

SPECIES COMPOSITION, COMMERCIAL LANDINGS, DISTRIBUTION AND SOME ASPECTS OF BIOLOGY OF SHARK (CLASS PISCES) OF PAKISTAN: MEDIUM-SIZED DEMERSAL SHARKS

Muhammad Moazzam^{1*} and Hamid Badar Osmany²

¹WWF-Pakistan, D-35, Block 6, PECHS, Karachi 75400, Pakistan

²Marine Fisheries Department, Government of Pakistan, Fish Harbour, West Wharf, Karachi 74000, Pakistan

*Corresponding author: mmoazzamkhan@gmail.com

ABSTRACT

Demersal species of sharks are main contributor of the elasmobranch landings in Pakistan which includes large-size, medium and small sharks. Fifteen species of medium-sized sharks comprising of *Echinorhinus brucus*, *Nebrius ferrugineus*, *Carcharhinus albimarginatus*, *C. altimus*, *C. amblyrhynchoidesi*, *C. amblyrhynchos*, *C. hemiodon*, *C. humani*, *C. limbatus*, *C. melanopterus*, *C. obscurus*, *C. plumbeus*, *C. sorrah*, *Glyphis gangeticus* and *Triaenodon obesus* are known to occur in Pakistan. Of these, only three species *Echinorhinus brucus*, *C. limbatus* and *C. sorrah* are still landed in commercial quantities whereas other species are either already locally extinct (*C. hemiodon* and *Glyphis gangeticus*) or seldom caught by fishing vessels in Pakistan. Bramble shark (*Echinorhinus brucus*) is the only species whose landings was observed to be increasing as compared to its catches prior to 2000 which is attributed to extension of the area of operation of trawlers which now fish up to the outer margin of continental shelf. The paper provides details about commercial landings and biological information (feeding habit and reproduction) of major medium-sized demersal shark species occurring in Pakistan.

Keywords: Medium-sized demersal sharks, *Echinorhinus brucus*, *Nebrius ferrugineus*, *Carcharhinus albimarginatus*, *C. altimus*, *C. amblyrhynchoidesi*, *C. amblyrhynchos*, *C. hemiodon*, *C. humani*, *C. limbatus*, *C. melanopterus*, *C. obscurus*, *C. plumbeus*, *C. sorrah*, *Glyphis gangeticus* and *Triaenodon obesus*.

INTRODUCTION

Sharks are commercially harvested in Pakistan mainly as bycatch of trawling, gillnetting, and lining. At present, there is no aimed fisheries for sharks in Pakistan (Moazzam and Osmany, 2021, 2022; Osmany and Moazzam 202). These shark species are categorized on the basis of marketing and disposal into three types: large-size demersal species (generally larger than 2.0 m TL), medium demersal species (between 1.0 and 2 m TL) and small demersal sharks (less than 1.0 m TL). Large-sized demersal sharks include pignore, spinner, bull, sicklefin lemon, tiger and zebra sharks and are considered as important component of commercially harvested sharks in Pakistan (Osmany and Moazzam, 2022).

There used to be an aimed fishery targeting medium-sized demersal sharks using bottom-set gillnets (multi-monofilament) and bottom-set longlines during 1986 and 2000. In addition, there used to be a reasonably large handline fisheries for medium-sized sharks based mainly in coastal village of Balochistan prior to 2000. However, because of depletion of the stocks of sharks, these fisheries died down by 2000. Even prior to 1999, there used to be an important shark fishery based in Balochistan, as substantial part of fleet was engaged in catching of shark (Siddiqui, 1956).

Under the national legislations, there is a blanket ban on the catching of all sharks as these are included in the Appendix-I (Protected Animal) of Sindh Wildlife Protection, Prevention, Conservation and Management Act, 2020. However, Sindh Wildlife Department does not have any established mechanism to ensure implementation on this ban. None of the medium-sized demersal sharks reported from Pakistan are protected under any other national fisheries legislations. Under Sindh Fisheries Ordinance, 1980 and Rule No. 5(3) SO (FISH)/L &A dated 18 May 2016 a ban is imposed on catching, marketing and sale of some shark species found in Sindh whereas under Balochistan Sea Fisheries Ordinance 1970 and Rule No. SO (Coord)Fish/2-I/2013/3148-54 dated 8 September, 2016 there is a ban on catching, retention, marketing and trade of some sharks found in Balochistan, however, these two rules do not include any medium-sized demersal shark species.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) enlists and regulates international trade of important threatened species including sharks, however, none of the medium-sized demersal sharks occurring in Pakistan are included in any of the CITES appendices. According to International Union of Conservation of Nature's Red List, some species of medium-sized demersal sharks known from Pakistan

are considered either critically endangered (CR) endangered (EN), vulnerable (VU), near threatened (NT) or data deficient (DD) (Moazzam and Osmany, 2021). In addition, none of the medium-sized demersal sharks known from Pakistan except *Carcharhinus altimus* is included in the Appendix-II of CMS (Convention on the Conservation of Migratory Species of Wild Animals) or considered as highly migratory species, Annex I of the 1982 Convention on the Law of the Sea (FAO, 1994).

There are few medium-sized demersal shark species that are known from in Pakistan which are either of rare occurrence historically or their catches have decreased in last few decades and now seldom seen in the landing centres. Blacktip reef sharks, (*Carcharhinu melanopterus*), whitetip reef shark (*Triaenodon obesus*) and grey reef shark (*C. amblyrhynchos*) are three most common sharks inhabiting Indo-Pacific reefs (Martin, 2007), however, these three species are now rarely reported from Pakistan. These species are known to be associated with coral reef habitats (Notarbartolo-di-Sciara and Jabado, 2021), and possibly because of extremely limited local coral areas, these species may be rare occurrence in Pakistan. Among the rare occurring medium-sized demersal shark, Pondicherry shark (*Carcharhinus hemiodon*) and Ganges shark (*Glyphis gangeticus*) seem to be of great importance because these are now considered to be locally extinct.

Present paper deals with medium-sized demersal sharks being landed at Karachi Fish Harbour and including some aspects of biology of important medium-sized demersal shark species including *Echinorhinus brucus*, *Nebrius ferrugineus*, *Carcharhinus albimarginatus*, *C. altimus*, *C. amblyrhynchoides*, *C. amblyrhynchos*, *C. hemiodon*, *C. humani*, *C. limbatus*, *C. melanopterus*, *C. obscurus*, *C. plumbeus*, *C. sorrah*, *Glyphis gangeticus* and *Triaenodon obesus*.

MATERIALS AND METHODS

In order to obtain information about seasonal changes in the landings and some biological aspects of medium-sized demersal shark, observations were recorded at Karachi Fish Harbour during December 2016 to March 2020, as per procedure described in Osmany and Moazzam (2022). During this period estimated catch of all medium-sized demersal sharks was recorded. The paper also looks into biological aspects of medium-sized demersal shark species including their food and feeding habits as well as information about their reproduction (mainly fecundity). The paper also narrates details about management and conservation of each species of medium-sized demersal shark.

RESULTS AND DISCUSSION

Medium-sized demersal sharks primarily inhabit bottom areas of coastal as well as offshore continental shelf waters of Pakistan. Medium-sized demersal sharks include elasmobranchs belonging to Orders Echinorhiniformes (Family Echinorhinidae), Charcharhiniformes (Family Carcharhinidae) and Orectolobiformes (Family Ginglymostomatidae). The species are categorized in the alphabetical in the present paper.

Order Echinorhiniformes
Family Echinorhinidae
Echinorhinus brucus (Bonnaterre, 1788)
(Fig.1-3)



Fig. 1. Bramble shark (*Echinorhinus brucus*).

Habit and Habitat: *Echinorhinus brucus* (Fig. 1) is a bathy-demersal shark that is found on or near the bottom of continental shelves and slopes at depths of 100–900 m (Caille and Olsen, 2000; Castro *et al.*, 1999; Compagno *et al.*, 2005). Along the coast of Pakistan, it is mainly found beyond a depth of 80 meters. This species is known from Western Atlantic (Virginia, Massachusetts, USA; Venezuela, Argentina), Eastern Atlantic (North Sea to

Mediterranean, Morocco to Cape of Good Hope, South Africa), Indian Ocean (India, Mozambique, Oman, Pakistan, South Africa) Western Pacific (Japan, Kiribati, southern Australia, New Zealand). Apparently absent in the Eastern Pacific (Bass and Compagno, 1986). Its presence and distribution in Pakistan are described by Moazzam and Osmany (2021).

