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Exploration of Marine Fish Biodiversity in the Bay of Bengal: A Comparative Study on Fish Landing Centers in Bangladesh

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ABSTRACT

This study investigated the availability of marine fish and shellfish species in various fish landing centers in Bangladesh from the Bay of Bengal, focusing on the coastal districts notably Chattogram, Patuakhali, and Borguna regions. Face-to-face interviews were conducted with a total of 330 (110 from each three landing centers) respondents for different aspects of fish biodiversity issues. The secondary data were also obtained from the manager, Upazila Fisheries Officer in proximity of the respective fish landing centers. The results observed that a total of 152 species were found, comprising 144 marine fish and 8 shellfish species, including 30 orders and 69 families dominating Perciformes (56%), Clupeiformes (12%) and Scombriformes (11%), highlighting the rich biodiversity of the marine ecosystem. More than 68% of all marine fish were categorized as Least Concern, with roughly 14% classified as Near Threatened and 6% as Vulnerable. The research examined the factors influencing the presence of these species, including type, availability, commercial status, consumer preferences, economic variables, and income levels. Notably, the highest demand species, hilsa (*Tenualosa Ilisha)*, was found to be closely linked to their availability, while less conventional species like octopus and shrimp exhibited erratic consumer demand despite their value. The study underscored the importance of understanding catching compositions and market dynamics in the fisheries sector, referencing the IUCN red list to address concerns regarding species under threat of extinction. Thus, the findings aim to inform sustainable management practices and enhance the economic viability of the fisheries industry in Bangladesh.

INTRODUCTION

Bangladesh comprises a substantial delta region, bordered to the south by the Bay of Bengal. In Bangladesh, the fishing industry is vital to the agro-based economic growth, poverty reduction, and creating employment of the nation. Moreover, fish is considered a highly healthy food due to its high protein content, complete amino acids, low saturated

fat, abundant omega-3 fatty acids, essential minerals, and dietary vitamins that benefit consumers' health **(Chakma *et al.*, 2022; Chakma *et al.*, 2024)**. Furthermore, it serves as a vital source of animal protein and contributes substantially to the country's foreign currency earnings. Bangladesh is domicile to 260 freshwater and 475 marine fish species with approximately 12 exotic species currently being cultivated within its boarder **(DoF, 2022)**. It emerged as a global leader in fish production, achieving a total output of 47.59 lakh MT in the FY 2021–2022. Aquaculture contributed 57.39% to the total fish production, benefiting from Bangladesh's vast water resources **(DoF, 2022)**. The Bay of Bengal in Bangladesh is known to host diverse marine life, encompassing 25 species of shrimp/ prawns, 15 types of crabs, and 5 varieties of lobsters and 50 cartilaginous species **(Hossain, 2001)**. In addition, Bangladesh's exclusive economic zone is home to over 400 marine fish species, among which 33 are categorized as threatened in various ways **(Hoq, 2014)**. For example, certain marine fish species, such as the giant grouper (*Epinephelus lanceolatus*), classified as Threatened, the yellow seahorse (*Hippocampus kuda*), also listed as Threatened, the large-tooth sawfish (*Pristis microdon*), categorized as Endangered, and the knife-tooth sawfish (*Anoxtaypristis cuspidate*), also classified as Endangered **(Hoq, 2014)**.

There are numerous fish landing centers scattered across Bangladesh, strategically positioned to support country's vibrant fishing industry. A fish landing center functions as a central location where a variety of fish and fisheries products gathered from different sources such as rivers, beels, haors, ponds, ghers, estuaries and the sea **(Ali *et al.*, 2004; Hanif *et al.*, 2015)**. The regions where marine fish are caught and brought ashore in Bangladesh are situated in south and south-eastern parts of the country **(Raisa *et al.*, 2022)**. Among these, the Chattogram Fish Landing Center at Fishery ghat, Pathorghata, Chattogram; the Patuakhali Fish Landing Center at Mohipur, Patuakhali; and the Barguna Fish Landing Center are notable for their size and significance in the local economy. Various types of fish are consistently brought to these landing centers from a variety of boats, trawlers, and fishing ships. These centers boast a wide range of fish species, encompassing both brackish and marine varieties, making them comprehensive hubs for fish trading and distribution. These fish landing sites are vital for supporting local economies and supporting livelihoods across the region they serve.

The abundancy of fish in the selective study areas are greatly attributed by many reasons such as, seasonal variation in fishing yields, fluctuation in consumer demand, market prices, and the geographical location of the fish market. As an illustration, the annual capture of marine finfish, which accounts for 75% of the demersal capture in Bangladesh's sea waters **(Lamboeuf, 1987)**, typically results in higher abundance of these species at marine fish landing center compared to unconventional marine fishes (such as, octopus, cuttlefish and squid), despite the latter having significant economic value for export **(Siddique *et al.*, 2016)**. This discrepancy underscores how catch volume influences the distributions and availability of different types of marine species in local

market. In addition, the concepts of conventional and non-conventional can differ based on geographical location and country-specific contexts **(Raisa *et al.*, 2022)**.

The study aimed to comprehensively document and analyze the presence of diverse fish species, including marine fishes, and shellfish in the landing center. It sought to identify the dominant orders of marine fishes and shellfish to gain insights into their composition and distribution patterns. Additionally, the study evaluated the conservation status of marine fishes, categorizing them based on the IUCN Red List criteria (e.g., Least Concern, Near Threatened, Vulnerable). It also investigated consumer demand for different fish species, including both conventional and non-conventional shellfish. The study further observed the seasonal availability of large fishes like sharks and rays during winter and monsoon periods. By providing insights into the current situation of marine species (fish and shellfish) availability across three landing centers, the study aimed to contribute valuable information for sustainable management and conservation efforts.

MATERIALS AND METHODS

Selection of the study area

The purpose of this study was for insight into the abundance of fish and shellfish species at the Chattogram Fish Landing Center at Fishery Ghat, Pathorghata, Chattogram, the Patuakhali Fish Landing Center at Alipur and Mohipur, Patuakhali, and the Borguna Fish Landing Center, involving availability of species, catch composition, customer demand degrees, period, and extinction threat status. Because these landing centers were adjacent to the Bay of Bengal, an extensive variety of brackish and marine water fish species were common (Fig. 1). All the data were collected from July 2023 and February 2024.

