INT. J. BIOL. BIOTECH., 20 (2): 365-377, 2023.

CONVERSION OF GILLNET TO LONGLINE FISHING: A STRATEGIC MODIFICATION TO MINIMIZE IMPACT OF FISHING OPERATIONS ON THE MARINE ECOSYSTEM

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ABSTRACT

Various types of gillnet are being used in coastal and offshore areas of Pakistan especially small scale fisheries of the country are predominantly depend on gillnet fishing operation in the Indus Delta, creeks systems, lagoons or shallow waters along the coast of Pakistan. Gillnets are known to be marred with high bycatch of non-target species including non-target fish species as well as endangered, protected and threatened species, even including turtles, dolphins and whales. In order to minimize the negative impact on the marine ecosystem, 7 pelagic gillnet fishing vessels based in Rehri, Karachi were converted to bottom-set longline fishing operations. A comparison of data of two modes of fishing was made which indicates that in the longlining operations catch of non-target species is almost eliminated whereas target species which includes daggertooth pike conger (*Muraenesox cinereus*), sea catfish (Family Ariidae) and spinycheek grouper (*Epinephelus diacanthus*) are dominated the catch. In gillnet operations, Indian mackerel *(Rastrelliger kanagurta*) is the dominating species whereas a number of non-target species also contribute substantially to the total catche. Present paper provides details of both fishing operations including fishing areas, soak time, catch composition and catches per unit effort.

Key words: Pelagic gillnet, bottom-set longline, catch composition, fishing areas, catch per unit effort, Rehri, Pakistan, northern Arabian Sea, *Muraenesox cinereus, Rastrelliger kanagurta*

Abbreviations:
ETP = Endangered, Protected and Threatened; OAL = Overall Length; IPC = Insulated Plastic Containers; GPS = Global Positioning System; CPUE = Catch Per Unit Effort.

INTRODUCTION

Although a variety of fishing gears are being used for catching fish in coastal and offshore waters of Pakistan, but gillnetting is the most popular method of catching fish in Pakistan (Hussain and Aamir, 2006). Many different types of gillnets based mainly on type of material and mode of operation are being used in Pakistan (Baloch *et al*., 2018; Khan, 1994; Siddiqui, 1956; Sorley, 1932). Monofilament pelagic gillnet became the most popular fishing gear since 1999 when targeted Indian mackerel (*Rastrelliger kanagurta*) fishery was started in Pakistan. Since then monofilament gillnets are used in almost all coastal villages of Pakistan using small and medium sized fishing crafts. Gillnets are known for high catch of no-target fish species as well as endangered, protected and threatened (ETP) species that may include turtles, dolphins and whales (Moazzam and Nawaz, 2014; Nawaz and Moazzam, 2014). In order to minimize or eliminate catch on non-target species various methods can be used including use of subsurface gillnetting (Kiszka, *et al*., 2021; Moazzam, 2021) or alternate fishing operations (for example longlining). Shifting from gillnetting to longlining is one such option which enables fishermen to catch high price target fish but also reduce bycatch of non-target species, therefore, negative impact of fishing on the ecosystem is minimized.

Rehri is a small coastal town in Karachi District Malir, Pakistan where a major population is engaged in fishing mainly gillnetting and other related trades. It is estimated that about 700 fishing boats locally known as "hora" (*sensu* Hussain and Aamir, 2006) are being used for catching mainly Indian mackerel by using pelagic monofilament gillnets. No estimates of landings, catch or bycatch of these fishing vessels is available, as there is no official data collection system exists in the area. A major part of catch of Indian mackerel is exported in frozen form, however, because of inadequacies in onboard handling and storage, a substantial part of the catch gets unfit for export and hence, used as a raw material for fishmeal. Additionally some other species which are caught in monofilament gillnet fisheries such as Indian scads are

exclusively used as raw material for fishmeal production. In order to minimize the wastage of the catch due to poor handling and inadequate storage and eliminate catch of non-target species including that of endangered, protected and threatened species, some selected boats from Rehri were converted to use bottom-set longlines. These fishing vessels were operated on quasi-commercial basis and data from each deployment of gillnet and longline was recorded separately, however, for analysis data for different years are pooled. Present paper provides information about both gillnet and longline fishing operations including fishing grounds, catch composition and catch per unit effort.

MATERIAL AND METHODS

Gillnetting which is the most common fishing gear being used in Pakistan is mainly operated through the "Hora" category of fishing boat (known as "Rachin" along Balochistan coast). These wooden boats are small, double-edged and are used in traditional fishing practices (Fig. 1). Overall length (OAL) of these boats ranges between 9.5 m to 14.5 m with a beam length between 3.2 to 5.4 m and are powered by longtail engines with capacity of 120 to 160 hp. There is no onboard facility for the perseverance of fish, therefore, the catch is kept below deck without ice. Some fishing boats, however, have either insulated plastic containers (IPC) or have in-built insulated holds for keeping fish with ice. Usually these boats are employed for 1 to 10 days fishing trips and operations of these boats are confined to the Indus Delta, its creeks systems, lagoons and shallow waters along the coast of Sindh and Balochistan.

Fig. 1. A typical "hora" boat being used for gillnet fisheries.

Fig. 2. A "hora" boat modified for operation of longline fishing. Installed line hauler is visible in the photo.