Seasonal Distribution: There is no distinct seasonal pattern of landings of bramble shark in Karachi Fish Harbour (Fig. 2). It is landed during 12 months out of 39 months study period. Highest monthly landings of 500kg was recorded in December, 2019 (Fig. 3) whereas in remaining 11 instances, the monthly landings was less than 60 kg/month. *E. brucus* used to be a rare occurring shark in Pakistan. Prior to 2000, it was known from only 2 specimens accidentally caught by bottom gillnetting. Bottom trawling in Pakistan used to target shrimp in shallower waters (less than 40 m), however, trawling for fish was started in 2000 with high opening bottom trawl net which is invariably carried out up to a depth of 180 m resulting in increase in landings of fishes inhabiting outer continental shelf along Pakistan coast including bramble shark.

In India, bramble shark used to be sporadically reported prior to 2002 when a targeted fishery for gulper sharks *Centrophorus* spp. was started in the deeper water along west coast of India. This fishery expanded substantially resulting in increase in the catches of deep-sea sharks including *E. brucus* (Akhilesh, *et al.*, 2011). During the period (2006-2007) the landings of bramble shark in Kochi Fisheries Harbour used to be contributing about 17 % of total shark landings (Vivekanandan and Sivaraj, 2008). Fishery for *Centrophorus* spp. ended in early 2009 when it became unprofitable, but *E. brucus* landings in other fisheries (by-catch in deep-sea shrimp trawls and other longline fisheries) continued, however, catches were substantially decreased (Akhilesh *et al.*, 2013). In contrast to India, landings of bramble sharks showed an increase in Pakistan because of deeper operation of the trawl fishing in recent years.

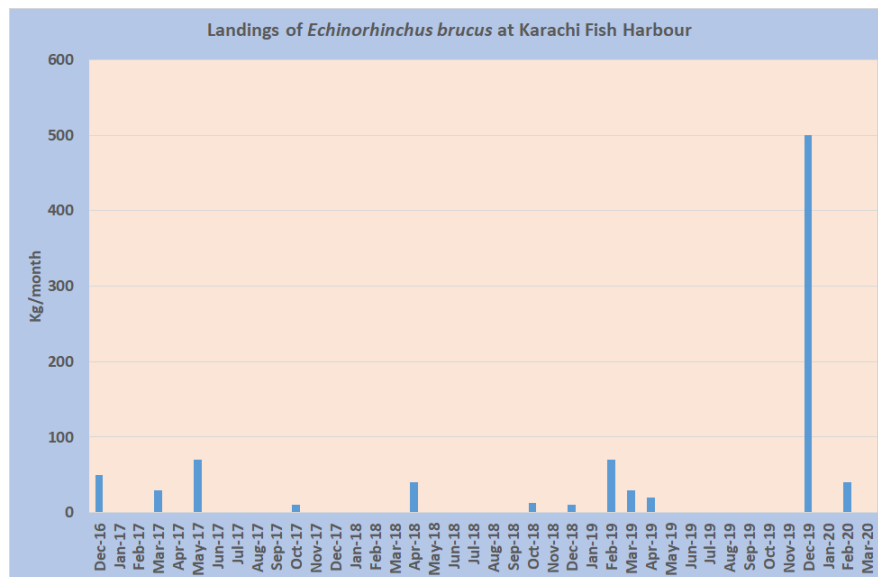


Fig. 2. Landings of bramble shark (*Echinorhinus brucus*) at Karachi Fish Harbour.

Biological Aspects: Bramble shark is considered to be a rare, large, sluggish, deep-water shark found on continental shelf and upper slope which is sometimes found in shallow water. Its maximum size is reported to be 310 cm (Compagno, 1984), however, most specimens in Pakistan was reported to be less than 150 cm (TL). On 21 March 2019, a specimen measuring 211 cm (TL) was recorded from Karachi Fish Harbour.

Females and males of bramble shark attain total length (TL) ranging from 46 to 318 cm and 51 to 300 cm, respectively (Akhilesh *et al.*, 2013). Size at maturity is unknown but adult males of 150 cm and adult females of 213 cm (TL) have been reported (Last and Stevens, 1994). Being a bathy-demersal fish, it feeds on deep dwelling fauna. According to Akhilesh *et al.* (2013), the analysis of stomach contents (index of relative importance in percentage) of bramble shark from the Indian water revealed that it feeds primarily on crustaceans (69 %) and teleosts (26 %) including *Hoplostethus* spp., *Gephyroberyx darwini* and *Saurida* spp.) whereas smaller specimens feed exclusively on crustaceans. Akhilesh *et al.* (2013) consider this species to be generalist feeder with a diet ranging from small crustaceans to elasmobranchs. Silas and Selvaraj (1972) reported Indian lizardfish *Synodus*

indicus and the schilbeid *Clupisoma* sp. (definitely as wrong identification as it is a freshwater species) in the stomach contents of *E. brucus*. Appukuttan and Nair (1988) reported partially digested deep-sea fishes in the stomach of a mature female individual. According to Cortés (1999), *E. brucus* feeds on finfishes (66.70 %) and chondrichthyes (33.30 %). Compagno (1984) reported that bramble shark may feed on unidentified species of catfish, ling, lizardfish, and shark of family Squalidae.

Akhilesh *et al.* (2013) reported that overall female to male ratio of the landings was 3:8:1 and females were more abundant in the landings in most months but the frequency of females to males varied seasonally. They also observed pregnant females in all months, which suggests a non-seasonal reproductive cycle for this species. Reproduction mode in bramble sharks is aplacental and viviparous (Breder and Rosen, 1966). According to Compagno (1984) it may breed in April in Indian waters with 15 to 24 pups are born having size between 29 and 90 cm. Cox and Francis (1997) reported fecundity to be 15 to 26 in New Zealand. Akhilesh *et al.* (2013) observed a fecundity of 10 to 36 from Kochi, India. Cadenat and Blache (1981) reported 15 embryos in Ivory Coast whereas Bass *et al.* (1976) observed 24 embryos in a female in South Africa. Ebenzer (1991) reported 52 embryos from Thoothar, India and Balasubramanian *et al.* (1993) observed 40 embryos at Tuticorin, India whereas Appukuttan and Nair (1988) reported 17 large sized oocytes in a female from Gulf of Mannar, India. The young are borne between sizes of 29-90 cm TL (Compagno, 1984) whereas Akhilesh *et al.* (2013) reported size at birth at off south-west India to be 42-46 cm TL. They further observed that new born pups lacked thorns (enlarged denticles), but small free-swimming pups (>45 cm TL) possessed small- to medium- sized thorns. Fecundity and stomach content analysis were not studied in Pakistan.



Fig. 3. A heap of *Echinorhinus brucus* at Karachi Fish Harbour.

Marketing: There is no specific market for bramble shark in Pakistan. Because of its unusual shape and colour and poor quality of meat, this species does not fetch good prices in local market and in most cases used for production of fish meal. The liver of bramble shark, like livers of other sharks, is used for extraction of oil which is used for smearing hull of fishing boats to keep the surface of hull smooth. Sometime fins of this species are dried and exported to Hong Kong.

Specific Conservation Measures: No information about stocks of bramble shark in Pakistan is available, however, this species may be highly vulnerable as it is known to have slow growth rates and long lifespan (Kabasakal, *et al.*, 2005). The bramble shark is a rare deep-water shark which has only been recorded sporadically and usually

solitarily at widely dispersed localities throughout the world (Kabasakal and Bilecenoglu, 2014). According to IUCN Red List this species is assessed as Endangered (EN). Considering its rarity and slow growth, there is a need for the development of a management plan for bramble sharks restricting or putting a ban on catching, landing, and marketing in Pakistan.

Order Charcharhiniformes
Family Carcharhinidae
Carcharhinus altimus (Springer 1950)
(Fig. 4-5)



Fig. 4. Bignose shark (*Carcharhinus altimus*).