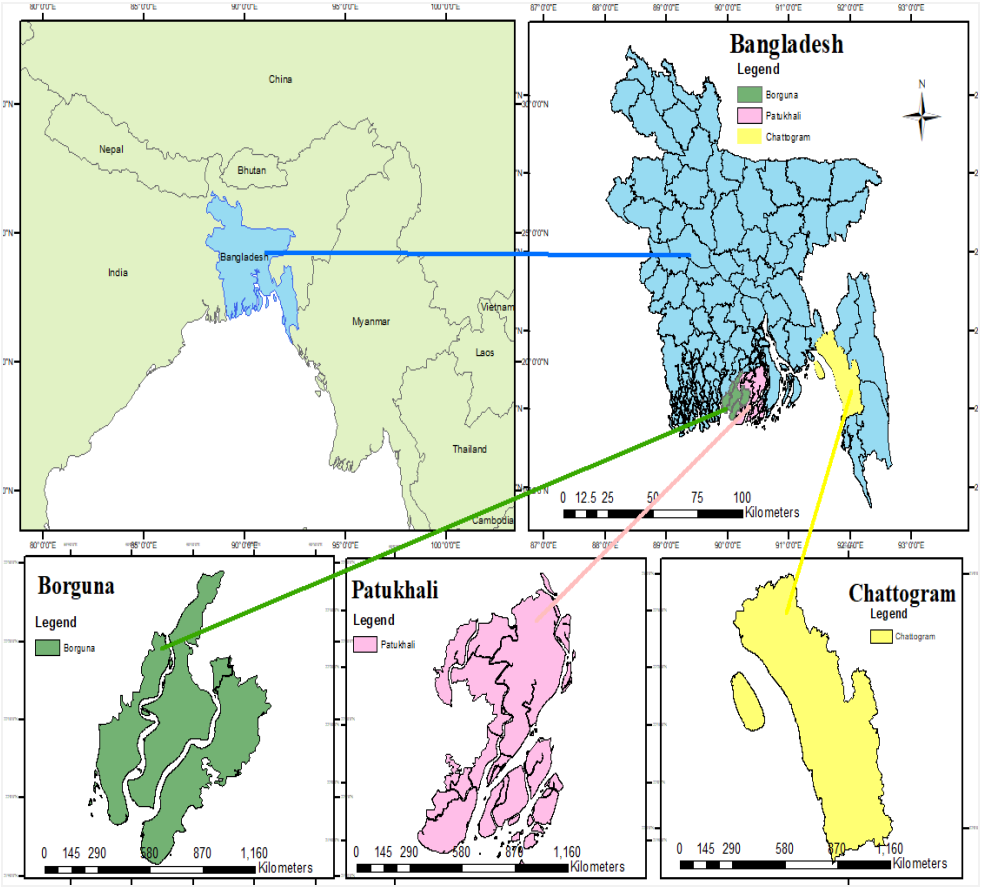

Fig. 1. Different colors indicate the location of three fish landing centers in Bangladesh

Procedural methods of data collection

The investigation focused on a fish landing center assessment that collected data from fish sellers, fishermen, operators (middlemen), and customers. Face-to-face interviews were conducted with a total of 330 (110 from each three landing centers) respondents for different aspects of fish biodiversity issues. The secondary data were also collected from the manager, respective fish landing centers along with the respective Upazila Fisheries Officer. To examine the diversity of fishes in the studied area, the study included trips to fish landing centers, photograph capture, interviews with local people, sampling, and secondary information collecting. The data were obtained using questionnaire-based conversations, participatory rural appraisals (PRA), and double-check discussions comprising significant informants. The questionnaire sheet was carried out by questioning the participants, aratdars (assemblers), and fishermen in the landing centers. All the collected information was evaluated, and the species identified at the landing sites were classified into several groups.

Collected sample identification

All fish and shellfish observed in the respective landing centers were carefully landed and documented. Important features including the local name, common name, picture, seasonal variability, and richness of all fishes were recorded for further evaluation and verification. Discussions and interactions were also conducted with local fishermen and commission agents to ask about seasonal fluctuation, availability, and customer requirement for the caught species. The species were subsequently recognized and thoroughly classified based on their morphometric and meristic traits. The varieties of fish found at the sampling sites were recognized employing morphometric and meristic features (Eschmeyer's Catalog of Fishes, California Academy of Sciences) **(Hussain, 2010; Van der Laan *et al.*, 2014)**. Following identification, fish species were comprehensively categorized based on the approach of **Bell (2006)** and **O'Hara *et al.* (2019)**.

Statistical data analysis

Following data collection, all the information was collected and coded in an MS Excel spreadsheet. The collected data were thoroughly reviewed and recorded cautiously before the actual tabulation. Finally, tables were generated in accordance with the current objectives. Data were provided in tabular format as it is straightforward to calculate, ordinarily utilized, and easy to comprehend. Following data gathering, it was validated to remove mistakes and ambiguity. Any discrepancies in the collected information were rectified and recorded. The data were analyzed and then evaluated by employing the tabular approach. Data from multiple appropriate approaches were formatted and put into a computerized method using Microsoft Excel 24 software.

RESULTS

Availability of fish species

The availability of fish species in three fish landing centers, especially in the three coastal districts obtained from the Bay of Bengal, Bangladesh is summarized in Table (1). A total of 152 species were documented, including 144 marine fish and 8 shellfish species. These species were categorized into 30 orders and 69 families, reflecting the rich diversity of the marine ecosystem. The predominant order of marine fish was Clupeiformes, comprising 18 species, closely succeeded by Siluriformes and Scombriformes, each with 18 and 16 species, respectively. In addition, several other significant orders, such as Eupercaria, Carangiformes, Cypriniformes and Gobiformes, each with 10 species, contributed substantially to the observed marine fish diversity. Moreover, some orders of fish were rarely found namely Decapoda (7 species), Acanthuriformes (5 species), Pleuronectiformes (4 species), Carangaria (4 species), and

Mugiliformes (6 species). The lowest orders were Beloniformes, Carcharhiniformes, Myliobatiformes, Tetraodontiformes, each with 3 species.

Conversely, certain orders exhibited lower species diversity, such as Beloniformes, Anguilliformes, Synbranchiformes, Anabantiformes, Aulopiformes, Perciformes, Syngnathiformes, Salmoniformes, Osteoglossiformes, Lophiiformes Ovalentari, Centrarchiformes, Cichliformes, Cyprinodontiformes, Myopsida each represented by only a few species. This detailed breakdown provides valuable insights into the abundance and distribution of marine fish and shellfish at the landing center. Furthermore, the predominant order of marine fish was Clupeiformes, comprising 18 species, followed closely by Siluriformes and Scombriformes, each with 18 and 16 species, respectively. In addition, several other significant orders, such as Eupercaria, Carangiformes, Cypriniformes and Gobiformes, each with 10 species, contributed substantially to the observed marine fish diversity. Besides, some orders of fish were rarely found namely Decapoda (7 species), Mugiliformes (6 species) Acanthuriformes (5 species), Pleuronectiformes (4 species), Carangaria (4 species) (Fig. 2).

Table 1. Availability of marine fish and shellfish species at three Fish Landing Centers in Bangladesh with their local name, common name, scientific name, order, demand and IUCN Red List status

SL No.	Local name	Common name	Scientific name	Order	Availability of fish species			Demand	IUCN red list status
					S_1	S_2	S_3		
			Fishes						
1	Balichata	Mottled loach	*Acanthocobitis botia*	Cypriniformes	-	-	+	High	LC
2	Kawa	Banded eagle ray	*Aetomylaeus nichofii*	Myliobatiformes	-	+	-	High	VU
3	Kartik	African pompano	*Alectis ciliaris*	Carangiformes	+	-	-	High	LC
4	Mola	Indian carplet	*Amblypharyngodon microlepis*	Cypriniformes	-	-	+	High	LC
5	Chacunda/ koiputi	Chacunda gizzard shad	*Anodontostoma chacunda*	Clupeiformes	+	-	-	High	LC
6	Bechi	Blue panchax	*Aplocheilus panchax*	Cyprinodontiformes	-	-	+	Medium	LC
7	Gagla	Gagora catfish	*Arius gagora*	Siluriformes	+	-	+	Low	NT
8	Ram kata	Spotted catfish	*Arius maculatus*	Siluriformes	+	-	-	Medium	NE
9	Gorala kata	Thickspined catfish	*Arius nenga*	Siluriformes	+	-	-	Medium	NE
10	Sia kata	Sona sea catfish	*Arius sona*	Siluriformes	+	-	-	Low	NE
11	Tak chanda	Cleftbelly travelly	*Atropus atropus*	Carangiformes	+	-	-	High	LC
12	Boma maitta	Bullet tuna	*Auxis rochei*	Scombriformes	+	-	-	High	LC
13	Maitta surma	Frigate tuna	*Auxis thazard*	Scombriformes	+	-	-	Low	LC
14	Bele	Scribbled goby	*Awaous grammepomus*	Gobiiformes	-	-	+	High	LC
15	Baila	Scribbled Goby	*Awaous guamensis*	Gobiiformes	+	-	-	High	LC
16	Kursha	Kalobans	*Bangana dero*	Cypriniformes	-	-	+	Low	LC
17	Hamiltoner koksha	Hamiltons barlia	*Barilius bendelisis*	Cypriniformes	-	-	+	Low	LC