Considering high bycatch of non-target species, gillnet operations are considered to be not friendly for the ecosystem health. It was, therefore, decided to modify a few gillnets into longliners (Fig. 2). For this modification, a total; of 15 boats were provided with longliing gears including a net hauler, a GPS/fish-finder, main-line, branch lines, hooks as well as insulated plastic containers (IPC) for keeping the

catch. For fishing, these converted longline boats normally deploy 4,000 to 5,000 hooks which are baited with sardines or mullets. The baited lines are laid down in the evening whereas these were hauled in the morning. For the present study, data is recorded from only 7 fishing boats, on each of which an observer was deputed to record information about fishing operation. Information about catch of each fish species is separately recorded.

As a control, a vessel of the same configuration with pelagic monofilament gillnets is used whereas its mode of operation is generally the same. An observer was also deputed on this gillnet vessel to record data of the fishing operation. A comparison of the catch of gillnet vessel is made with the average catch of 7 longline vessels which includes fishing grounds, fish catch, catch per unit effort and other parameters. Data from gillnet boat was collected during November 2019 and February 2021 whereas data from longline boats was collected for the period between November 2018 and February 2021. Data for gillnet and longline fishing vessels for each moth is separately pooled for the analysis.

RESULTS AND DISCUSSION

Gillnetting and longlining are important traditional fisheries of the coastal areas of Pakistan, however, escalated demand of a particular species may lead to an increase in fleet engaged in that fishery. Because of the increase in demand of Indian mackerel since 2000, a major part of the fleet in coastal areas has started exploiting this schooling fish using monofilament net. Longline fishing method is used only by a few fishing boats and that too in a particular season. No previous information about the catch composition and other details of two fisheries from the coastal area of Pakistan is available.

Fig. 3. Catch of gillnet operation consisting mainly of the Indian mackerel.

Species Composition

During the fishing operations of both gillnets and longlines a number of species of fishes and shellfishes were caught. The catch on board these vessels was kept with ice and landed in chill form. Fishermen are familiar with the fishing grounds through their traditional knowledge, therefore, operated in specific areas which are known as important fishing grounds for operation of gillnets or longlines.

Gillnet Operations: Monofilament gillnet was used to target small pelagic species mainly Indian mackerel (*Rastrelliger kanagurta*) which was the most dominating species caught in this fishing gear (Fig. 3). During the study period 23 species of fishes and shellfishes (shrimp and crabs) were caught. Fig. 4 shows the percentage composition of 10 dominating species caught in the gillnet operations along Pakistan coast. Indian mackerel was recorded to be the most dominating species which contributed about 54 % followed by Indian scad (*Decapterus russelli*) that contributed about 10 %. Tiger-toothed croaker (*Otolithes ruber*), sin croaker (*Johnius dussumieri*) and Savalai ribbonfish (*Lepturacanthus savala*)

contributed about 10 %, 8 % and 6 % respectively whereas other species including miscellaneous fishes (Teleost), three spotted swimming crab (*Portunus sanguinolentus*) and jarbua terapon (*Terapon jarbua*) contributed 4, 3 and 2 %, respectively. Sawtooth barracuda (*Sphyraena putnamae*) and spotted seerfish (*Scomberomorus guttatus*) contributed mere 1 % whereas other 13 species contributed less than 1 %. There were spatial and temporal (seasonal) changes in the composition of the fish and shellfish in the catches of gillnets. The catch of these gillnets is an important source of raw material for export such as Indian mackerel, three-spotted swimming crab and groupers whereas other fishes are locally consumed or used as raw material for fishmeal production (such as Indian scads).

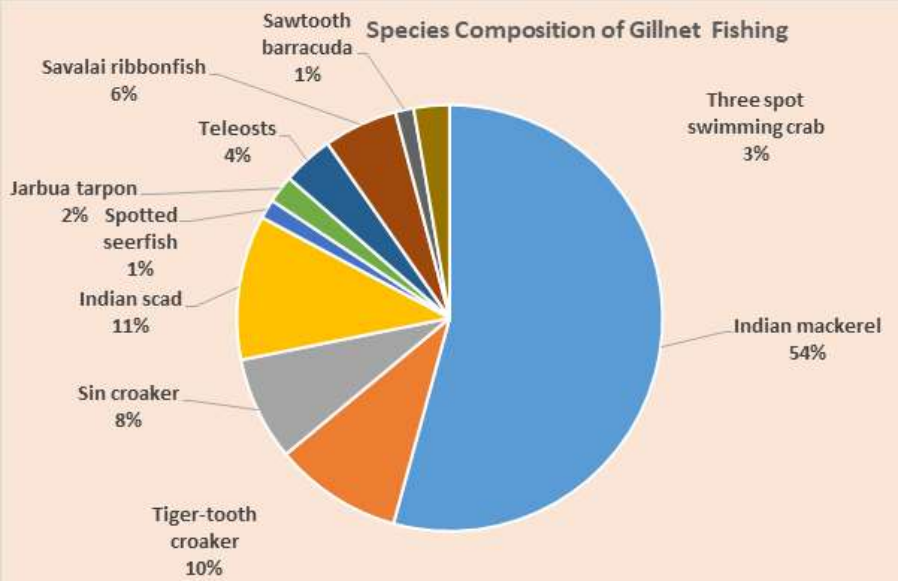

Fig. 4. Percentage composition of 10 dominating species in gillnet catches (pooled data)

Fig. 5. (a) Longline line being hauled with a daggertooth pike conger; (b) typical catch of one haul of longline operation showing daggertooth pike congers

