes. These fishes are fast swimmers.

3.2 Carnivorous and herbivorous finfishes of the Sonmiani Bay

The collected specimens of finfishes throughout the study were split into two groups based on their mode of nutrition; Bianchi [91] was followed during the observation. Fish were divided into groups based on their feeding habits and food preferences (Table 4). The finfishes of Sonmiani Bay were divided in this way to better understand the area’s food webs. Table 4 shows the list of herbivorous and partly herbivorous fishes which are 31 species, belong to three families of bony fishes. Fishes like mullets, herring, shads, sardine, and thryssa are herbivorous while some members of family clupeidae are partly zooplankton eaters.

Carnivorous Finfishes		
Family	Species	Common name
Batrachoididae	<i>Allenbatrachus grunniens</i>	Grunting toadfish
Bothidae	<i>Pseudorhombus elevatus</i>	Deep flounder
Soleidae	<i>Euryglossa orientalis</i>	Oriental sole
	<i>Solea elongata</i>	Elongate sole
Cynoglossidae	<i>Cynoglossus bilineatus</i>	Roundhead tongue sole
	<i>Cynoglossus dispar</i>	Carrot tongue sole
	<i>Cynoglossus dubius</i>	Carrot tongue sole
	<i>Cynoglossus puncticeps</i>	Speckled tongue sole
	<i>Paraplagusia bilineata</i>	Double lined tongue sole
	<i>Cynoglossus sp.</i>	Tongue sole
Platycephalidae	<i>Cociella crocodila</i>	Crocodile flathead
	<i>Platycephalus indicus</i>	Bartail flathead
Callionymidae	<i>Callionymus marleyi</i>	Sand dragonet
Synodontidae	<i>Sauridaundo squamis</i>	Brushtooth lizardfish
Polynemidae	<i>Eleutheronematetra dactylum</i>	Fourfinger threadfin
	<i>Polynemus heptadactylus</i>	Seven thread tassel fish
	<i>Polynemus indicus</i>	Indian threadfin

Carnivorous Finfishes		
Family	Species	Common name
Ariidae	<i>Arius arius</i>	Threadfin sea catfish
	<i>Arius caelatus</i>	Engraved catfish
	<i>Arius crossoccheilus</i>	Roughback sea catfish
	<i>Arius dussumieri</i>	Blacktip sea catfish
	<i>Arius maculatus</i>	Spotted catfish
	<i>Arius platystomus</i>	Flatmouth sea catfish
	<i>Arius sagor</i>	Sagor sea catfish
	<i>Arius sona</i>	Sona sea catfish
	<i>Arius subrostratus</i>	Shovelnose sea catfish
	<i>Arius tenuispinis</i>	Thinspine catfish
	<i>Arius thalassinus</i>	Giant catfish
Plotosidae	<i>Plotosuslineatus</i>	Striped eel catfish
Lutjanidae	<i>Lutjanusrussellii</i>	Russell's snapper
	<i>Lutjanus lunulatus</i>	Lunartail snapper
Leiognathidae	<i>Gazzaminuta</i>	Toothpony
	<i>Leiognathus berbis</i>	Berber ponyfish
	<i>Leiognathus blochi</i>	Tow-blotch ponyfish
	<i>Leiognathus daura</i>	Goldstripe ponyfish
	<i>Leiognathus equulus</i>	Common ponyfish
	<i>Leiognathus fasciatus</i>	Striped ponyfish
	<i>Leiognathus splendens</i>	splendid ponyfish
	<i>Secutor insidiator</i>	Pugnose ponyfish
Gerreidae	<i>Gerres filamentosus</i>	Whipfin silver biddy
	<i>Gerres poieti</i>	Strongspine silver biddy
Mullidae	<i>Upeneus vittatus</i>	Striped goatfish
Sillaginidae	<i>Sillago sihama</i>	Silver sillago
Terapontidae	<i>Terapon jarbua</i>	Jarbua terapon
Scatophagidae	<i>Scatophagus argus</i>	Spotted scat
Harpadontidae	<i>Harpadon nehereus</i>	Bombay duck
Carangidae	<i>Alectis indicus</i>	Indian threadfish
	<i>Alepes djedaba</i>	Shrimp scad
	<i>Alepes melanoptera</i>	Blackfin scad
	<i>Atule mate</i>	yellowtail scad
	<i>Carangoides caeruleopinnatus</i>	Coastal trevally
	<i>Carangoides malabaricus</i>	Malabar trevally
	<i>Carangoides oblongus</i>	Coach whip trevally
	<i>Caranxig nobilis</i>	Giant trevally
	<i>Caranx para</i>	Banded scad