Habit and Habitat: It is commonly known as bignose shark (Fig. 4) which is locally it is known as “jangli ham” in Sindh and Balochistan. It is generally considered as reef-associated and found in shallow coastal waters to depth of 800 m (Froese and Pauly, 2022). It is one of the shark species that has patchy but circumglobal distribution in tropical and warm seas (Compagno and Niem, 1998). According to Froese and Pauly (2022) it is known from Western Atlantic (Florida, USA to Venezuela). Eastern Atlantic (Senegal to Ghana), the Mediterranean Sea, Western Indian Ocean (Red Sea, Mozambique, South Africa, Madagascar, Pakistan, Oman, the Maldives, and India), Western Pacific (China, Taiwan, and Australia), Central Pacific (Hawaii) and Eastern Pacific (Gulf of California and southern Mexico, Colombia, and Ecuador). Its occurrence and distribution along Pakistan coast were detailed by Moazzam and Osmany (2021).

Seasonal Distribution: This species seems to be more common in the commercial landings at Karachi Fish Harbour than most other species of medium-sized sharks except spot-tail shark (Fig. 5). It is landed in 19 months out of 39 months of the study period (December 2016 to March 2020). Highest monthly landings of 3,220 kg was recorded in October 2019 (Fig. 5) whereas in March 2018 the monthly landings of bignose shark at Karachi Fish Harbour was 1,410 kg. Its landings were recorded to be 410 kg in March 2017. Because of confusion in identification, the anecdotal information about its landings prior to 1999 is not available but there seems to be no reason to be sure that its catches must have substantially decreased since 1999.

Biological Aspect: Bignose shark is known to achieve a maximum length of 300 cm (Randall, *et al*, 1990) but during the present study most of the specimens were recorded to have a length between 80 to 170 cm. Male individuals reach maturity at 2.16-2.17 m TL and females at 2.26-2.82 cm TL (Compagno, 1984)

The bignose shark feeds mainly on demersal teleosts (including lizardfishes, croakers, flatfishes, and batfishes), chondrichthyes (including *Squalus* dogfishes, *Holohalaelurus* catsharks, *Dasyatis* stingrays, and chimaeras), and cephalopods (Compagno, 1984; Compagno *et al.*, 1989; Hennemann, 2001). Cortés (1999) reported that its diet consists of teleosts (80.00 %), decapod crustacean (3.30 %), benthic invertebrates (3.30 %) and squid/cuttlefish (13.40 %). Bowman *et al.* (2000) reported that its diet from mid-Atlantic varies with the size but mainly dominated by teleosts followed by chondrichthyes and cephalopods.

Mode of reproduction in bignose shark is aplacental viviparous (Dulvy and Reynolds, 1997). The litter size in bignose shark is 1-13 (average 9) after a gestation period of 10 months (Compagno, 1984; Hennemann, 2001). In the Mediterranean, sharks give birth in August and September, however in Madagascar, young are born in September

and October. Size at birth in bignose shark was reported to be 60-75 cm TL (Last and Stevens, 1994) whereas White *et al.* (2006) recorded size at birth to be 70-90 cm TL. Fecundity and stomach content analysis were not studied in Pakistan.

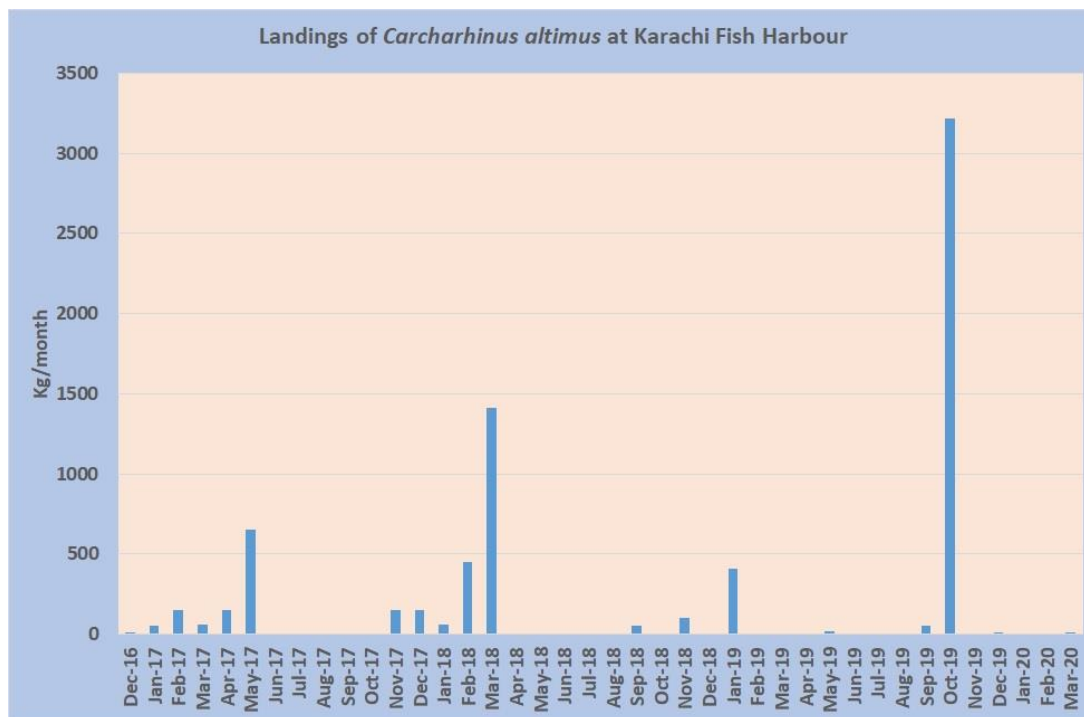


Fig. 5. Landings of bignose shark (*Carcharhinus altimus*) at Karachi Fish Harbour.

Marketing: There is no specific market for bignose shark in Pakistan. Its meat is considered to be of better quality and locally consumed whereas its fins are exported to Hong Kong in dried form. There is no restriction on catching, landing, and marketing of this shark, therefore, there is no ban on export of its fins. Its offal is dried and used as a raw material for fish meal.

Specific Management Measures: According to IUCN Red List, this species is assessed as Near Threatened (NT). It is listed as a highly migratory species under the 1995 UN Agreement on the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks but there are no significant conservation measures has been taken for this species in most countries except in USA waters where harvesting of bignose sharks is prohibited and if it is caught, it must be released immediately and safely into the water.

The species is known to be slow-reproducing and faces widespread heavy fishing pressure in its range of distribution, although documents to this effect are not readily available. There is evidence that its numbers have recently declined in the Maldives. It is believed that being highly migratory species therefore, there is a single stock in the international waters which is harvested by many fisheries mainly as bycatch. There is no legislation or management measures in place for protection and conservation of bignose sharks in Pakistan, however, there is a need for collection of more biological and fishery information so as to adopt an appropriate management strategy.

Carcharhinus amblyrhynchoides (Whitley, 1934)

(Fig. 6)

Habit and Habitat: This species is commonly known as graceful shark (Fig. 6) and locally called “karpic” or “moey” in Sindh and “moozi” in Balochistan. It is considered to be a neritic species that can be found from close to shore to the outer continental shelf to a maximum depth of 50 m (Last and Stevens, 1994). It is known to be widely distributed in the Indo-Pacific area between Gulf of Aden to southwestern India, Sri Lanka, Gulf of Thailand, Philippines, Vietnam, Indonesia, east to Papua New Guinea, north to Taiwan and south to Australia (Froese and Pauly, 2022). Its occurrence and distribution along Pakistan coast were reviewed by Moazzam and Osmany (2021).



Fig. 6. Graceful shark (*Carcharhinus amblyrhynchoides*).

Seasonal Distribution: It is among the rare occurring sharks along Pakistan coast which was observed to be landed on 4 occasions (January 2017, September 2018, August 2019 and October 2019). Although previously (before, 1999) it used to be occasionally landed but was never found to be abundant.

Biological Aspects: Graceful shark is known to grow to a maximum size of 167 cm (Compagno, 1984; Froese and Pauly, 2022), however, during the present study the maximum size observed to 101 cm on 7 January 2017, however, other specimens ranged between 70 and 79 cm. Last and Stevens (2009) reported that both male and female attain sexual maturity at a length of 110 to 120 cm.

This species is known to feed mainly on fishes, however, crustaceans and cephalopods are also consumed (Last and Stevens, 1994). Cortés (1999) reported that its diet consists of teleosts (89.30 %), decapod crustacean (4.90 %), chondrichthyes (2.90 %) and squid/cuttlefish (2.90 %). According to Salini *et al.* (1992) the food of *C. amblyrhynchoides* from nearshore area of Albatross Bay, Australia consisted of teleosts (98.90 %), crabs (0.60 %), isopods (0.40 %) and shrimp (0.10 %).