18	Katabukha	Beardless sea catfish	*Batrachocephalus mino*	Siluriformes	-	+	-	High	NE
19	Kaikka	Garfish	*Belone belone*	Beloniformes	+	+	-	Medium	NE
20	Danchoukka	Oriental sole	*Brachirus orientalis*	Pleuronectiformes	+	-	-	Low	LC
21	Kathal Pata	Pan sole	*Brachirus pan*	Pleuronectiformes	-	-	+	Low	LC
22	Nuna bele	Bumblebee goby	*Brachygobius nunus*	Gobiiformes	-	-	+	Medium	NE
23	Kuil	Duckbill sleeper	*Butis butis*	Gobiiformes	+	+	-	Low	LC
24	Hangor	Blacktail reef shark	*Carcharhinus amblyrhynchos*	Carcharhiniformes	+	-	-	Low	EN
25	Chaga	Squarehead catfish	*Chaca Chaca*	Siluriformes	+	-	-	Low	LC
26	Lambu	Elongate glass-perchlet	*Chanda nama*	Ovalentaria	+	-	+	Low	LC
27	Potka	Milkspotted puffer	*Chelonodon patoca*	Tetraodontiformes	+	+	-	Low	LC
28	Korati chela	Dorab wolf-herring	*Chirocentrus dorab*	Clupeiformes	+	-	-	High	LC
29	Chitol	Clown knieffish	*Chitala chitala*	Osteoglossiformes	+	-	-	High	NT
30	Kaoa mach	Araucanian herring	*Clupea bentincki*	Clupeiformes	+	-	-	Low	LC
31	Olua	Goldspotted grenadier anchovy	*Coilia dussumieri*	Clupeiformes	+	+	+	High	LC
32	Rekha	Finger fish	*Coius quadrifasciatus*	Anabantiformes	-	+	-	Low	LC
33	Kamila	Indian pike conger	*Congresox talabonoides*	Anguilliformes	-	+	-	High	LC
34	Kukurjiv	Malabar tonguesole	*Cynoglossus macrostomus*	Pleuronectiformes	-	+	-	Low	VU
35	Moori	Hump-head	*Cyrtocara moorii*	Cichliformes	-	+	-	High	VU
36	Shapla pata mach	Pale edged sting ray	*Dasyatis zugei*	Myliobatiformes	+	-	+	Low	VU
37	Nilambori	Redtail scad	*Decapterus kurroides*	Carangiformes	+	-	-	Medium	LC
38	Nilambori	Shortfin scad	*Decapterus macrosoma*	Carangiformes	+	-	-	Medium	LC
39	Nilambori	Japanese scad	*Decapterus maruadsi*	Carangiformes	+	-	-	Medium	LC

40	Ek thouta	Wrestling halfbeak	*Dermogenys pusilla*	Beloniformes	-	-	+	Medium	DD
41	Bish tara	Concertina fish	*Drepane longimana*	Acanthuriformes	+	-	-	Low	NE
42	Pan mach	Spotted Sickle fish	*Drepane punctata*	Acanthuriformes	+	-	-	Low	NE
43	Chela/ Oceanic chapila	Rainbow sardine	*Dussumieria acuta*	Clupeiformes	+	-	-	High	LC
44	Kuli mach	Lutea sleeper	*Eleotris lutea*	Gobiiformes	+	-	-	Low	NE
45	Tailla mach	Four finger Threadfin	*Eleutheronema tetradactylum*	Carangaria	+	+	+	High	NE
46	Bol poa	Brownspotted grouper	*Epinephelus chlorostigma*	Perciformes	+	-	-	High	LC
47	Cuti Cuti	Conta Catfish	*Erethistes pusillus*	Siluriformes	-	-	+	Medium	LC
48	Oceanic moilla	White sardine	*Escualosa thoracata*	Clupeiformes	+	-	-	High	LC
49	Churi	Smallhead hairtail	*Eupleurogrammus muticus*	Scombriformes	+	-	-	High	NE
50	Hature Hangor	Hammer head shark	*Eusphyra blochii*	Carcharhiniformes	-	+	-	High	EN
51	Bom maitta	Kawakawa	*Euthynnus affinis*	Scombriformes	+	-	-	High	LC
52	Nuna Baila	Puntang goby	*Exyrias puntang*	Gobiiformes	+	-	-	Low	LC
53	Thuitta mach	Red cornetfish	*Fistularia villosa*	Syngnathiformes	+	-	-	High	LC
54	Gang Tengra	Indian gagata	*Gagata cenia*	Siluriformes	-	-	+	High	LC
55	Dome mach	Whipfin silver-biddy	*Gerres filamentosus*	Eupercaria	+	-	-	Medium	LC
56	Ghagra bele	Masked Goby	*Gobius personatus*	Gobiiformes	-	+	-	High	DD
57	Chapila	Ganges river gizzard shad	*Gonialosa manmina*	Clupeiformes	+	-	+	High	LC
58	Loitta	Bombey duck	*Harpadon nehereus*	Aulopiformes	+	+	+	High	NT
59	Ilish	Kelee shad	*Hilsa kelee*	Clupeiformes	+	-	-	High	LC
60	Shapla pata	Honeycomb stingray	*Himantura uarnak*	Myliobatiformes	-	+	-	High	EN
61	Chaukha	Coromandel ilisha	*Ilisha filigera*	Clupeiformes	+	-	-	High	DD