Longline Operations: Longline is used to target demersal species mainly daggertooth pike conger (*Muraenesox cinereus*) which fetches high prices in the local market (Fig. 5). During the study period 26 species of fishes were caught in the longline operation along the coastal waters of Pakistan. Fig. 6 shows the percentage composition of 10 dominating species caught in the longline operations. In longline operations, daggertooth pike conger was the target species, as it fetched high prices in the local and export market. This species contributed about 65 % of the total catch of longline operations; of which 48 % is contributed by large-size daggertooth pike conger whereas small sized congers contributed about 17 %. Sea catfishes (Family Ariidae), spinycheek grouper (*Epinephelus diacanthus*) and cobia (*Rachycentrum canadum*) contributed 14 %, 7 % and 6 % respectively. Grunts (*Pomadasys spp.*), large groupers (dominated by *Epinephelus malabaricus*) and requiem sharks (*Carcharhinus spp.*) contributed 3 %, 2 % and 2 % respectively whereas stingrays (*Himantura spp.*) and sin croaker (*Johnius dussumieri*) each contributed about 1 %. Remaining 16 species contributed insignificant in the total catches of the longline

operations. Like catches of gillnet, marked spatial and temporal variation in contribution of each species was noticed during the study.

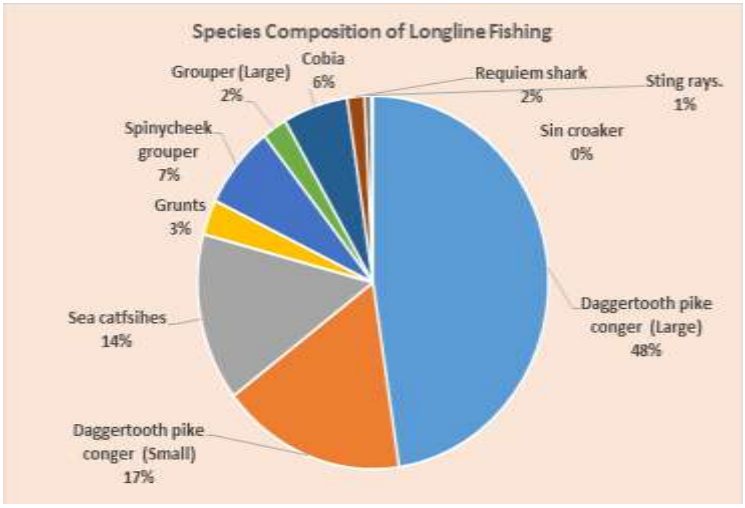

Fig. 6. Percentage composition of 10 dominating species in longline catches (pooled data).

Fishing Grounds

Fishing including both gillnetting and longlining is carried out along the coast of Pakistan depending on the target species. In case of traditional gillnet fisheries, Indian mackerel (*Rastrelliger kanagurta*) is the main target species which inhabit coastal waters mainly along the south of creeks of the Indus Delta and shallow coastal waters along the continental shelf of Pakistan. Main fishing grounds for gillnet fisheries are located on the mouth of large creeks such as Kahjar, Sir, Kahir, Wari, Chhan, Khuddi, Korangi and Pitiani creeks along Sindh and along Sapat, Phor and Sonmiani areas along Balochistan coast (Fig. 7).

Daggertooth pike conger (*Muraenesox cinereus*), especially large-sized specimens, are main target species of the longline fisheries. Traditional longlining for this species is undertaken in comparatively deeper waters along Balochistan coast mainly in, Sonmiani, Phor, Sapat and Kund Malir areas along Balochistan coast as well as in the offshore waters along the mouth of Phitti, Khajar, Ghora Bari and Indus Swatch areas. The location of fishing areas for gillnet and longline are mainly dependent on the seasonal abundance of the target species and mainly selected based on traditional knowledge.

Fig. 7. Major fishing grounds along Sindh and Balochistan coasts

A marked seasonal variation in the fishing grounds for longlining and gillnetting was observed during present study. All fishing vessels that were used for collection of data were provided with satellite based GPS (Global Positioning System), therefore, location of each fishing station for both gillnet and longline operations was recorded. The data of fishing areas are plotted for the gillnet and longline (Fig. 8) which indicates locations of the fishing areas during different months of the year. It was noticed that October to December were the peak season for both gillnetting and longlining which were carried out in a wider area between the Indus Swatch and Sonmiani Bay.