Carnivorous Finfishes		
Family	Species	Common name
	<i>Caranxsex fasciatus</i>	Bigeye trevally
	<i>Decapterus russelli</i>	Indian scad
	<i>Scomberoides commersonnianus</i>	Talang queenfish
	<i>Scomberoides toli</i>	Needlescaled queenfish
	<i>Selaroides leptolepis</i>	Yellowstripe scad
	<i>Carangid sp.</i>	<i>Carangid sp.</i>
Haemulidae	<i>Plectorhinchus pictus</i>	Trout sweetlips
	<i>Pomadasys argyreus</i>	Bluecheek silver grunt
	<i>Pomadasys commersonni</i>	Spotted Grunter
	<i>Pomadasys kaakan</i>	Javelin grunter
	<i>Pomadasys maculatum</i>	Saddle grant
	<i>Pomadasys olivaceum</i>	Olive grant
	<i>Pomadasys stridens</i>	Stripped grunter
Sparidae	<i>Acanthopagrus berda</i>	Picnic seabream
	<i>Acanthopagrus latus</i>	Yellowfin seabream
	<i>Argyrops spinifer</i>	King soldier bream
	<i>Cheimerius nufar</i>	Santer seabream
	<i>Crenidens crenidens</i>	Karanteen seabream
	<i>Rhabdosargus sarba</i>	Goldlined seabream
Sciaenidae	<i>Johnieops sina</i>	Sin croaker
	<i>Johnius aneus</i>	Greyfin croaker
	<i>Johnius belangerii</i>	Belanger's croaker
	<i>Johnius carutta</i>	Karut croaker
	<i>Johnius dussumieri</i>	Bearded croaker
	<i>Johnius glaucus</i>	Pale spotfin croaker
	<i>Otolithes cuvieri</i>	Lesser tigertooth croaker
	<i>Otolithes ruber</i>	Tigertooth croaker
	<i>Paranibea semiluctuosa</i>	Half mourning croaker
	<i>Umbrina canariensis</i>	Canary drum
Lethrinidae	<i>Lethrinus microdon</i>	Smalltooth emperor
	<i>Lethrinus ramak</i>	Yellow banded emperor
Gobiidae	<i>Bolephthalmus sp.</i>	Goby
	<i>Oligolepis acutipennis</i>	Sharptail goby
	<i>Oplopomus oplopomus</i>	Spinecheek goby
	<i>Oxyurichthys microlepis</i>	Maned goby
	<i>Oxyurichthys papuensis</i>	Frogface goby
	<i>Trypauchen vagina</i>	Burrowing goby