62	Chapila	Bigeye ilisha	*Ilisha megaloptera*	Clupeiformes	+	-	-	High	LC
63	Sal fish	Indo-Pacific sailfish	*Istiophorus platypterus*	Carangiformes	+	-	-	Low	VU
64	Poa	Silver croaker	*Johnius argentatus*	Eupercaria	-	+	-	High	LC
65	Koitor	Coitor croaker	*Johnius coitor*	Eupercaria	+	-	-	Low	LC
66	Rickshaw mach	Skipjack Tuna	*Katsuwonus pelamis*	Scombriformes	+	+	-	High	LC
67	Med	Bigmouth sea catfish	*Ketengus typus*	Siluriformes	-	+	-	High	NE
68	Bata	Bata	*Labeo bata*	Cypriniformes	-	-	+	Medium	LC
69	Bhangan	Boga labeo	*Labeo boga*	Cypriniformes	-	+	+	High	LC
70	Rui	Roho labeo	*Labeo rohita*	Cypriniformes	-	-	+	Medium	LC
71	Koral/Vetki	Barramundi	*Lates calcarifer*	Carangaria	+	+	+	High	LC
72	Gutum	Annandale loach	*Lepidocephalichthys annandalei*	Cypriniformes	-	-	+	Low	LC
73	Churi	Savalai hairtail	*Lepturacanthus savala*	Scombriformes	+	-	-	High	NE
74	Somudra koi	Triple tail	*Lobotes surinamensis*	Acanthuriformes	+	+	-	High	LC
75	Lal koral	Yellowstreaked snapper	*Lutjanus lemniscatus*	Eupercaria	+	-	-	High	LC
76	Tara baim	Lesser spiny eel	*Macrognathus aculeatus*	Synbranchiformes	+	-	-	High	LC
77	Kaowa mach	Torpedo scad	*Megalaspis cordyla*	Carangiformes	+	-	-	Medium	LC
78	Fattara mach	Humpback anglerfish	*Melanocetus johnsonii*	Lophiiformes	+	-	-	Low	LC
79	Kuirar Khil	Deocata pipefish	*Microphis deocata*	Syngnathiformes	-	-	+	Medium	NT
80	Parki mach	Flathead grey mullet	*Mugil cephalus*	Mugiliformes	+	+	-	High	LC
81	Kamila	Common pike conger	*Muraenesox bagio*	Anguilliformes	+	-	-	Low	LC
82	Ghulsha	Gangetic mystus	*Mystus cavasius*	Siluriformes	-	-	+	Medium	LC
83	Nuna Tengra	Long whiskers catfish	*Mystus gulio*	Siluriformes	+	-	+	High	LC
84	Tengra	Tengara catfish	*Mystus tengara*	Siluriformes	-	-	+	High	LC
85	Mat mach	Engraved catfish	*Nemapteryx nenga*	Siluriformes	+	-	-	High	NE
86	Batasi	Indian potasi	*Neotropius atherinoides*	Siluriformes	-	-	+	Medium	LC

87	Colombo	Pink salmon	*Oncorhynchus gorbuscha*	Salmoniformes	+	-	-	Medium	NE
88	Bamus	Bengal eel	*Ophisternon bengalense*	Synbranchiformes	-	-	+	Medium	LC
89	Poa mach	Pama croaker	*Otolithoides pama*	Eupercaria	+	-	+	High	DD
90	Foli chanda	Silver Pomfret	*Pampus argenteus*	Scombriformes	+	+	+	High	VU
91	Rupchanda	Chinese pomfret	*Pampus chinensis*	Scombriformes	+	+	-	High	NE
92	Pangas mach	Pangas catfish	*Pangasius pangasius*	Siluriformes	+	+	+	High	LC
93	Fhopa chanda	Himalayan glassy perchlet	*Parambassis baculis*	Perciformes	+	-	-	High	LC
94	Bashpata	Broad-mouthed mullet	*Paramugil parmatus*	Mugiliformes	+	-	+	Medium	LC
95	Kukur jeeb	Doublelined tonguesole	*Paraplagusia bilineata*	Pleuronectiformes	+	-	-	Low	LC
96	Kalo chanda	Black Pomfret	*Parastromateus niger*	Carangiformes	+	-	-	High	LC
97	Konkon	Eastern Pacific bonito	*Pelamys chiliensis*	Scombriformes	-	+	-	Medium	LC
98	Choukka	Indian pellona	*Pellona ditchela*	Clupeiformes	+	+	-	Low	LC
99	Kadi poa	Donkey croaker	*Pennahia anea*	Eupercaria	+	-	-	High	LC
100	Chikka mach	Longfin mojarra	*Pentaprion longimanus*	Eupercaria	+	+	-	High	LC
101	Parshe bata	Goldspot mullet	*Planiliza parsia*	Mugiliformes	+	-	-	Low	NE
102	Bata	Greenback mullet	*Planiliza subviridis*	Mugiliformes	+	-	-	High	LC
103	Gang Magur	Gray eel-catfish	*Plotosus canius*	Siluriformes	-	-	+	Medium	NE
104	Topshe	Paradise threadfin	*Polynemus paradiseus*	Carangaria	+	+	+	High	LC
105	Shada datina	spotted javelinfish	*Pomadasys hasta*	Eupercaria	+	+	-	High	NE
106	Boro kalo poa	Blackspotted croaker	*Protonibea diacanthus*	Eupercaria	+	-	-	High	NT
107	Chewa	Elongate mudskipper	*Pseudapocryptes elongatus*	Gobiiformes	+	-	-	High	LC
108	Chilik poa	Blotched tiger-toothed croaker	*Pterotolithus maculatus*	Eupercaria	+	-	-	High	LC

109	Mola punti	Glass-barb	*Puntius guganio*	Cypriniformes	-	-	+	High	LC
110	Kuna faissha	Raconda	*Raconda russeliana*	Clupeiformes	+	-	-	High	LC
111	Bhol	Trout brab	*Raiamas bola*	Cypriniformes	-	-	+	Medium	LC
112	Bora	Indian mackerel	*Rastrelliger kanagurta*	Scombriformes	+	+	-	High	DD
113	Khorsula	Corsula	*Rhinomugil corsula*	Mugiliformes	+	+	-	Low	LC
114	Rita	Rita	*Rita rita*	Siluriformes	+	-	-	High	LC
115	Jatrik mach	Indian oil sardine	*Sardinella longiceps*	Clupeiformes	+	-	-	Medium	LC
116	Bele	Greater lizard fish	*Saurida tumbil*	Aulopiformes	+	-	-	Low	LC
117	Dahuk	Walking goby	*Scartelaos histophorus*	Gobiiformes	+	+	+	Low	LC
118	Chitra.	Spotted scat	*Scatophagus argus*	Acanthuriformes	-	+	-	Medium	LC
119	Chapa mach	Barred queenfish	*Scomberoides tala*	Carangiformes	+	-	-	High	LC
120	Surma	King mackerel	*Scomberomorus cavalla*	Scombriformes	+	-	-	High	LC
121	Champa	Narrow-barred Spanish mackerel	*Scomberomorus commerson*	Scombriformes	+	+	-	High	NT
122	Maitta	Indo-Pacific king mackerel	*Scomberomorus guttatus*	Scombriformes	+	+	-	High	DD
123	Aila	Blackbanded trevally	*Seriolina nigrofasciata*	Carangiformes	+	-	-	Medium	LC
124	Faisa	Gangetic hairfin anchovy	*Setipinna phasa*	Clupeiformes	+	-	+	High	LC
125	Phasa	Scaly hairfin anchovy	*Setipinna taty*	Clupeiformes	+	-	-	High	LC
126	Kachki	Yellowtail mullet	*Sicamugil cascasia*	Mugiliformes	-	-	+	High	LC
127	Java	Streaked spinefoot	*Siganus javus*	Acanthuriformes	-	+	-	Medium	LC
128	Tular dandi	Flathead Sillago	*Sillaginopsis panijus*	Eupercaria	+	-	+	High	NE
129	Tular dandi	Flathead sillago	*Sillago domina*	Eupercaria	-	+	-	High	NE
130	Darkuta	Sawtooth barracuda	*Sphyraena putnamae*	Carangaria	+	-	-	High	NE
131	Korati mach	Scoophead	*Sphyrna media*	Carcharhiniformes	+	+	-	Low	CR
132	Chunobele	Bearded worm goby	*Taenioides cirratus*	Gobiiformes	+	-	-	Medium	DD