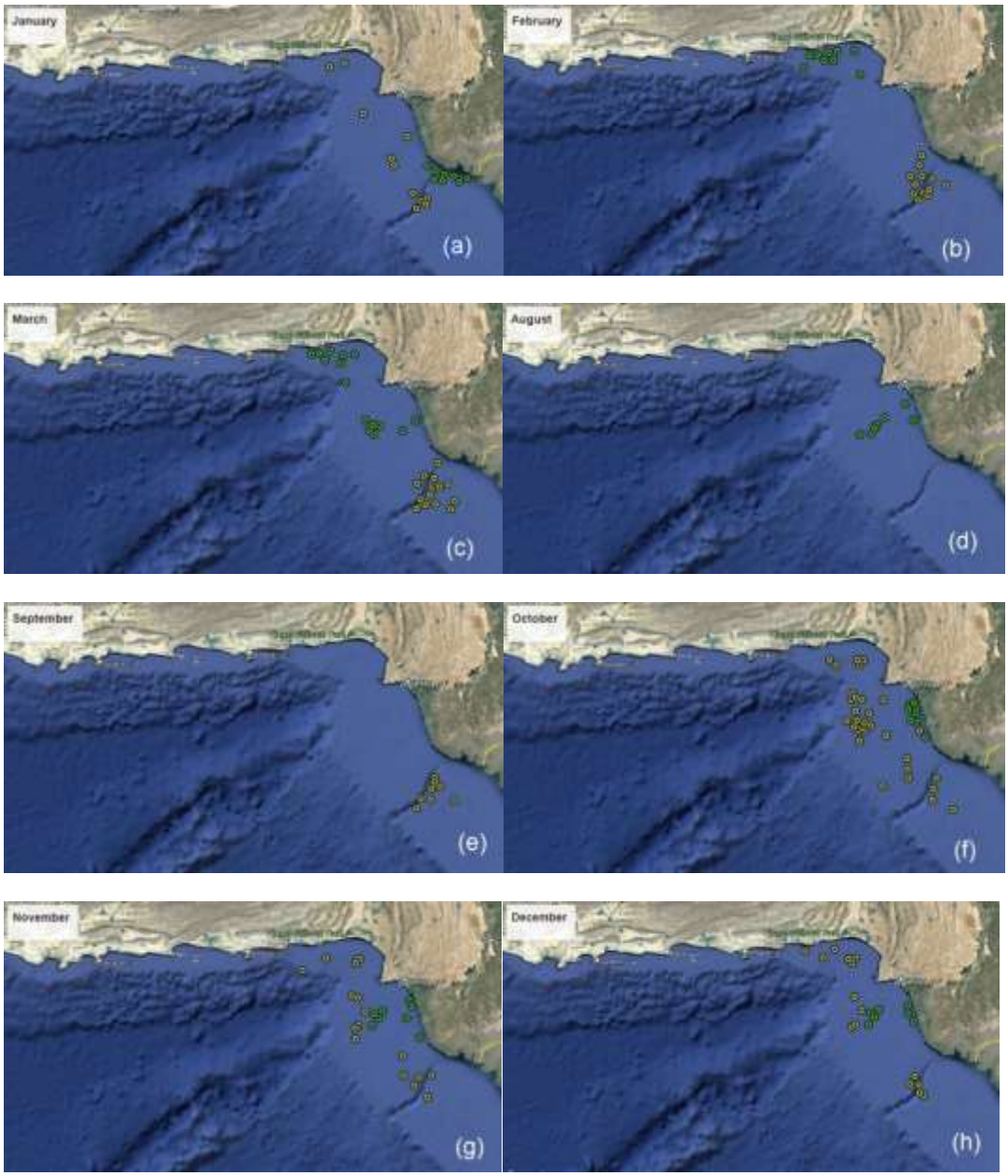

Fig. 8. Monthly changes in the fishing grounds for longline and gillnet fishing operations. (Green circles= longlines; yellow circles = gillnets)

January: During January gillnet fishing operations were carried out near the coastline in Khajar and Kahir Creek areas (Fig. 8a), however, longlining was done mainly in the Indus Swatch area as well as in the offshore waters of Karachi and in the Sonmiani Bay.

February: During February gillnet fishing operations were carried out along Balochistan coast near Phor or Sapat (Fig. 8b) whereas longlining in this month was restricted to the Indus Swatch area.

March: In March longlining was restricted to the Indus Swatch area whereas gillnetting was carried out off Karachi coast, off Sonmiani Bay and Sapat area (Fig.8c).

April, May, June- July: Fishermen of the coastal villages along Sindh coast observe a close season for 4 months during April and July mainly because of rough seas under the influence of southwest monsoon. The data of catches of longline and gillnet fishing during this period is not available.

August: During August no longlining activities were undertaken whereas gillnetting was carried out in the offshore waters of Karachi and Phitti Creek areas (Fig. 8d).

September: During September no gillnetting activities were undertaken whereas longlining was restricted to the Indus Swatch area (Fig. 8e).

October: In October, gillnet operations were carried out along the mouth of creeks of Indus Delta between Phitti and Hajamro Creeks. Longlining during October was carried out in wider offshore areas between the Indus Swatch and Sonmiani Bay. Major part of longlining during this period, however, was restricted to offshore waters of Karachi and Phitti Creek (Fig 8f).

November: Like October, longlining during November was carried out in wider offshore areas between the Indus Swatch and Sonmiani Bay. Gillnet operations during November were carried out along the mouth of creeks of Indus Delta between Phitti and Waddi Khuddi Creek and offshore waters of Karachi (Fig.8g).

December: In December, longlining was carried out in wider offshore areas between the Indus Swatch and Sonmiani Bay (Fig. 8h). Gillnet operations were carried out along the mouth of creeks of Indus Delta between Phitti and Waddi Khuddi Creek and offshore waters of Karachi (Fig.8h).

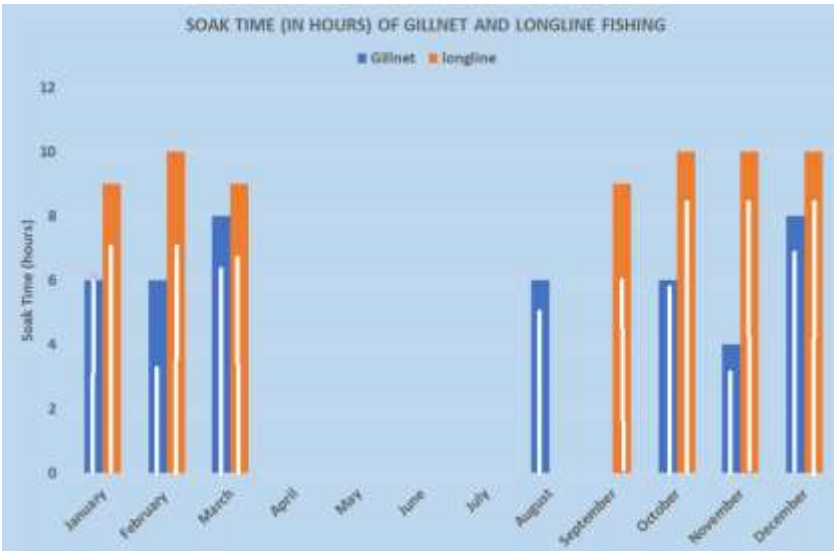

Fig. 9 Soak time observed during the present study for longline (orange bar) and gillnet fisheries (blue bar). White lines within the bars indicate average soak time observed during the month.