Like most other sharks, its mode of reproduction is aplacental viviparity (Dulvy and Reynolds, 1997). Litter size ranges between 2-8 pups per litter borne after a gestation period of 9-10 months (Last and Stevens, 1994). Size at birth was reported to be 52-55 cm TL (Compagno and Niem, 1998). Fecundity and stomach content analysis were not studied in Pakistan.

Marketing: There is no specific market for graceful shark in Pakistan. Its meat is locally consumed, and its fins are exported to Hong Kong in dried form. There is no ban on catching, landing, and marketing of this shark, therefore, there is no restriction on export of its fins. Its offal is dried and used as a raw material for fish meal.

Specific Management Measures: According to IUCN Red List, this species is assessed as Near Threatened (NT). It is not an abundant shark in Pakistan and other countries in its range of distribution. Its landings in the region was reported to have been declined during 1970s and 1980's (Compagno, 1984). In Pakistan, its catches were observed to be declined since 1980's and 1990's and now it is seldom landed. There is no legislation or management measures in place for protection and conservation of graceful sharks in any of the countries, however, there is a need for collection of more biological and fishery information so as to adopt an appropriate management strategy (Simpfendorfer *et al.* 2021a).

Carcharhinus amblyrhynchos (Bleeker, 1856)

This species is commonly known as blacktail reef shark. In Balochistan it is called "gwareen". It is known from Indo-West Pacific area including Red Sea, East Africa, Seychelles, Madagascar, western Mascarenes, and Persian Gulf east to Marquesas Islands and Easter Island, north to South China Sea and Hawaiian Islands, south to New Caledonia; Galápagos Islands (Frickle *et al.*, 2022; Froese and Pauly, 2022). This species feed on fishes, cephalopods (squids and octopi) and crustaceans (crabs and lobsters). According to Cortés (1999), food of blacktail reef shark consists of decapod crustaceans (12.70 %), benthic algae (1.4 %), bony fishes (69.30 %) and squids/cuttlefish (16.60 %). Reproduction in blacktail reef shark is aplacental viviparity (Dulvy and Reynolds, 1997). Sexual maturity is achieved around seven years of age, when the males are 1.30 to 1.45 m long, and females are 1.22–1.37 m long (Perrine, 1995). 1 to 6 pups are born every other year with a size range of 50 to 75 cm TL (Compagno, 1984). Fecundity and stomach content analysis were not studied in Pakistan.

According to IUCN Red List, this species is assessed as Endangered (EN). Since in its range of distribution, it is taken by multispecies fisheries mainly for its meat and fins. Degradation of coral reefs due to anthropogenic factors is another reason of their depletion. Although no estimates of landings of the blacktail reef sharks available in Pakistan but it used to be occasionally seen in the landing centres before 1985. There is evidence of similar declines in some other global populations. Anderson *et al.* (1998) reported, in the Chagos Archipelago, blacktail reef shark numbers in 1996 had fallen to 14% of 1970s levels. According to Robbins *et al.* (2006) population of blacktail reef shark populations had declined by 97% in the Great Barrier Reef areas as compared to no-entry zones where fishing boats are not allowed to operate.

Carcharhinus albimarginatus (Ruppell, 1837)

(Fig. 7)

Habit and Habitat: This species is commonly known as silvertip shark (Fig. 7) locally known as “barkali”. It is a coastal shark of rarest occurrence in Pakistan but known to prefer coral habitat and continental shelf area as well to a depth of 800 m (Last and Steven, 1994). This species is widely distributed in the Indo-Pacific area including east Africa, Red Sea, Madagascar, Seychelles, Aldabra Islands, Mauritius and the Chagos Archipelago Hawaiian Islands, Clipperton Island (France), New Caledonia and Tuamotu Archipelago, Mexico south to Ecuador, including Mexico in the Gulf of California (Froese and Pauly, 2022; Frickle *et al.*, 2022). Its occurrence in Pakistani waters was reviewed by Moazzam and Osmany (2021).



Fig. 7. Silvertip shark (*Carcharhinus albimarginatus*).

Seasonal Distribution: It is one of the rarest shark occurring along the coast of Pakistan. During the present study, it was landed in Karachi Fish Harbour only on two occasions in September, 2017 and March, 2019. Previously, it used to be caught occasionally in the coastal area but never in abundance.

Biological Aspects: Silvertip shark can grow to a maximum total length (TL) of 300 cm (Randall *et al.*, 1990), however, during the present study, two recorded specimens have of length 1.2 and 1.4 cm (TL). Males have been reported to be sexually mature after attaining a length of 1.6–1.8 m whereas females reach maturity at 1.6–2.0 m length (Espinoza *et al.*, 2016)

This species feed mainly on benthic and midwater fishes, small sharks, ray, cephalopods, and crustaceans (Bacchat *et al.*, 2006; Compagno, 1984; 2001). Randall (1977) reported that this species feeds on blacktail reef shark (*Carcharhinus amblyrhynchos*) whereas according to Allen (2004) it also consumes squids. Compagno, *et al.* (1989) reported that food of this species may consist of lanternfish, snake mackerel, sole, tuna, wahoo, wrasse, eagle rays and octopii. Cortés (1999) reported that food of silvertip shark consists of benthic invertebrates (6.0 %), finfish (74.90 %), other fishes (6.30 %) and cephalopods (12.50 %). During the present study, no stomach content analysis of this shark was carries out.

Its mode of reproduction is aplacental viviparity with oophorous embryos (Dulvy and Reynolds, 1997). This species gives birth to 1 to 11 pups per litter after a gestation period is about one year (Compagno, 1984). Size at birth was reported to 55 to 80 cm (Randall *et al.*, 1990). During the present study, no information about fecundity and size at birth could be collected.

Marketing: There is specific market for silvertip shark in Pakistan. Its meat is locally consumed, and its fins are exported to Hong Kong in dried form. There is no restriction on catching, landing and marketing of this shark, therefore, there is no ban on export of its fins. Its offal is dried and used as a raw material for fish meal.

Specific Management Measures: According to IUCN Red List, this species is rated as vulnerable (VU). There is no legislation in place in Pakistan or any of the regional countries for protection of this species. Silvertip shark is susceptible to overfishing, due to its slow reproductive rate and tendency to stay in a certain area. It is believed to have been extirpated by Indonesian artisan fishers at Scott Reef off northern Australia and is likely becoming rare in many other parts of its range, therefore, there is a need for development a management regime for this species in its range of distribution.

Carcharhinus brevipinna (Müller & Henle 1839)
(Fig.8-10)

Habit and Habitat: The spinner shark is a slender, grey-bronze shark (Fig. 8) named for its distinctive aerial “spinning” behaviour at the surface. In Pakistan (both Sindh and Balochistan) it is called “shid” or “shidda”. It is mainly found on the continental shelf from close inshore to offshore areas. The spinner shark is widely distributed in Atlantic, Mediterranean and Indo-West Pacific areas. In the western Atlantic it is known from Cape Cod, Massachusetts (U.S.A.) to the southern waters of Brazil. In the eastern Atlantic Ocean, it is found from Spain to Namibia, including the southern Mediterranean Sea. In the Indo-West Pacific, the spinner shark is found in the Red Sea, south to South Africa, eastward to Indonesia, northward to Japan, and then south to Australian waters (Burgess, 2009).. Depth of habitat ranges from 0-100 m but its juvenile may move into shallower bays with tides. Its presence and distribution in Pakistan were described by Moazzam and Osmani (2021).



Fig. 8. Spinner shark (*Carcharhinus brevipinna*) landed at Kund Malir on March 1, 2022.

Seasonal Distribution: There is no distinct seasonal pattern of landings of spinner shark in Karachi Fish Harbour (Fig. 9). It is almost landed in 16 months out of 39 months study period. Highest monthly landings of 800 kg was recorded in November 2017 whereas in May, 2018 monthly landings was reported to be 400 kg and in June, 2017 it was reported to be 330 kg. Landings in other months during the study period were less than 270 kg. It may be pointed out that there are no aimed fisheries for sharks in Pakistan since last 2 decades, therefore, landings are based on bycatch of fisheries such as trawling, gillnetting, and longlining in the coastal area over the shelf. There is little data available on seasonality and distribution of spinner shark due to an inability to distinguish it from other members of the genus *Carcharhinus*. They are frequently mistaken for blacktip sharks (*Carcharhinus limbatus*) as they have a superficially similar appearance. However, spinner sharks grow to a larger size than blacktips and have a distinctly marked black tip on the anal fin (in adults) where black tip sharks do not.