133	Ilish	Hilsa shad	*Tenualosa ilisha*	Clupeiformes	+	+	+	High	LC
134	Chandona ilish	Toli shad	*Tenualosa toli*	Clupeiformes	+	+	+	Low	VU
135	Barguni	Jarbua terapon	*Terapon jarbua*	Centrarchiformes	-	+	+	High	LC
136	Thapa	Ocellated puffer fish	*Tetraodon cutcutia*	Tetraodontiformes	-	-	+	Low	LC
137	Potka	Green pufferfish	*Tetraodon fluviatilis*	Tetraodontiformes	-	-	+	Low	LC
138	Madhu faissha	Longjaw thryssa	*Thryssa setirostris*	Clupeiformes	+	-	-	High	LC
139	Tuna	Yellowfin tuna	*Thunnus albacares*	Scombriformes	-	-	+	High	LC
140	Tuna	Bigeye tuna	*Thunnus obesus*	Scombriformes	+	-	-	High	VU
141	Churi	Largehead hairtail	*Trichiurus haumela*	Scombriformes	-	+	-	High	LC
142	Chuna kholisa	Honey gourami	*Trichogaster chuna*	Anabantiformes	-	-	+	Medium	LC
143	Boal	Wallago	*Wallago attu*	Siluriformes	-	-	+	High	VU
144	Kakila	Freshwater garfish	*Xenentodon cancila*	Beloniformes	-	-	+	Medium	LC
			Shellfish						
1	Golda chingri	European lobster	*Homarus gammarus*	Decapoda	+	+	-	High	LC
2	Maya mach	Cuttle fish/Squid	*Loligo vulgaris*	Myopsida	+	+	-	Low	DD
3	Golda Chingri	Giant freshwater prawn	*Macrobrachium rosenbergii*	Decapoda	+	+	+	High	LC
4	Loilla Chingri	Yellow shrimp	*Metapenaeus brevicornis*	Decapoda	+	-	-	High	LC
5	Guraicha	Karnafuli shrimp	*Palaemon karnafuliensis*	Decapoda	+	-	-	High	LC
6	Lobster	Mud Spiny Lobster	*Panulirus polyphagus*	Decapoda	-	-	+	High	LC
7	Shada icha	Indian prawn	*Penaeus indicus*	Decapoda	+	+	-	High	LC
8	Bagda chingri	Giant tiger prawn	*Penaeus monodon*	Decapoda	+	+	+	High	LC

Note: S_1: Chattogram Fish Landing Center, Chattogram; S_2: Alipur and Mahipur Fish Landing Center, Patuakhali; S_3: Pathorghata Fish Landing Center, Borguna; + = present; - = absent; LC= Least Concern; NE= Not Evaluated; NT= Near Threatened; VU= Vulnerable and DD= Data Deficient.

Fig. (2) also indicates that the lowest orders of species are notably, Beloniformes, Carcharhiniformes, Myliobatiformes, Tetraodontiformes, each with 3 species. Conversely, certain orders exhibited lower species diversity, such as Beloniformes, Anguilliformes, Synbranchiformes, Anabantiformes, Aulopiformes, Perciformes, Syngnathiformes, Salmoniformes, Osteoglossiformes, Lophiiformes, Ovalentari, Centrarchiformes, Cichliformes, Cyprinodontiformes, Myopsida each represented by only a few species. This detailed breakdown provides valuable insights into the abundance and availability of marine fish and shellfish in the landing center.

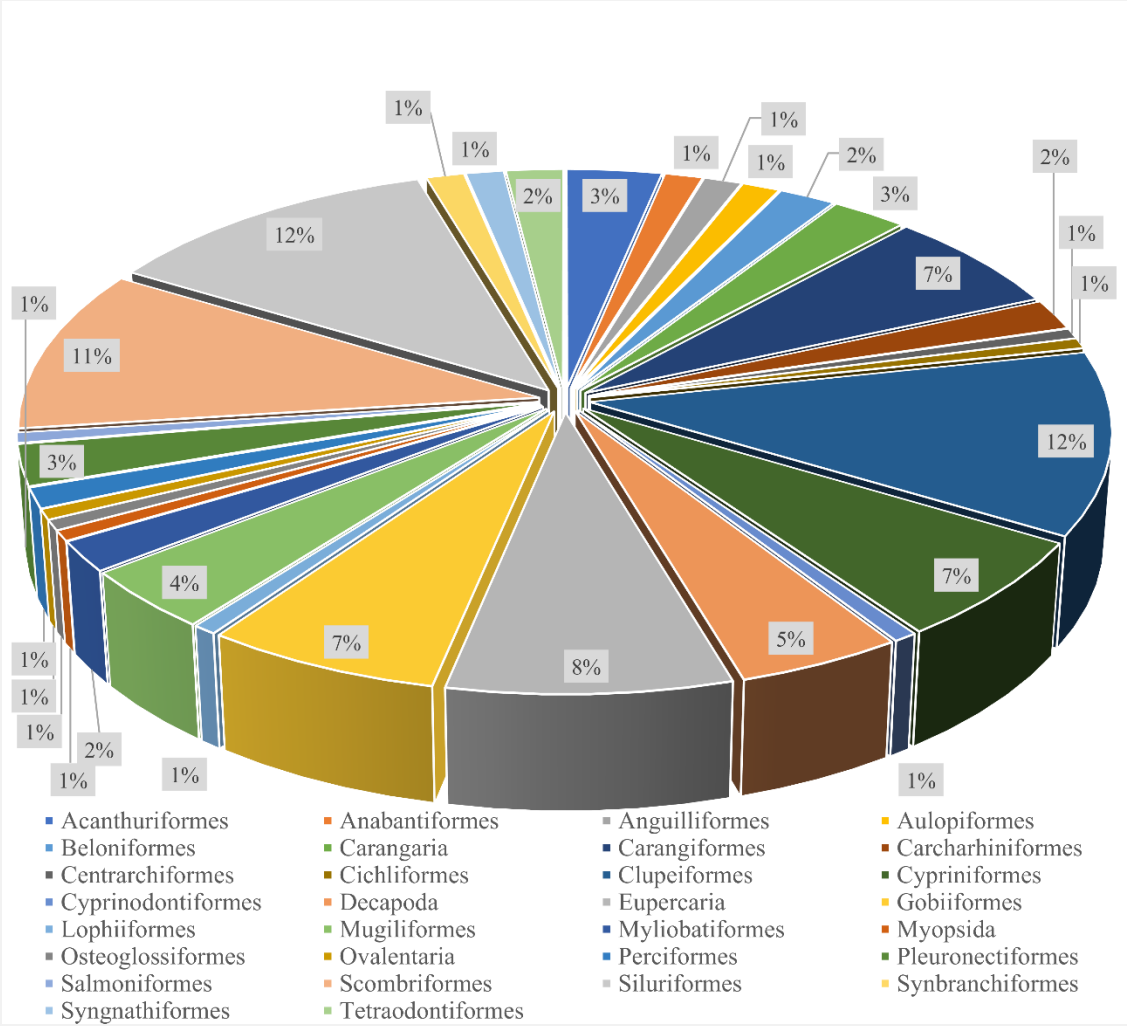

Fig. 2. Total percentage of available marine fish and shellfish in various orders in the fish landing center

In the Chattogram Fish Landing Center, a notable presentation of 104 species was documented, encompassing 97 marine fish species and 7 shellfish species. The Patuakhali sites exhibited a total of 48 species, inclusive of 43 marine fish species and 5 shellfish species (Fig. 3). Lastly, the Borguna Fish Landing Center featured an array of 53 species, including 50 marine fish species and 3 shellfish species. The highest percentage of fish diversity was the highest observed in all three fish landing centers than shellfish species. These highest percentage indicated that the sea going fishers catch bulk compositions of fish species rather than shellfish. This cause may be due to the different factors like market demand, ease to icing and handling in the sea, among others.