Soak Time

Soak duration is the length of time that fishing gear remains in the water, between deployment of gear to its hauling (Misa *et al*., 2016). Average soak time varies among gillnet and longline fisheries and is dependent on factors such as the target species, length of gillnet, number of hooks deployed and the time required to bring them aboard (Ward *et al*., 2004). Soak time observed during the present study for longline and gillnet fisheries is given in Fig. 9.

During present study, soak time was observed to be a maximum of 9 to 10 h with an average of about 7 to 8 h for longlining. In these operations, the longline wasa placed in the late afternoon (between 16:00 and 18:00 hrs.) and heaved early in the morning (between 02:00 and 04:00 hrs.). No longlining was done during the daytime. In case of gillnetting, soak time varies and mainly depends on target species. If gillnet was targeted to catch Indian mackerel or Indian scad, the net was placed in sea for 2 to 4 h whereas in other cases gillnet was paced for 6 to 8 h dependent on fishing ground, condition of sea and target species (Fig. 9). In month of November, the soak time for gillnet was 2 to 4 h as small pelagic (Indian mackerel or Indian scads) were mainly targeted whereas in case where targets were demersal fishes, the gillnet was placed for 6 to 8 h.

Catch Per Unit Effort (CPUE)

In fisheries, the catch per unit effort (CPUE) is an indirect measure of the abundance of a target species. Changes in the catch per unit effort are inferred to signify changes in abundance of the target species (Puertas and Bodmer, 2004). Declines in CPUE may indicate that the fish population cannot support the level of harvesting. Increases in CPUE may mean that a fish stock is recovering and more fishing effort can be applied. CPUE can, therefore, be used as an index of stock abundance. During the present study, seasonal variations in catch per unit effort of both gillnet and longline were noticed indicating marked differences between two methods of fishing.

Seasonal Variation in CPUE of the Gillnet Fisheries: Use of gillnet for catching commercially important fish is the most common method used in Pakistan. Coastal communities are largely dependent on the operation of gillnets in coastal and offshore waters. During the present study, an average catch rate of 261 kg/day was observed in case of monofilament gillnet fisheries. A marked seasonal variation in the catch rates (in terms of CPUE) was observed (Fig. 10). The gillnet fishery was observed to be restricted to only seven month of the year. There was no coastal gillnet operation during monsoon months (April to July) whereas no fishing was also done during September mainly because of prevailing rough seas. Highest average CPUE was recorded in the month of March when a catch rate of 406 kg/ day was recorded. High CPUEs were also recorded in December, August, November and January when these were recorded to be 327, 319, 239 and 106 kg/day respectively. Lowest CPUE of 96 kg/day was recorded in the month of October whereas in February, the CPUE was recorded to 125 kg/day.

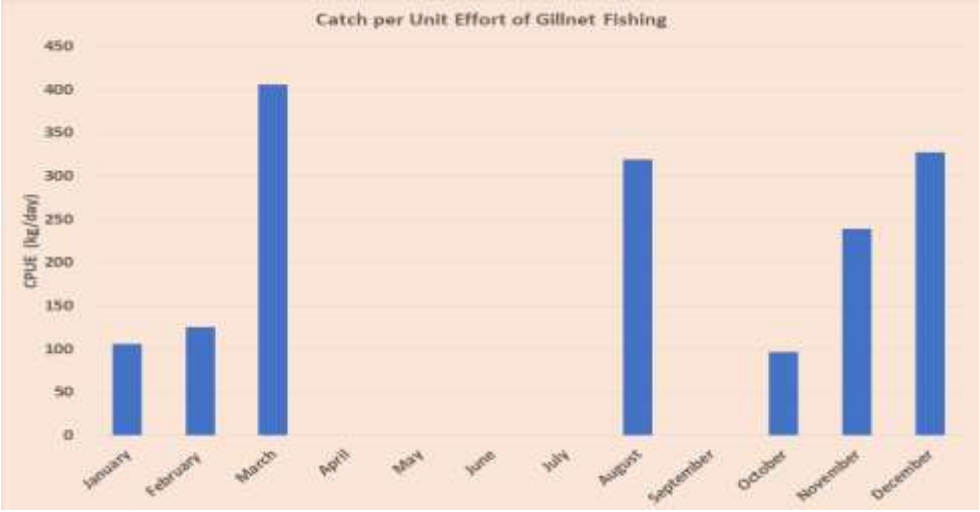

Fig. 10. Catch per unit effort (kg/day) of gillnet catches of small scale fisheries (pooled data).

Seasonal Variation in CPUE of the Longline Fisheries: Gillnet boats converted in coastal longline vessels have a comparatively lower average CPUE of 157 kg/day as compared to 261 kg/day for gillnet fisheries. A marked seasonal variation in the catch rates (in terms of CPUE) was also observed in longline fisheries (Fig. 11). Longline fishing was observed to be carried out also for seven month in a year whereas no longline fishing was done during monsoon months (April to August) because of rough seas (Fig. 11). Highest average CPUE of longlining (169 kg/day) was recorded in the month of November. High CPUEs

were also recorded in January, March, September, October and December when CPUEs were recorded to be 131,123, 121,153 and 139 kg/day respectively. Lowest CPUE of 92 kg/day was recorded in the month of February. It can be seen that CPUE in case of longlines is much lower than those recorded for the gillnet fishing operations.