Carnivorous Finfishes		
Family	Species	Common name
Serranidae	<i>Epinephelus fuscoguttatus</i>	Brown-marbled grouper
Muraenesocidae	<i>Muraenesox bogio</i>	Common pike conger
Ophichthidae	<i>Cirrhimuraena playfairii</i>	Fringelip snake eel
Ambassidae	<i>Ambassis gymnocephalus</i>	Bald Glassy Perchlet
	<i>Ambassis ambassis</i>	Commerson's glassy
Belonidae	<i>Strongylura strongylura</i>	Spottail needlefish
	<i>Tylosurus crocodile scrocodilus</i>	Crocodile needlefish
Chirocentridae	<i>Chirocentrus nudus</i>	Whitefin wolf-herring
Hemiramphidae	<i>Hyporhamphus dussumieri</i>	Dussumier's halfbeak
	<i>Hyporhamphus limbatus</i>	Congaturi halfbeak
Sphyraenidae	<i>Sphyraena obtusata</i>	Obtuse barracuda
Lactariidae	<i>Lactarius lactarius</i>	False trevally
Carangidae	<i>Megalaspis cordyla</i>	Torpedo scad
	<i>Parastromateus niger</i>	Black pomfret
Drepanidae	<i>Drepane punctata</i>	Spotted sicklefish
Nemipteridae	<i>Nemipterus bipunctatus</i>	Delagoa threadfin bream
Trichiuridae	<i>Lepturacanthus savala</i>	Savalai hairtail
	<i>Trichiurus lepturus</i>	Largehead hairtail
Scombridae	<i>Auxist hazard</i>	Frigate tuna
	<i>Rastrelliger kanagurta</i>	Indian mackerel
Stromateidae	<i>Pampus argenteus</i>	Silver pomfret
	<i>Pampus chinensis</i>	Chinese silver pomfret
Aluteridae	<i>Alutera monoceros</i>	Yellow finned leather jacket
Tetraodontidae	<i>Arothron lepoardus</i>	Banded leopard blowfish
	<i>Lagocephalus laevigatus</i>	Smooth puffer
	<i>Lagocephalus lunaris</i>	Green rough backed blowfish
Triacanthidae	<i>Pseudotriacanthus strigilifer</i>	Long-spined tripodfish
	Carnivorous Elasmobranch fishes	
Herbivorous finfishes		
Family	Species	Common name
Mugillidae	<i>Liza carinata</i>	Keeled mullet

Carnivorous Finfishes		
Family	Species	Common name
Clupeidae*	<i>Liza subviridis</i>	Greenback mullet
	<i>Liza tada</i>	Tade gray mullet
	<i>Valamugil cunnesius</i>	Longarm mullet
	<i>Valamugil seheli</i>	Blue spot mullet
	<i>Valamugil speigleri</i>	Speigler's mullet
	<i>Liza sp.</i>	Liza Juvenile
	<i>Dussumieria acuta</i>	Rainbow sardine
	<i>Escualosa thoracata</i>	White sardine
	<i>Hilsa kelee</i>	Kelee shad
	<i>Ilisha megaloptera</i>	Bigeye ilisha
	<i>Ilisha melastoma</i>	Indian ilisha
	<i>Opisthopterus tardoore</i>	Tardoore
	<i>Sardinella albellia</i>	White sardinella
	<i>Sardinella gibbosa</i>	Goldstripe sardinella
	<i>Sardinella longiceps</i>	Oil sardine
	<i>Sardinella melanura</i>	Blacktip sardinella
	<i>Sardinella sindensis</i>	Sind sardinella
	<i>Tenualosa toli</i>	Toli shad
	<i>Anodontostoma chacunda</i>	Chacunda gizzard shad
	<i>Nematolosa nasus</i>	Bloch's gizzard shad
	<i>Ilisha sp.</i>	<i>Ilisha sp.</i>
Engraulidae	<i>Coilia dussumieri</i>	Gold spotted grenadier anchovy
	<i>Stolephorus commersonii</i>	Commerson's anchovy
	<i>Stolephorus indicus</i>	Indian anchovy
	<i>Thryssa hamiltonii</i>	Hamilton's thryssa
	<i>Thryssa malabarica</i>	Malabar thryssa
	<i>Thryssa mystax</i>	Mustached thryssa
	<i>Thryssa setirostris</i>	Longjaw thryssa
	<i>Thryssa vitrirostris</i>	Orangemouth anchovy
	<i>Thryssa sp.</i>	<i>Thryssa sp.</i>
*Partly zooplankton eaters		

Table 4.
Carnivorous and herbivorous finfishes collected in the Sonmiani Bay, Balochistan during the study period December 2001 to November 2002.