Biological Aspects: Spinner sharks feed primarily on small bony fish, including members of family Carangidae (jacks/trevallies), Clupeidae (sardines/herrings), Elopidae (tenpounders), Engraulidae (anchovies), Gerridae (mojarras), Haemulidae (grunts), Mugilidae (mulletts), Pomatomidae (bluefish), Sciaenidae (croakers), Scombridae (bonitos), Cynoglossidae (tounge-soles), unidentified fishes, squid, cuttlefish, and octopi (Compagno (1984). According to Compagno *et al.*, (1989) it also feeds on squid/cuttlefish and small sharks. Cortés (1999) reported that the food of spinner shark consisted of decapod crustacean (2.00 %), benthic algae (1.00 %), teleosts (90.60 %), chondrichthyes (0.50 %), squid and cuttlefish (5.90 %).

The spinner shark is an active, fast swimming shark that is often seen leaping out of the water. This happens when feeding, spinner sharks will often swim through schools of small fish, spinning along their longitudinal axis, snapping at fish as they move through the water toward the surface. When they breach the surface, they can be seen spinning in the air – sometimes as much as 20 feet above the water surface. The spinner sharks are known congregate around fishing vessels mainly trawler to feed on the discarded bycatch and may be incited into feeding frenzies (Compagno, 1984). Stomach content analysis was not studied in Pakistan.

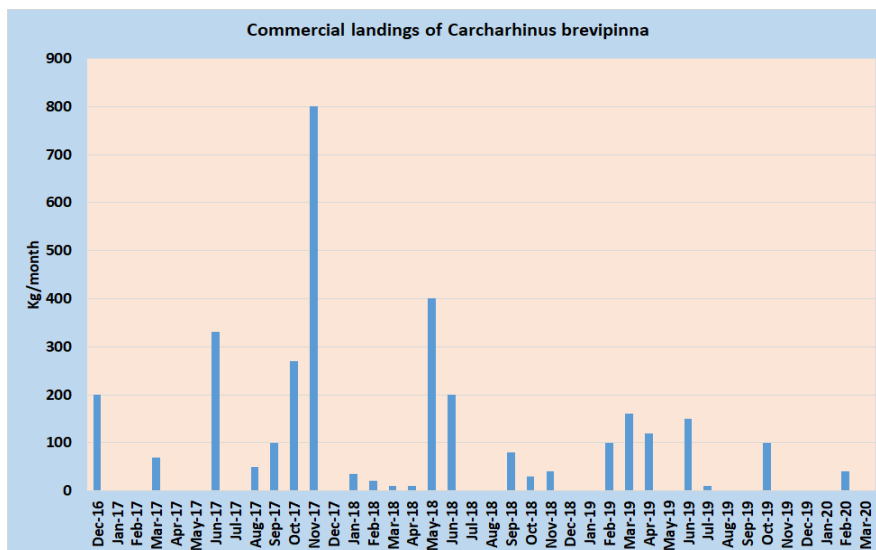


Fig.9. Commercial landings of *Carcharhinus brevipinna* at Karachi Fish Harbour.

Reproduction in spinner sharks is aplacental viviparity (Dulvy and Reynolds, 1997). This species has the smallest ova relative to the fully developed embryo of any known viviparous shark (Capape *et al.*, 2003). Females give birth to three to 20 (usually seven to 11) pups every other year, after a gestation period of 11–15 months. According to Cortés (2000) fecundity was observed to be minimum 8, maximum 13 in the eastern Indian Ocean, minimum 6 and maximum 15 in southwestern Indian Ocean and according to Compagno (1984) it was minimum 3, maximum 15 in the Natal, South African coast.

The length at birth is 66–77 cm in the north-western Atlantic (Fowler *et al.*, 2005) 61–69 cm off Tunisia (Capape *et al.*, 2003) and 60 cm off South Africa (Van der Elst and Borchert, 1993). During the present study 6 pups dissected from a female at Karachi Fish Harbour having a size range between 45 and 48 cm (Fig. 10).



Fig. 10. Foetuses dissected from a female spinner shark (*Carcharhinus brevipinna*) at Karachi Fish Harbour.

Marketing: There is specific market for spinner sharks in Pakistan. Its meat, like meat of other sharks, is consumed locally whereas its fins are exported to Hong Kong. There is no ban on catching, landing and marketing of this shark, therefore, there is no restriction on export of its fins. Its offal is dried and used as a raw material for fish meal. There is no specific market for juveniles or foetus of *C. brevipinna*.

Specific Conservation Measures: No information about stocks of spinner shark in Pakistan is available, however, noticeable reduction in the catches of this species is reported during last 40 years. There is no management regime in place for conservation and protection of the stocks of this species in Pakistan and in the regional countries. Spinner shark is assessed as globally as Vulnerable (VU). It is not evaluated by Convention of Migratory Species (CMS) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Like other sharks, *Carcharhinus brevipinna* is sensitive to fishing pressure because of late age of maturity and limited fecundity (3-20 pups). Its use of inshore waters for its nursery areas makes them susceptible to habitat destruction due to development of coastal areas (Compagno *et al.* 2005). There is a need for development of a management plan for spinner sharks restricting or putting a ban on catching, landing, and marketing in Pakistan.

Carcharhinus hemiodon (Müller & Henle 1839)

This is one of the species which used to be sporadic occurrence prior to 1970's but since early 1980's it was not seen in any landing centres in Pakistan in last 40 years indicating that it may be locally extinct. This species is known to occur in rivers but there is no authentic record of its occurrence in the River Indus. Elsewhere this species is known from Gulf of Oman, India, Sri Lanka as well as scattered localities from the eastern Indian Ocean and the western Pacific ranging from India to New Guinea. According to Notarbartolo-di-Sciara and Jabado (2021), it is small and rare Indian–West Pacific inshore shark which also used to occur in the Arabian Sea, but it has not been recorded since 1979. There are a few recent records of their presence in Sri Lanka and India, however, it is assessed to be Critically Endangered (CR) by IUCN Red List. It is believed to be locally extinct in some areas of its distribution. Little is known about its biology, however, considering shape of its teeth and habitat of occurrence, it can be speculated to consume small fishes, cephalopods (cuttlefish/squid) and crustaceans (Compagno and Niem, 1998). Like other sharks, its mode of reproduction ought to be aplacental viviparity (Dulvy and Reynolds, 1997).

Carcharhinus humani White and Weigmann 2014

This species was described from off Socotra Islands, Yemen by White and Weismann (2014) and now known from Western Indian Ocean: South and East Africa, Seychelles and Madagascar to Persian Gulf (Eschmeyer, 2020; Froese and Pauly, 2020). It is called human whaler's shark and is small little-known coastal shark species limited to the Western Indian Ocean and is of rare occurrences in the Arabian Sea and Persian Gulf (Notarbartolo-di-Sciara and Jabado, 2021). Although there is no authentic record of this species from the area but its occurrence in Pakistani waters cannot be overruled (Moazzam and Osmany, 2021). No aspect of its biology including feeding and reproduction is known. Because of limited available information about the species, it is assessed as Data Deficient (DD) by IUCN Red List.

Carcharhinus limbatus (Müller and Henle, 1839) (Fig. 11-12)

Habit and Habitat: This species is commonly known as blacktip shark (Fig. 11) locally called as called “karpic” or “kanti” in Sindh and “kalawani kanaitar” in Balochistan. This shark is known to found both inshore and offshore waters (up to a depth of 100 m) mainly on or adjacent to continental shelf area (Compagno, 1984). It may also be found at the mouth of rivers and in the estuarine areas including in the muddy bays, mangrove swamps and lagoons (Compagno *et al.*, 2005). It is one of cosmopolitan shark which is reported from Western Atlantic (Nova Scotia, Canada to Brazil), Eastern Atlantic (Senegal to Democratic Republic of the Congo, Madeira, and the Canary Islands), Mediterranean Sea, Indo-Pacific area (Persian Gulf, Red Sea, Madagascar, South Africa to China, Australia, Tahiti, Marquesas, and Hawaii) and Eastern Pacific (Baja California, Mexico to Peru, including the Galapagos Islands). Its occurrence and distribution along Pakistan coast were reviewed by Moazzam and Osmany (2021).