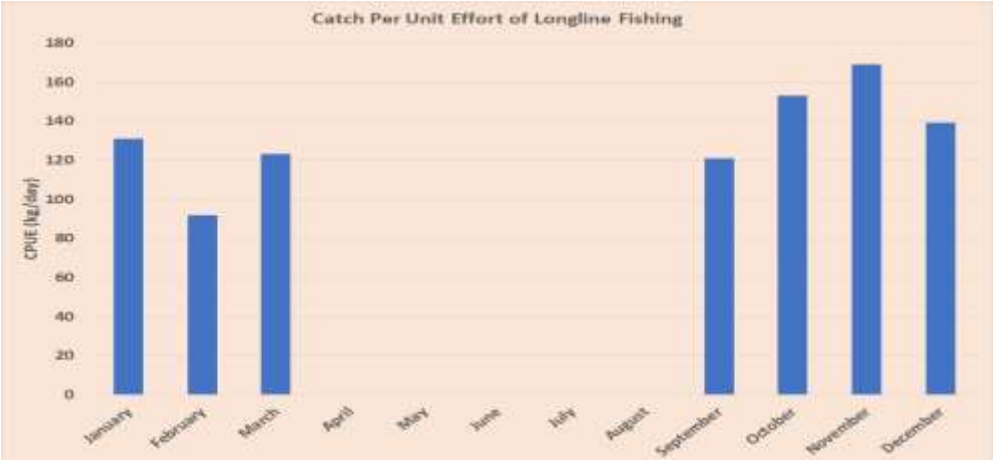

Fig. 11. Catch per unit effort (kg/day) of longline catches of converted fishing boats (pooled data).

Catch Per Unit Effort (CPUE) of the Dominating Species

Marked difference in catches per unit effort was observed between different species caught by gillnet and longline fisheries. On average CPUEs of gillnet caught fishes were observed to be higher as compared to the species which are caught in longline fisheries. Indian mackerel (*Rastrelliger kanagurta*) was found to have highest CPUE in case of gillnet fisheries whereas large daggertooth pike conger (*Muraenesox cinereus*) have highest CPUE in longline fisheries.

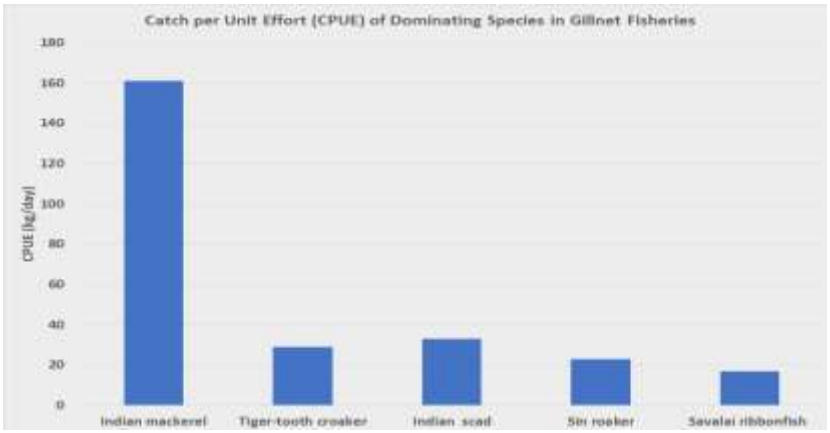

Fig. 12. Average catch per unit effort (kg/day) of dominating species in gillnet fisheries (pooled data).

CPUE of the Dominating Species in the Gillnet Fisheries: Average catch per unit efforts of five dominating species in gillnet fisheries including Indian mackerel (*Rastrelliger kanagurta*), Indian scad (*Decapterus russelli*), tiger-toothed croaker (*Otolithes ruber*), sin croaker *(Johnius dussumieri*) and Savalai ribbonfish (*Lepturacanthus savala*) are given in Fig. 12 which indicates that average CPUE of Indian mackerel to be 161 kg/day. Average CPUEs of the remaining four species were comparatively very low ranging between 17 and 33 kg/day. Indian scad has an average CPUE of 33 kg/day, tiger-toothed croaker has 29 kg/day followed by sin croaker (23 kg/day) and Savalai ribbonfish (17 %). Catches per unit effort of remaining species in gillnet were found to be less than these figures. It may be added that a close season of four months starting from April to July during which fishing activities in coastal villages were stopped because of the rough southwest monsoon.

Marked seasonal variation in the catches per unit effort were noted in different species caught in gillnet fisheries of Rehri Goth (Fig. 13). In case of Indian mackerel (*Rastrelliger kanagurta*) highest CPUE was recorded in month of March (236 kg/day) followed by 208 kg/day in August, 199 kg/day in November, 150 kg/day in December and 106 kg/day in January. Insignificant catches per unit efforts (>22 kg /day) of Indian mackerel were observed in February and October. April to July and September) were observed as closed season. Indian mackerel is one of the important exportable fish, however, small sized and improperly handled Indian mackerel are used as raw material for production of fishmeal.

Indian scad (*Decapterus russelli*) was the second most dominating species in the catches of gillnet fisheries which has the highest average CPUE in the month August (115 kg/day). Average CPUEs in the months of January, February and March were 17, 16 and 26 kg/day respectively whereas in the remaining 8 months, Indian scads are not represented in the catches of gillnet fisheries (Fig. 13). Indian scad is mainly used as raw material for production of fishmeal.