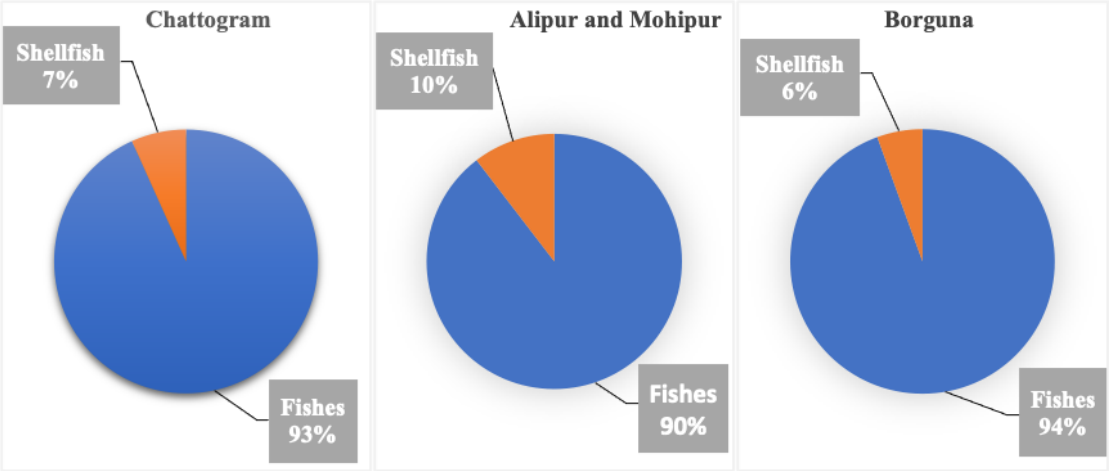

Fig. 3. Comparison of fish and shellfish availability of three fish landing centers in Bangladesh

Availability of commercial and non-commercial fish

Fig. (4) reveals that the availability of fish species observed from three different fish landing centers were categorized based on their commercial values. Across these centers, a total of 55 species were recognized as commercially significant including *Tenualosa Ilisha, Lates calcarifer, Pampus argenteus, Pangasius pangasius, Polynemus paradiseus, Harpadon nehereus, Coilia dussumieri, Eleutheronema tetradactylum, Macrobrachium rosenbergii,* and *Penaeus monodon,* while 97 species were categorized as non-commercial. Specifically, in the Chattogram Fish Landing Center, 46 commercially important species and 58 non-commercial species were recorded. In the Patuakhali Fish Landing Center, 27 species were deemed commercially important, and 21 were non-commercial. Lastly, in the Borguna Fish Landing Center, 20 species were identified as commercially important, and 34 were labeled as non-commercial.

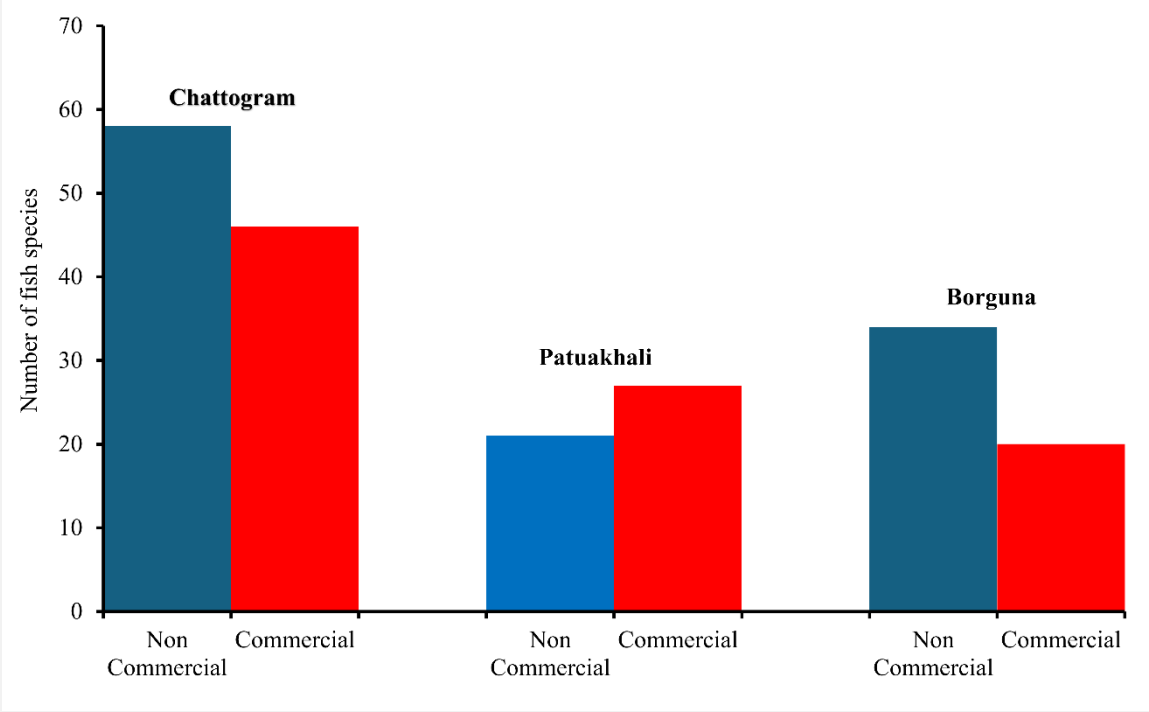

Fig. 4. Comparison of the commercial and non-commercial marine fishes among the landing centers

IUCN red list status

The global IUCN Red List was categorized into seven (7) types, and the recorded marine species observed in the three-landing center demonstrated that 68% species were dominated as Least Concern, 14% were Not Evaluated, 4% were Near Threatened, 5% were Data Deficient and 6% were Vulnerable, 1% were Critically Endangered, 2% were Endangered (Fig. 5). The Near Threatened species were *Arius gagora*, *Chitala chitala*, *Harpadon nehereus*, *Microphis deocata*, *Protonibea diacanthus* and *Scomberomorus commerson*, while the Vulnerable species were *Aetomylaeus nichofii*, *Thunnus obesus*, *Dasyatis zugei*, and *Pampus argenteus*.

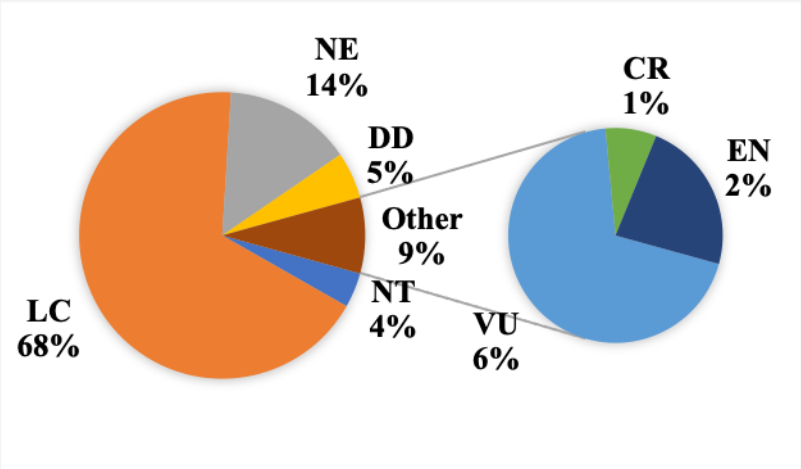

Fig. 5. Different colors indicate the percentage of the IUCN Red List status from the present study

Common fish and shellfish species

In three fish landing centers, two common shellfish species were found: *Macrobrachium rosenbergii* and *Penaeus monodon*, as shown in Fig. (6). On the other hand, the ten common fish species were *Coilia dussumieri*, *Eleutheronema tetradactylum*, *Harpadon nehereus*, *Lates calcarifer*, *Pampus argenteus*, *Pangasius pangasius*, *Polynemus paradiseus*, *Scartelaos histophorus*, *Tenualosa ilisha*, and *Tenualosa toli*.