Seasonal Distribution: There is no distinct seasonal pattern of landings of blacktip shark in Karachi Fish Harbour (Fig. 12). It was reported to be landed in 15 months out of 39 months study period. Highest monthly landings of 3,200kg was recorded in December, 2018 (Fig. 12) whereas in March, 2019 the monthly landings of blacktip shark at Karachi Fish Harbour is 1,121 kg. In remaining 13 months, the monthly landings were less than 460 kg. *C. limbatus* used to be a common occurring shark prior to 1999 mainly at Ormara where major catch is originated from handline shark fisheries.



Fig. 11. Blacktip shark (*Carcharhinus limbatus*).

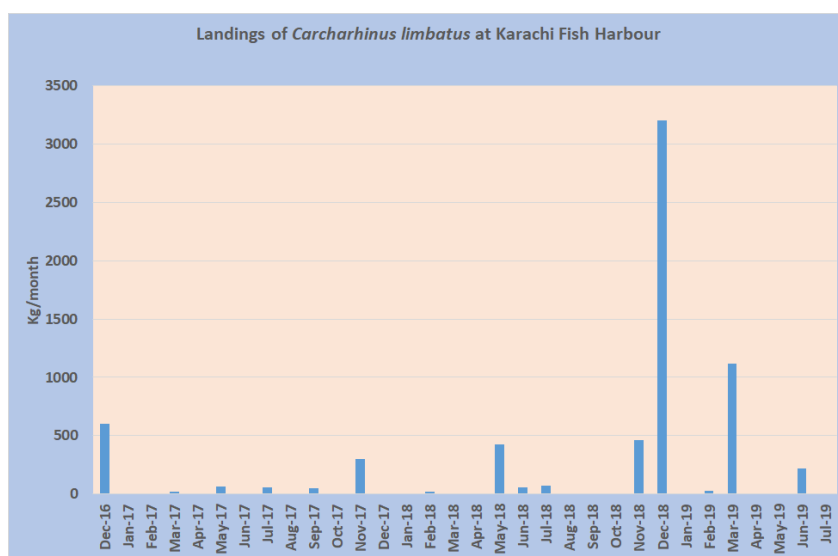


Fig. 12. Landings of blacktip shark (*Carcharhinus limbatus*) at Karachi Fish Harbour.

Biological Aspect: Blacktip shark is known to grow to a maximum size of 275 cm (Lafrance, 1994; Froese and Pauly, 2022), however, during the present study the maximum size observed to 186 cm on 17 December 2018, however, other specimens from Pakistan ranged between 75 and 150 cm. Age at maturity was reported to be 4-5 years for males, and 6-7 years for females (Burgess and Branstetter, 2009). The length at maturity was reported to be 145 cm TL for males and 156 cm TL for females (Castro, 1996).

This species is known to feed mainly on pelagic and benthic fishes, also small sharks and rays, cephalopods, and crustaceans (Myers, 1999). Cortés (1999) reported that its diet consists of teleosts (88.90 %), decapod crustacean (2.10 %), chondrichthyes (4.50 %), benthic invertebrates (0.10 %), and molluscs (0.20 %), algae/seaweed (0.10 %) and squid/cuttlefish (4.10 %) According to Dudley and Cliff (1993) who studied the biology of *C. limbatus* including its food from Natal, South Africa from 1978 to 1991 and found that teleosts contribute 72.30 %, chondrichthyes 22.90 %, squid and cuttlefish 2.70 %, dolphins 1.70 % and spiny lobster 0.40 %. Randall (1980) observed southern meagre (*Argyrosomus hololepidotus*), dusky sharks (*Carcharhinus obscurus*), tenpounder (*Elops saurus*), common ponyfish (*Leiognathus equula*), salema porgy (*Sarpa salpa*), narrow-barred Spanish mackerel (*Scomberomorus commerson*), Indo-Pacific kingfish (*S. guttatus*), Mozambique tilapia (*Oreochromis mossambicus*), lesser sandshark (*Rhinobatos annulatus*), scalloped spiny lobster (*Panulirus homarus*) and cuttlefish (*Sepia sp.*). Compagno *et al.* (1989) reported that food of blacktip shark consists of Spanish mackerel, grunter, kob, ladyfish, seabream, sole, small rays, small sharks, and rock lobsters. Its stomach contents were not analysed during present study.

Like most other sharks, its mode of reproduction is aplacental viviparity (Dulvy and Reynolds, 1997). Smith (1997) and Myers (1991) reported litter size 1 to 10. Size at birth was reported to be 52-55 cm TL (Compagno and Niem, 1998), 38-72 cm TL (Compagno, 1984) and 55-66 cm TL (White *et al.*, 2006). This species is known to have nursery and pupping grounds which are located in the inshore waters where pregnant females go to parturition, however, no such nursery or pupping area is known in Pakistan.

Marketing: There is no specific market for blacktip shark in Pakistan. Its meat is locally consumed, and its fins are exported to Hong Kong in dried form. There is no ban on catching, landing, and marketing of this shark, therefore, there is no restriction on export of its fins. Its offal is dried and used as a raw material for fish meal.

Specific Management Measures: According to IUCN Red List, this species is assessed as Near Threatened (NT). This species is commonly caught in commercial fisheries in some countries in its range of distribution, however, has limited landings in Pakistan. Its landing in Pakistan is reported to have been declined substantially since 1990's and now seldom seen in landing centres. There is no legislation or management measures in place for protection and conservation of blacktip sharks in Pakistan, however, there is a need for collection of more biological and fishery information so as to adopt an appropriate management strategy.

Carcharhinus melanopterus (Quoy and Gaimard, 1824)

It used to be occurring commonly in Pakistan about 30 years back since then almost vanished from commercial landings at Karachi Fish Harbour and other landing centres of Pakistan (Moazzam and Osmany, 2021). Recently Akbar Ali Asif, an amateur diver posted a photo of this species from Churna Island on social media (Moazzam and Osmany, 2021). This species is widely distributed in the Indo-Pacific area extending from East Africa to the Hawaiian Islands and the Tuamoto Archipelago north to Japan and south to Australia (Fricke *et al.*, 2022). It is a Lessepsian migrant as this shark is now known to colonize the eastern Mediterranean Sea crossing Suez Canal. In 1970's and 1980's this species was frequently caught by handlines in coral habitat south of Ormara, Balochistan but this handline fishing was stopped in 1999 and boats those were engaged in this fishing shifted to gillnetting for Indian mackerel and Indian oil sardinellas. This species prefers to consume on small fishes but also feed on cephalopods and crustaceans (Last and Stevens, 1994). Like other sharks, its mode of reproduction is viviparous and aplacental (Dulvy and Reynolds, 1997). According to IUCN Red List it is assessed to be Vulnerable (VU).

Carcharhinus obscurus (Lesueur 1818)

It is Medium-sized shark which has nearly circumglobal distribution in tropical and subtropical waters which is reported from Pakistan by Hoda (1988). However, it is one of the rarest sharks occurring along the coast of Pakistan and not seen at any fish landing centres in last 25 years, therefore, is no more a commercially important species in Pakistan. It is known to feed on bottom and pelagic bony fish, sharks, skates, rays, cephalopods, gastropods, crustaceans, sometimes mammalian carrion and inorganic objects (Compagno *et al.*, 1989; Froese and Pauly, 2022). Like other sharks, its mode of reproduction is viviparous and placental (Dulvy and Reynolds, 1997). Litter size 3-14 pups with the sizes at birth ranging between 70 and 100 cm (TL). According to IUCN Red List, it is assessed to be Endangered (EN).

Carcharhinus plumbeus (Nardo, 1827)
(Fig. 13)



Fig. 13. Sandbar shark (*Carcharhinus plumbeus*).

Habit and Habitat: This species is commonly known as sandbar shark (Fig. 13) locally known as “kanati” in Sindh and Balochistan. It is a benthopelagic and oceanodromous sharks that is found in coastal areas as well as up to depth of 500 m (Goldshmidt, *et al.*, 1996). It is one of the rarest shark occurring in Pakistan. This species is widely distributed globally in warm temperate and tropical areas. According to Froese and Pauly (2022), Menni and

Lucifora (2007), Smith (1997) and Grove and Lavenberg (1997), it is known from western Atlantic (southern Massachusetts, USA to Argentina, Gulf of Mexico, Bahamas, Cuba and south and west Caribbean), eastern Atlantic (Portugal to Democratic Republic of the Congo and the Mediterranean). Indo-Pacific (scattered records ranging from the Red Sea, Persian Gulf and East Africa to the Hawaiian Islands) and eastern Pacific (Revillagigedo and Galapagos islands). Its occurrence in Pakistani waters was reviewed by Moazzam and Osmany (2021).