Tiger-toothed croaker (*Otolithes ruber*) which is an important food fish mainly consumed locally has the highest average CPUE of 88 kg/day in the month of February (Fig. 13). Average CPUE of this species were observed to be 8, 5, 30, 21 and 34 kg/day in March, August, October, November and December respectively. In the remaining 6 months, tiger-toothed croaker was not represented in the catches of the gillnet fisheries.

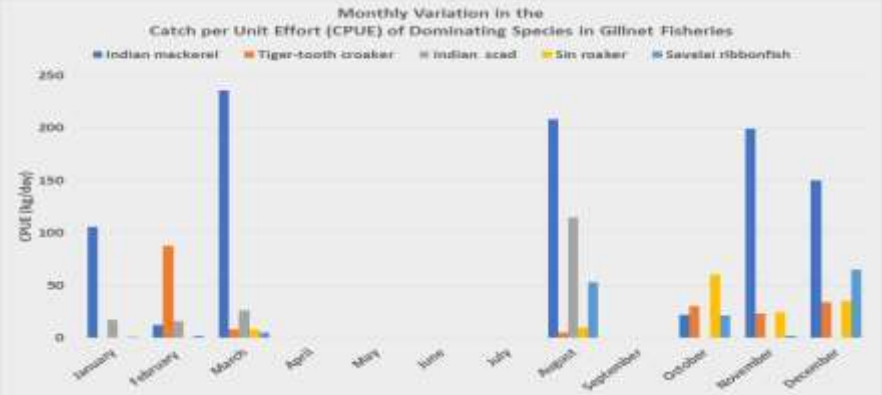

Fig. 13. Monthly variation in catch per unit effort (kg/day) of dominating species in gillnet fisheries (pooled data).

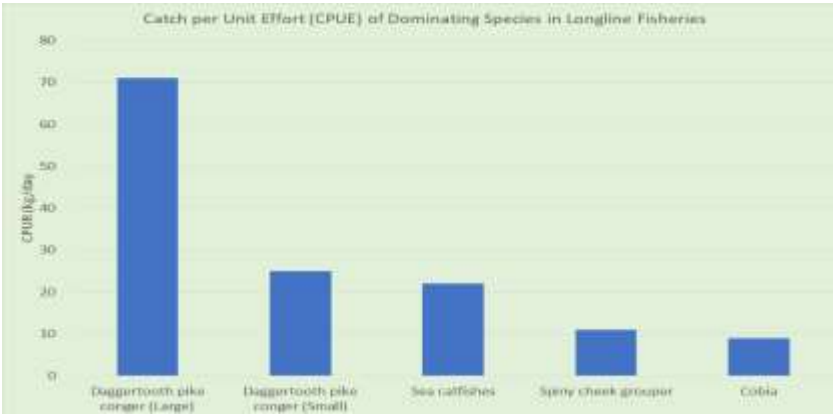

Fig. 14. Average catch per unit effort (kg/day) of dominating species in longline fisheries (pooled data).

Sin croaker *(Johnius dussumieri*) which is also an important food fish mainly consumed locally has the highest average CPUE of 60 kg/day in the month of October (Fig. 13). Average daily CPUEs of this species were observed to be 8, 10, 24 and 35 kg in March, August, November and December respectively. In the remaining seven months, sin croaker was not represented in the catches of the gillnet fisheries.

Savalai ribbonfish (*Lepturacanthus savala*) is an important exportable commodity from Pakistan. Its highest average CPUE of 65 kg/day was recorded in the month of December (Fig. 13). Average CPUE of this species were observed to be 1, 2, 5, 53, 21 and 2 kg/day in January, February, March, September,

October and November respectively. In the remaining five months, Savalai ribbonfish was not represented in the catches of the gillnet fisheries.

CPUE of the Dominating Species in the Longline Fisheries: Average catch per unit effort of five dominating species in longline fisheries including large daggertooth pike conger (*Muraenesox cinereus*), small daggertooth *pike conger*, sea catfishes (Family Ariidae), spinycheek grouper (*Epinephelus diacanthus*) and cobia (*Rachycentrum canadum*) is given in Fig. 14. Average CPUE of large daggertooth *pike conger* was recorded to 71 kg/day whereas average CPUEs of the remaining four species comparatively low ranging between 9 and 25 kg/day. Small daggertooth pike conger has an average CPUE of 25 kg/day, sea catfishes has 22 kg/day followed by spinycheek grouper (11 kg/day) and cobia (9 kg/day). Catches per unit effort of remaining species were found to be less than these figures. A closed season of four months starting from April to August for longline fishing activities was observed because of the rough southwest monsoon.

Marked seasonal variation in the catches per unit effort were noted in different species caught in longline fisheries (Fig. 15). In case of large daggertooth pike conger (*Muraenesox cinereus*)) highest CPUE was recorded in month of February (96 kg/day) followed by CPUEs in November (85 kg/day), December (71 kg/day), October (69 kg/day) and January (82 kg/day). Catches per unit effort of 50 kg /day were observed in March and September whereas in the remaining months (April, May, June, July and August) large daggertooth pike conger was not represented in the catches of longline fisheries. Daggertooth pike conger (large) is one of the important fish which fetches high prices in local markets as it is usually consumed in the upcountry cities.

Small daggertooth pike conger is an exportable commodity. It was the second most dominating species in the catches of longline fisheries and had an average CPUE in the month November (60 kg/day). Average CPUEs in the months of January, February, March, September, October and December were recorded to be 29, 37, 47, 46, 33 and 37 kg/day respectively whereas the remaining 5 months are close season for longline fisheries (Fig. 15).