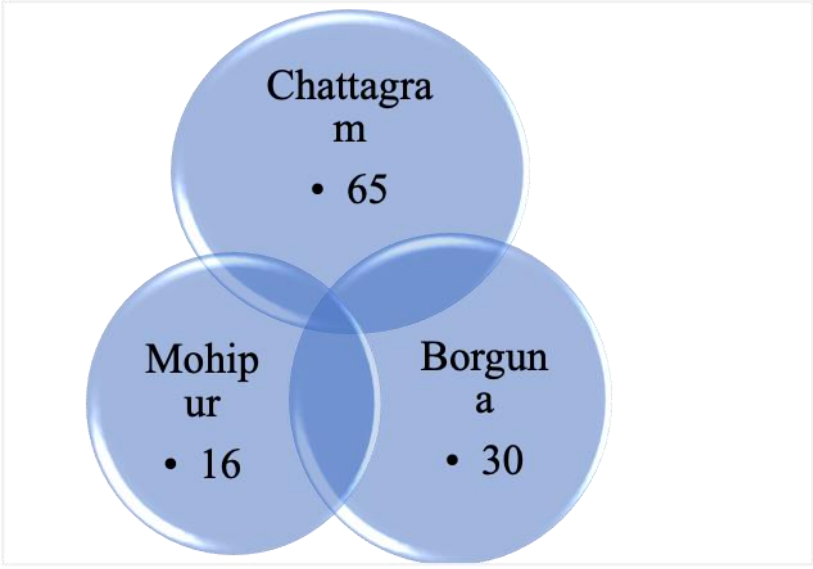

Fig. 6. Common fish and shellfish species in three fish landing centers, Bangladesh

Consumer demand

The study conducted in three fish landing centers revealed that 41% of the marine fish species were classified as having a high demand, 32% were considered to have a medium demand, and 27% were categorized as having a low demand (Fig. 7). The high demand category comprised 46 different fish species including *Tenualosa Ilisha, Lates calcarifer, Pampus argenteus, Pangasius pangasius, Polynemus paradiseus, Harpadon nehereus, Macrobrachium rosenbergii,* and *Penaeus monodon.* The medium demand category included 36 species, and the low demand category encompassed 30 species. In addition, all the recorded shellfish including saltwater shrimp and prawn were highly demanded by the consumers.

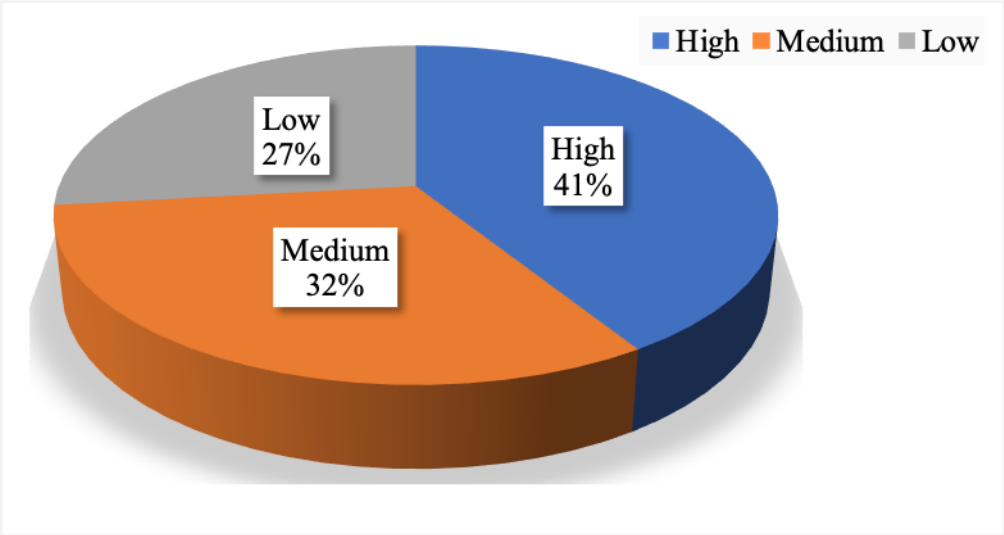

Fig. 7. Different colors indicate the consumer demand of marine fish and shellfish species

DISCUSSION

The studied fish landing center recorded a total of 152 marine species, comprising 144 marine fish species and 8 shellfish species. The current study strongly corroborates the findings of **Ahsan *et al.* (2014)**, who highlighted the abundance of fish diversity in the Patuakhali landing centers, Bangladesh. They reported a total of 138 fish species at the Patuakhali fish landing center. Although, **Roy *et al.* (2020)** found a total of 60 species from Shibsa River, Paikgachha, Bangladesh. In addition, **Islam *et al.* (2015)** reported 114 fish species belonging to 12 orders, 36 families were collected and identified in Payra River, Patuakhali, Bangladesh. The vicinity of the Patuakhali fish landing center, located near the confluence of the Payra River and the Bay of Bengal, revealed a total of 61 species, comprising 56 finfish and 5 shellfish species, belonging to 22 families and 11 orders **(Rahat *et al.*, 2022)**. Additionally, a total of 138 freshwater, brackish, and marine fish and shellfish species were reported, of which 126 were finfish and the remaining 12

were crustaceans **(Siddique *et al.*, 2016)**. In contrast, **Kamal *et al*. (2022)** recorded a total of 54 species in the Cox's Bazar BFDC landing center in Bangladesh, consisting of 42 marine fish species and 7 shellfish species. The predominant orders were Perciformes (56%), Scombriformes (17%), and Clupeiformes (10%), a result which is lower than the finding of the present study. The current findings also differ from those of **Rahman *et al*. (2019)**, who recorded only 33 fish species at Basurabad Beel in Bangladesh. These discrepancies may be attributed to factors such as fishing seasons, species availability, the duration of fishing trips, fishing gear used, and other variables.

The **IUCN (2021)** categorized marine fish and shellfish species observed in the landing centers as follows: Least Concern, Not Evaluated, Near Threatened, Data Deficient, Vulnerable, Critically Endangered, and Endangered. Notable species in the Near Threatened category include *Arius gagora*, *Chitala chitala, Harpadon nehereus, Microphis deocata, Protonibea diacanthus,* and *Scomberomorus commerson.* The Vulnerable category includes *Aetomylaeus nichofii, Thunnus obesus, Dasyatis zugei*, and *Pampus argenteus.* The current study revealed that, of 152 fish species from 69 families, 106 were least concerned, 22 were not evaluated, 8 were data deficient and vulnerable, and 6 were neatly threatened. These findings are more significant compared to those of **Rubel *et al.* (2022)**, who reported on the fish biodiversity in Galachipa River, Bangladesh. Although **Kamal *et al.* (2022)** found that higher than 56% of the total fish diversity were categorized as Least Concern, nearly 10% were classified as Near Threatened and 2% were marked Vulnerable. These findings are consistent with the present findings. Furthermore, **IUCN (2021)** indicates that while the overall production of the Bombay duck (*Harpodon nehereus*) has doubled over the past twenty years, its proportion of the total fish production has experienced a slight decline. Specifically, it decreased from 1.79% in the period of 2002–2003 to 1.55% in 2018–2019.