Seasonal Distribution: Being one of the rarest shark, it was landed at Karachi Fish Harbour only in August 2019. Previously it used to be landed occasionally in this and other landing centres. In 2013 and 2014, for example, it was landed in almost all months except June, July and October. It is worth mentioning that June and July are close fishing seasons and major fishing activities decreased substantially during these months. The reasons of its practical disappearance from Pakistan are not known.

Biological Aspects: Sandbar shark can grow to a maximum length of 250 cm (Frimodt, 1995), however, during the present study the recorded specimen has a length 1.9 m (TL). Males have been reported to be sexually mature after attaining a length of 1.40 m (TL) whereas females reach maturity at 1.6–1.48 m total length (Piercy *et al.*, 2016).

This species feed mainly on bony fishes, also small sharks, cephalopods, and shrimps (Compagno *et al.*, 1989), rays and gastropods. Young feed heavily on crustaceans such as blue crabs and mantis shrimp (Murdy and Musick, 2013). Randall (1977) reported that this species feeds on blacktail reef shark (*Carcharhinus amblyrhynchos*) whereas according to Allen (2004), it also consumes squids. Compagno, *et al.* (1989) reported that food of this species may consist of lanternfish, snake mackerel, sole, tuna, wahoo, wrasse, eagle rays and octopi.

Cortés, (1999) reported that food of sandbar shark consists of benthic crustaceans (25.30 %), benthic algae (0.10 %), finfish (55.00 %), chondrichthyes (6.30 %) and cephalopods (13.30 %). Stillwell and Kohler (1993) reported that sandbar shark in USA, between Cape Hatteras and Georges Bank feed on skate eggs (0.42 %), benthic invertebrates mainly *Cancer* crab (0.19 %), finfish dominated by family Gadidae, Cottidae, Bothidae, Pleuronectidae and *Scomber scombrus*, *Pomatomus saltatrix*, *Lophius americanus* and *Limanda ferruginea* (65.50 %), rays including *Raja erinacea* (32.28 %), cephalopods including *Illex* (0.73 %) and animal remains (0.83 %). Bowman *et al.* (2000) examined stomach contents of *C. plumbeus* from middle Atlantic (offshore and inshore north and inshore south of Cape Hatteras) and found bivalve - *Spisula solidissima* (1.00 %), hake- *Urophycis tenuis* (5.50 %), croaker- *Leiostomus xanthurus* (23.40 %), eel- *Ophichthys cruentifer* (29.40 %), finfish (39.90 %) and animal remains (0.80 %). Stomach content of sandbar shark was also studied by Medved and Marshall (1981) in Chincoteague Bay, Virginia, USA which included eel (*Anguilla rostrata*), menhaden (*Brevoortia tyrannus*), blue crab (*Callinectes sapidus*), cancer crab (*Cancer irroratus*), lady crab (*Ovalipes ocellatus*), mummichog (*Fundulus heteroclitus*), spot croaker (*Leiostomus xanthurus*), bluefish (*Pomatomus saltator*), northern puffer (*Sphoeroides maculatus*), squilla and cuttlefish. During the present study, no stomach content analysis of any specimen of this shark was carried out.

Its reproduction is aplacental viviparous with oophorous embryos (Dulvy and Reynolds, 1997). This species gives birth to 1 to 10 pups per litter (Randall *et al.*, 1990; Smith *et al.*, 1998). Gestation period is estimated as 8 to 12 months and size at birth was reported to 56 to 75 cm (Compagno, 1984). During the present study, no detailed information about fecundity and size at birth could be collected, however, a female was dissected on 16 October, 2014 that have two pups each having a size of 69 cm TL.

Marketing: There is specific market for silvertip shark in Pakistan. Its meat is locally consumed and its fins are exported to Hong Kong in dried form. There is no restriction on catching, landing and marketing of this shark, therefore, there is no ban on export of its fins. Its offal is dried and used as a raw material for fish meal.

Specific Management Measures: According to IUCN Red List, this species is rated as Vulnerable (VU). There is no legislation in place in Pakistan or any of the regional countries for protection of this species. Sandbar shark is susceptible to overfishing, due to its slow reproductive rate and tendency to stay in a certain area. Although this species used to be frequently landed in Karachi Fish Harbour and other landing centres prior to 2014 but since then it is almost disappeared from the commercial landings indicating its susceptibility to fishing pressure, therefore, there is a need to develop a management regime for sandbar shark in Pakistan and other regional countries.

Carcharhinus sorrah (Müller and Henle, 1839)

(Fig. 14-17)

Habit and Habitat: This species of medium shark is known as spot-tail shark (Fig. 14) and locally called as “karpic”, “karaint” or “kayon” in Sindh and “kanaitar” in Balochistan. This species is generally associated with

reefs but may also be found in brackish waters as well as on the continental shelf to a depth of 140 m (Froese and Pauly, 2022). It is known to be widely distributed in the Indo-Pacific area extending from East Africa (including Madagascar, Mauritius, Madagascar, and Seychelles) to Red Sea, Gulf of Aden, Oman, Persian, Gulf, Pakistan, India, Sri Lanka, to the Philippines, north to China and Taiwan, south to Australia and from Vanikolo Island (Santa Cruz Islands), northern Vanuatu and the Solomon Islands (Froese and Pauly, 2022; Frickle *et al.*, 2022). Its occurrence in Pakistani waters was reviewed by Moazzam and Osmany (2021).



Fig. 14. Spot-tail shark (*Carcharhinus sorrah*).



Fig. 15. A heap of spot-tail shark (*Carcharhinus sorrah*) at Karachi Fish Harbour

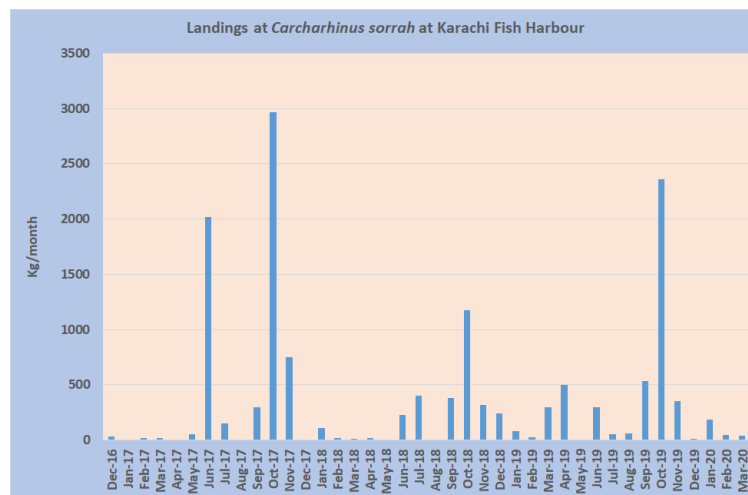


Fig. 16. Landings of spot-tail shark (*Carcharhinus sorrah*) at Karachi Fish Harbour.

Seasonal Distribution: Spot-tail shark is most commonly occurring medium-sized shark being landed at Karachi Fish Harbour (Fig. 15). It is landed in 33 months out of 39 months of the study period (December 2016 to March 2020). Highest monthly landings of 2,965 kg was recorded in October 2017 (Fig. 16) whereas in October 2019, June, 2017 and October, 2018 the monthly landings of spot-tail shark at Karachi Fish Harbour was 2,360 kg, 2,020 kg and 1,175 kg respectively. Although anecdotal information about its landings prior to 1999 is not available, however, its landings were observed to have decreased substantially.

Biological Aspect: Spot-tail shark is known to achieve a maximum length of 160 cm (Sommer *et al.*, 1996) but during the present study most of the specimens were recorded to have a length between 70 to 140 cm. Males reach maturity at 128 cm whereas females mature between 110 and 118 cm (Compagno, 1984).