There were 119 species of bony fish from 42 families and 5 species of elasmobranchs from four families among the carnivorous finfishes (Table 4). Sharks and rays dwell in the sea by nature, although some live in estuaries and bays, where they are voracious feeders among the school of fish. They are predators with formidable

jaws that attack their prey. In the Sonmiani Bay waters, carnivorous fishes were discovered to be far more abundant than herbivorous fishes (**Table 4**).

4. Discussion

Fish feeding habits and trophic relationships always remain in focus and interest in scientific essays for ages therefore, fish diets have been extensively studied, primarily through stomach content analysis, as providing important information on the ecology, physiology, and ethology of species, with huge difference in the way applications [135, 136].

Coastal waters especially lagoons have great importance because they provide feeding and nursery ground to a variety of fish and other species, highly dynamic because of high temperature and high transmission of light up to the bottom [137]. These water bodies can be exposed to very strong fluctuations of salinities due to seasonal variations of precipitation and evaporation. In addition, in the shallow environments, the seasonal fluctuations of temperatures are often more pronounced than in the adjacent sea and can make stressing conditions for many aquatic species. Due to such variabilities, their vulnerability makes these water bodies as a unique position at terrestrial, freshwater, and marine interfaces [138]. Coastal lagoons, along with estuarine environments and coastal wetlands, have been defined as Critical Transition Zones (CTZs). Those organisms that cover these areas as distributed in order to three-dimensional scales that are more likely to subordinate with the environment and reserve consumption [139]. The biotic and abiotic factors support creation of numerous types of niches and habitats for living and dispersal of organisms [140]. The temperature and salinity may cause the divergence in structure and function of many benthic and pelagic communities because these communities are constantly interacting and suffering from these ecological factors [141–144]. The higher temperature supports the productivity and ultimately abundance of species in particular areas [145–147]. The feeding habits of the fauna may change due to the effect of salinity so therefore, salinity has a great influence on ecosystem as well as distribution and feeding habits of residential species. Tidal fluctuations cause a significant change and play a vital role in communication and other approaches which juveniles and other fauna adopted to take a sequential change [148]. These are the areas which organisms utilize and are distinct in habitat differences and accessibility due to the tidal flux [149]. However, seasonal and monthly variations also affect intertidal shallow environments, productivity, and the distribution and diversity of fish species.

In spite of primary productivity, the presence of vegetation also improves the food opportunity to the herbivores and carnivores species as the mangrove vegetation and allied mudflats have been reported as an important breeding and feeding site of a number of marine species [15]. The ecological status and environmental conditions of habitat can be the indicator of the faunal diversity and also provide the detailed information about the life history of fish species and decapods, and supportive feeding environment along with habitat requirements to complete the lifecycle are supposed to be helpful in the protection and restoration of the communities inhabiting in these areas [6, 150].

The marine fisheries policies of developing countries such as Pakistan are aimed at achieving the following objectives: filling protein gaps as regards improving marine fish supplies for domestic use, encouraging jobs, growing fishermen's economic interests, and increasing foreign exchange through exporting fish and shellfish. Maximum attention is being paid in Pakistan to achieve the ultimate goal that is, earning foreign