The landing center study observed 3 endangered species, accounting for 2% of the total observed species, demonstrating a high level of conservation concern. In addition, 9 vulnerable species, making up 6% of the observed species, were noted, highlighting the need for proactive conservation efforts. The study also recorded 103 least concerned species, comprising 68% of the observed species, indicating a relatively stable population. Furthermore, 6 near threatened species, representing 4% of the observed species, and 22 species that have not been evaluated, accounting for 14% of the observed species, were documented. Notably, the IUCN Red List status of **Bangladesh (2000)** identifies three species as endangered, and these species were found in substantial quantities at the fish landing center. This finding underscores the urgent need for conservation measures, as these species are declining due to overexploitation. Comparative analysis revealed that the study conducted by **Rahman *et al.* (2015)** reported 7 endangered, 7 vulnerable, and 2 critically endangered species in the Rabnabad channel, indicating a lower count compared to the present study. Similarly, the research by **Galib *et al.* (2013)** documented 10 endangered, 6 critically endangered, and 10

vulnerable species from the Choto Jamuna River, highlighting a higher count than the current study. These comparisons provide valuable insights into the availability and IUCN status of endangered and vulnerable species across different locations.

In three fish landing centers, 41% were high demand of marine fish species, 32% were medium demand of marine fish species, and 27% were low consumer demand of marine fish species. The number of high demand fish species was 46 species, medium demand fish species was 36 and low demand fish species was 30. The demand for certain marine organisms (i. e., *Tenualosa ilisha*) from customers was relatively high all the year round. These demand for fish primarily depends on special aspects such as fish kind, quality, fish price, consumer income, and flavor **(Dey *et al.*, 2008; Rahman *et al.*, 2012)**. Consumer demand for marine fishes is generally lower than for freshwater fishes, possibly due to higher pricing and reduced availability in domestic markets, while demand for hilsa is evermore significantly higher owing to its mouth-watering taste and traditional uses in our country **(Kamal *et al.*, 2022)**. Although, **Barua *et al.* (2014)** stated that due to the over exploitation of human, fishermen caught a total of 152 species as commercial important fish species, along with the by-catches species from the Bay of Bengal. The demand for fish is primarily triggered by some common factors, such as consumer income, incoming black fish in the market, paucity in the peak seasons, low catch compositions, etc. **Dey *et al.* (2008)** argued that the earnings flexibility of all fish kinds continuously declines as per capita family investments rises, even though none of the fish types become worse goods in the highest income quartile.

The presence of several commercially important species, such as the Wallago attu, *Tenualosa ilisha*, and *Penaeus monodon*, highlights the economic significance of these aquatic resources **(Hossain, 2001)**. However, the study also identified several species with threatened conservation status, including the Vulnerable *Wallago attu* and *Tenualosa toli*, and the Endangered *Eusphyra blochii* **(IUCN, 2021)**. The prevalence of threatened species underscores the need for effective management and conservation strategies to protect these vulnerable populations.

The observed differences in species availability and demand across the three sampling stations suggest spatial variations in habitat quality and anthropogenic pressures. For instance, the higher availability of species at Station 3 may be attributed to the relatively less disturbing nature of this location, which is situated in a more remote area compared to the other two stations. In contrast, the lower availability of species at Stations 1 and 2 could be linked to factors such as habitat degradation, overfishing, and pollution, which are common issues in more urbanized and industrialized areas **(Hossain *et al.*, 2001)**.

CONCLUSION AND RECOMMENDATIONS

The present study noted that multiple elements, such as the type of fish, availability, commercial status, consumer tastes, and income levels, impacted the presence of marine fish in the landing centers. Conversely, the factors shaping consumer demand for fish included the variety of fish, cost, preferences, income, and flavor. Notably, the demand for certain key marine fish like hilsa was directly linked to their availability. However, this pattern did not hold for less conventional marine species like octopus and crab, which, despite their significant export value, saw erratic consumer demand. The research also referenced the IUCN Red List, which freaks a pivotal role in determining the conservation status of various common and large fish species, pinpointing those that are at risk of endangerment or vulnerability. The research underscores the urgent need for effective conservation strategies to protect vulnerable and endangered species, as identified by the IUCN Red List. It advocates for sustainable fishing practices, habitat restoration, and community involvement in conservation efforts to ensure the sustainable viability of fish availability. Furthermore, ongoing monitoring and research are essential to adapt management strategies to changing environmental and market conditions. Considering consumer tastes and the market's valuation, as well as the broader goal of preserving the diversity of fish species, it is imperative to safeguard these threatened species from extinction. Moreover, understanding the patterns of species availability can inform us about peak seasons, shifts in demand, and the necessary measures for effective conservation management of these marine beings. Overall, the study emphasizes the importance of balancing economic interests with ecological sustainability to preserve the rich biodiversity of marine resources in Bangladesh, ultimately contributing to food security and the livelihoods development of local communities.

Based on the study's findings and the conservation status of fish species in three Fish Landing Center, below are some management and conservation recommendations:

1. Specific regions within the south-central coastal district should be designated as protected zones to conserve the habitats of endangered and vulnerable fish species.
2. Enforce and improve existing environmental laws and regulations to prohibit unlawful activities including deforestation, sand mining, and pollution on riverbanks and in neighboring areas.
3. Encourage the use of sustainable fishing methods, such as controlled seasons, catch caps, and gear limitations.
4. Raise awareness among local people about the value of biodiversity and sustainable river management practices.
5. Develop climate change adaptation strategies that consider potential impacts on river biodiversity, such as altered water flow patterns and increased temperatures.

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AUTHORSHIP CONTRIBUTIONS

Md. Mahmudul Hasan: Data collection, Formal analysis, Methodology, Writing-original draft, review & editing. **Newton Saha:** Formal analysis, Methodology, Writing-original draft, review & editing. **Pranta Saha:** Formal analysis, Writing-original draft, Writing -review & editing. **Abdullah-Al- Hasan:** Formal analysis, Writing-original draft, Writing - review & editing. **Tania Tabassum:** Formal analysis, Writing-original draft, Writing - review & editing. **Md. Sazedul Hoque:** Investigation, Writing- original draft, writing- review & editing. **Suprakash Chakma:** Conceptualization, Investigation, Methodology, Formal analysis, Writing-original draft, Writing- review & editing.

DECLARATION OF INTEREST

The authors declare no conflicts of interest in the current study.

ETHICS APPROVAL STATEMENT

This research work has been approved by Patuakhali Science and Technology University's Institutional Ethical Committee (IEC) with the number PSTU/IEC/2023/73. Participants in this study were informed about the research goal, data utilization, and potential risks. They were given the option to ask questions and could withdraw at any time. Before inclusion, we received written informed consent. Privacy rights were scrupulously enforced, and acquired data were anonymized to prevent individual identity. Confidentiality and security procedures were implemented to protect the data.

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