Sea catfishes (Family Ariidae), which are important food fish are mainly consumed locally. They hadhave the highest average CPUE of 40 kg/day in the month of November (Fig. 15). Average CPUEs of this species were observed to be 8, 2, 19, 17, 30 and 28 kg/day in January, February, March, September, October and December respectively whereas the remaining 5 months are closed season for longline fisheries.

Fig. 15. Monthly variation in catch per unit effort (kg/day) of dominating species in longline fisheries (pooled data).

Spinycheek grouper (*Epinephelus diacanthus*) is an important food fish which is mainly consumed locally as well as exported to Persian Gulf countries. It has the highest average CPUE of 35 kg/day in the month of October (Fig. 15). Average daily CPUEs of this species were observed to be 9, 30, 12 and 21 kg in January, March, November and December respectively. In the remaining seven months, spinycheek grouper was not represented in the catches of the longline fisheries.

Cobia (*Rachycentrum canadum*) is an important exportable commodity from Pakistan. Its highest average CPUE of 31 kg/day was recorded in the month of October (Fig. 15). Average CPUEs of this

species were observed to be 20, 16. 12 and 26 kg/day in January, March, September, November and December respectively. In the remaining seven months, cobia was not represented in the catches of the longline fisheries.

Ecosystem Impact of the Gillnetting and the Longlining

Fishing operations are known to have a major impact on the ecosystem, as one or many species of fishes are removed from the ecosystem due to these activities. In some cases, the catch of a particular species in large quantities may lead to ecosystem readjustment. Removal of prey species through fishing, may affect predator fish species which may lead to imbalance in the species composition and abundance. However, some fishing operations, because of their selectiveness and quantification, have little or no major impact on the ecosystem functioning. Gillnetting is known to have a major impact on the ecosystem, as along with "target species" large quantities of bycatch are also caught whereas longline operations, in most cases, are aimed to target particular species with only limited or no bycatch.

During present study, highest catch per unit effort (CPUE) in gillnet fisheries was reported in case of Indian mackerel which is being harvested by a large fleet of about 7,000 boats in Sindh and about 6,000 boats in Balochistan. Its annual landings are estimated to be 19,910 m. tons (Anonymous, 2023). Indian mackerel is an important secondary producer as it feeds on phytoplankton mainly diatoms, dinoflagellates, crustaceans, molluscs, foraminiferans and ciliates (Hakimelahi *et al*., 2020). According to Noble (1974), Indian mackerel feed on phytoplankton during June-August and on zooplankton during the other months along Cochin, Indian coast indicating its importance as secondary and tertiary producer.

Indian mackerel and Indian scad form an important part of the diet of pelagic predatory species such as common dolphinfish (*Coryphaena hippurus*) indicating their importance as a link between prey and predators (Das *et al*., 2018; Ghosh, *et al*., 2021). The trophic role of Indian mackerel and Indian scads, therefore, cannot be ignored. With a CPUE of 236 kg/day in March and an average of 161 kg/day in gillnet fishery as observed during present study indicate that their removal from the ocean through such fishing operation may seriously impact ecosystem functioning.

During the present study, large and small sized daggertooth pike conger (*Muraenesox cinereus*) are the main component of the demersal longlining fisheries with an average CPUE of 96 kg/day which is much lower than those observed for fishes caught in gillnet fisheries. *M. cinereus* is a demersal species which occupies the highest trophic level in the demersal ecosystem as it feeds on bottom dwelling fish and shellfish (Devadoss and Mahadevan, 1979; Koh *et al*., 2020). Although fleet size of demersal longlining is not known, however, it is estimated that there are about 300 full time and another 400 part-time demersal longline vessels. Its annual landings are estimated to be 3,443 m. tons (Anonymous, 2023). With the small size of the longline fleet, limited landings and smaller CPUE, the longline fishing may have no major impact on the ecosystem functioning.

During present study period, only one olive Radley turtle (*Lepidochelys olivacea*) was found entangled in gillnet on 5 February, 2020, however, this fisheries is known to be marred with entanglement of turtle, coastal cetacean (Indian Ocean humpback dolphins and Indo-Pacific finless porpoise), mobulids and sunfish, however, no entanglement of these megafauna was observed during the study. As compared, demersal longline is known to have no bycatch of megafauna except incidental entanglement of sea turtles. However, such events are extremely rare. Demersal longline fisheries, therefore, have no impact on the population of endangered, threatened and protected (ETP) species whereas gillnetting is considered to have serious issue of bycatch of ETP species.

CONCLUSION

Gillnet is an important fishery of Pakistan which is known to have negative impact on the ecosystem functioning because of high catch of some species like Indian mackerel and Indian scad. CPUE of major species caught by gillnet fisheries is high (236 kg/day for Indian mackerel in March) whereas fleet size of gillnet vessels is extremely high (about 7,000). This tends to indicate that gillnet fishing may have a major impact on ecosystem functioning. In comparison, the fleet size of longline fisheries is small (300 full time and another 400 part-time demersal longline vessels) and average CPUE of dominating species (daggertooth conger pike) is 96 kg/day. This tends to suggest that longline fishing has no major impact on ecosystem functioning in the coastal areas. For the improvement of the ecosystem functioning, the conversion from gillnetting to longlining in the coastal fisheries, therefore, seems to be justified.

ACKNOWLEDGEMENT

The authors are indebted to Cdr. (R.) Ghazi Salahuddin, Director (Sindh and Balochistan), WWF-Pakistan for his guidance and support for conducting the study. Funds for the modification and operation of the fishing vessels are provided through Sustainable Fisheries Entrepreneurship Project funded by the Engro Foundation which is greatly acknowledged.

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(*Accepted for publication April 2023*)