exchange, which has established the marine fishing industry of Pakistan as an export supplier. The need for protection of fishery resources arises from the industrial sector, as it is understood from the natural predation of fish stocks [151]. Food quality and quantity are the two biggest exogenous elements impacting fish growth and indirectly, maturation and mortality, thus linked to health of fish [135]. Traditionally, data on the quality and quantity of food consumed by fish, which can be derived from the feeding habit studies, which has just been made available for fisheries research by incorporating it into appropriate fisheries models likewise; multispecies virtual population analysis which, after scaling up to the overall biomass of predators and prey, provides estimates of the total biomass consumed by predators [135]. There are numerous challenges that need to be studied for the feeding biology of particular species as also variable in a group of same species; developmental or growth diversity includes morphological diversity from the smallest to the largest in body size; as the species passes through various ontogenic stages during its development and may have a preference of different types of food during each stage therefore, exhibit variable feeding habits; behavioral diversity due to exploration of high habitat diversity expanding from marine to fresh-water due to migratory in nature, etc. Few scientists have studied the diet variations in fishes and explain the changes in diet composition with reference to habitat and season [152]. Whereas, the different authors have worked on feeding habits of various finfishes [134, 153–155]. It has been reported that 25 different food items represent zooplankton (0.54%), phytoplankton (82.53%), algae (0.92%), copepod fragment (2.69%), debris (4.86%), plant-like matter (7.34%), and unidentified matters (0.77%) in some clupeidae species [156]. Investigation on feeding habitat of Sin croaker narrated that it's active carnivore and depends on the benthic crustacean, fishes, shrimp as food [156].

Systematic analysis of feeding characteristics of marine fish species during the early development stage, feeding habits, and growth of larvae and juveniles can provide the information about the nutrient feeding, that should be given through biological food for nutritional improvement and enhance the survival rate of fingerlings in culture condition. Therefore, systematic study serves as a model for large-scale generation of larvae and juveniles of marine fish [156].

Not only the opportunistic feeders, some other species also obtain their food according to the availability and abundance in their habitat and like opportunistic feeders, they adapted different ways to obtain food such as basic food, which is only utilized in favorable conditions, second is incidental food that's utilized during unfavorable conditions, and then obligatory food that comprises anything that is fed for survival not as a habit. A “food-based conservation” approach is favored with the eco-reinstatement as deal with the fish habitat and fish communities. It seems extremely obvious now not to rely on abstract sampling procedures for merely descriptive assessment of food and feeding biology in fish. Therefore, investigating only the ingested food to examine the feeding habit of fish is not a reliable method and items present in the gut addressed the single picture of feeding habit because feeding habit depends upon the availability of food in the environment. So, this method just provides a piece of limited information and does not explain the factors affecting the gaining or selection of food. It has been suggested to collect the plankton community when fish is sampled for the study so, it can be helpful to determine the availability and selectivity of food [95]. Food science is an applied science and the detailed feeding biology of fish can contribute to formulate feeding design for better management and growth of fish for the culture of species. Due to the contradiction and insufficient information about available food and feeding habit, molecular level studies have been suggested to validate the information on feeding habits as obtaining of food through smelling is

related with some chemicals in the fish body. Therefore, the study through molecular taste science can also provide advanced tools and techniques in biological sciences.

5. Conclusions

Lagoons are the imperative feature of any coast line that offers important ecosystem services, such as coastline protection, shelter and food for migratory and resident animals, fisheries resources, and recreation for human populations. These intertidal benthic and pelagic areas have a variety of sizes according to species diversity and distribution of species is greatly influenced by the change in biotic and abiotic factors; Abiotic factors mainly include salinity and temperature as affect the intertidal shallow environments, primary productivity, and the distribution and diversity of fish species. The ecological status and habitat environmental conditions can be the indicator of the faunal diversity and also provide the detailed information about the life history of fish species and decapods, along with particular supportive feeding environment and habitat requirements to complete the life cycle. These ecological indicators supposed to be helpful in the protection and restoration of the communities inhabiting in these areas. There are numerous challenges that need to be studied for the feeding biology of particular species as also variable in a group of same species and as well as developmental or growth feeding diversity as the species passes through various ontogenic stages during its development and may have a preference of different types of food during each stage therefore, exhibit variable feeding habits; behavioral diversity due to exploration of high habitat diversity.

Conflict of interest

The authors declare no conflict of interest.

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