Carcharhinus sorrah feeds mainly on bony fishes as well as cephalopods and crustaceans (Last and Stevens, 1994). According to Cortés (1999) its diet consists of teleosts (72.10 %), chondrichthyes (1.40 %), squid and cuttlefish (15.60 %), decapod crustaceans (9.90 %), molluscs (0.20 %) and algae (0.80 %). Salini *et al.*, (1992) reported that spot-tail shark in the in the estuary of estuary, Albatross Bay, north-eastern Gulf of Carpentaria, Australia feeds on teleosts (86.40 %), brachyuran crabs (13.10 %) and penaeid shrimps (0.50 %) whereas in the offshore Albatross Bay its diet consists of teleosts (85.0 %), brachyuran crabs (1.60 %), penaeid shrimps (0.20 %), benthic crustaceans (0.10 %), molluscs (11.60 %) and stomatopods (1.50 %). Compagno *et al.* (1989) reported that it feed fishes of family Scombridae and Serranidae as well as on octopi.

Like other requiem shark the mode of reproduction in *Carcharhinus sorrah* is aplacental viviparity (Dulvy and Reynolds, 1997). It is reported to produce 3 (range 1-8) pups after a gestation period of 10 month (Stevens and Wiley, 1986). During the present study two females were observed to have pups in their bellies which were dissected out. One of them contain two pups having total lengths (TL) of 53 and 56 cm (Fig. 17a) and other contains 7 fetuses with the length of 42 to 47 cm (Fig. 17b).



Fig. 17. Foetuses of spot-tail shark dissected from two females (a) two full grown pups (53, 56 cm TL); (b) developing foetuses 42-47 cm (TL).

Marketing: There is specific market for spot-tail shark in Pakistan. Its meat is locally consumed whereas its fins are exported to Hong Kong in dried form. There is no ban on catching, landing, and marketing of this shark, therefore, there is no restriction on export of its fins. Being one of the commonly caught shark, its fins are dominating in the shark trade market in Pakistan. Its offal is dried and used as a raw material for fish meal.

Specific Management Measures: According to IUCN Red List, this species is assessed as Near Threatened (NT). The spot-tail Shark is regularly targeted and taken as bycatch throughout its distribution (White *et al.*, 2006). The fisheries of spot-tail sharks are relatively well managed in Northern Australia and Queensland (Johnson *et al.* 2014; Simpfendorfer *et al.*, 2021b; Bradshaw *et al.* 2013, Grubert *et al.* 2013). Once the second most abundant species of shark in Australian waters, however, many populations appear to be in decline worldwide (Simpfendorfer *et al.*, 2021b). Information about its stocks in Pakistan is not available, however, its population is considerably reduced as compared to status in 1970s to 1990's which is evident from noticeable decreased in its catch. There is no aimed fisheries for this shark in Pakistan, but it is a predominantly occurring species in bycatch of bottom set gillnetting in Pakistan. There is no legislation or management measures in place for protection and conservation of spot-tail sharks in Pakistan, however, there is a need for collection of more biological and fishery information so as to develop and adopt an appropriate management strategy.

Glyphis gangeticus (Müller and Henle, 1839)

According to Notarbartolo-di-Sciara and Jabado (2021) Ganges shark is a rarely occurring Indo-West Pacific shark confined to freshwater, estuarine, and coastal habitats including Arabian Sea. There is no doubt that the Ganges sharks used to occurring in Pakistan but never common. A specimen collected from Karachi was described by Günther (1883) as *Carcharia murrayi* which is considered to be a synonym of this species (Compagno *et al.*, 2010). No specimen of this species was recorded from Pakistan, although monitoring of shark catch is being done for past 50 years in all major fish harbours. It seems that it is already locally extinct. Monitoring has also been done in Indus estuarine area and also in lower reaches of the River Indus but so far, no evidence of its presence in the area could be collected. Considering its rarity and other biological parameters, this species is assessed as Critically Endangered (CR) by IUCN Red list.

Triaenodon obesus (Ruppell, 1837)

It also used to be occasionally caught by handline fisheries of Ormara, Balochistan in 1970s and 1980s. It also used to be landed frequently in Karachi Fish Harbour during the same period. However, it is not seen in any landing centres in last 20 years, possibly it became locally extinct. According to Notarbartolo-di-Sciara and Jabado (2021) it is a medium-sized reef shark widely distributed across the tropical Indian (including Arabian Sea), and Pacific Oceans usually associated with coral reef habitats. It feeds on small fishes and benthic animals such as crabs, lobsters and octopi (Compagno, 1984). It is assessed as Vulnerable (VU) according to IUCN Red List.

Order Orectolobiformes
Family Ginglymostomatidae.
Nebrius ferrugineus (Lesson 1831)
(Fig. 18)



Fig. 18. Tawny nurse shark (*Nebrius ferrugineus*)-head-ventral and dorsal views.

Habit and Habitat: This species is commonly known as tawny nurse shark (Fig. 18). It is a coastal shark that is distributed from intertidal areas to a depth of 70 m (Compagno, 1984; 2001). It is known to be concentrated in coral reefs and subtidal rocky areas mainly hiding in crevices and among ledges. It is known to be distributed in Indo-West Pacific area extending from South Africa, Seychelles, Madagascar, Red Sea, Persian Gulf, western Mascarenes east to Society Islands and Marquesas, north to southern Japan, south to northern Australia and New Caledonia (Frickle and Eschmeyer, 2022). Its occurrence in Pakistani waters was reviewed by Moazzam and Osmany (2021).

Seasonal Distribution: It is one of the rarest sharks occurring along the coast of Pakistan. During the present study, it was landed in Karachi Fish Harbour only on three occasions in March 2017, May 2018, and November 2019. Previously (prior to 1999), it was used to be caught frequently in coastal fisheries along sandy and rocky shores especially in Goth Manjhar in Sindh and Bundewari, Taq and Daran (Jiwani) along Balochistan coast where these used to be occasionally caught in handline gears.

Biological Aspects: Tawny nurse shark is one of the medium-sized shark which can attain a maximum length of 3.2 m (Compagno, 1984), however, during the present study, all three recorded specimens have of length 0.9, 1.1 and 1.3 m (TL). Maturity is reached by males at lengths of approximately 225 cm TL and by females around 230 cm TL (Bester, 2022).

This species having a benthic habitat feed upon a wide diversity of benthic invertebrates including corals including *Stylophora sp.* sea urchins, crustaceans (e.g., crabs and lobsters) and sea urchins (Compagno, 1984; 2001). The tawny nurse shark also feeds on small fishes as well as occasionally sea snakes. Randall (1980) reported that this shark feeds on surgeonfish (*Acanthurus nigricans*) and xanthid crabs in Marshall Islands. Hiat and Shrasburg (1960) reported that species consumes rabbit fish (*Siganus sp.*) in Eniwetok, Marshal Islands. The tawny nurse shark is one of the shark that specialize in preying upon octopus (Compagno, 1984; Smale, 1996). Cortés, (1999) reported that food of tawny nurse shark consists of molluscs (10 %), finfish (30 %) and cephalopods (60%). During the present study, no stomach content analysis of any specimen of this shark was done.

Its reproduction is aplacental viviparous with oophorous embryos (Dulvy and Reynolds, 1997; Teshima *et al.*, 1995). This species gives birth to litters of up to 8 pups, each measuring approximately 40-60 cm (TL) in length at birth (Compagno, 1998; White, *et al.*, 2006). During the present study, all three specimens examined were male, therefore, no information about fecundity and size at birth could be collected.

Marketing: There is specific market for tawny nurse shark in Pakistan. Its meat is considered to be of poor quality and have bad taste, therefore, this species is generally not liked. It is rarely caught in commercial fishing operations and usually discarded and thrown overboard. Its fins are, however, exported to Hong Kong in dried form. There is no restriction on catching, landing and marketing of this shark, therefore, there is no ban on the export of its fins. Its offal is dried and used as a raw material for fish meal.

Specific Management Measures: According to IUCN Red List, this species is rated as Vulnerable (VU). There is no legislation in place in Pakistan or any of the regional countries for protection of this species. This species inhabits predominantly in coral areas. In Pakistan, one such habitat i.e. Astola Island has already been declared as Marine Protected Area, although there is no restriction on fishing in this MPA. There is plans to declare additional MPAs along the coast of Pakistan some of which may be having corals that are preferred habitat for tawny nurse sharks. With control of commercial activities, these MPAs may provide a solace for this species. Rarity of occurrence of this species in Pakistan is of serious concern which may be indicative of local depletion of its population. There have been reports of local extinctions in waters around India and the Gulf of Thailand due to increased fisheries catch as well as habitat degradation (Bester, 2022).

CONCLUSION

Medium-sized sharks are represented is represented by 15 species which are mainly caught by gillnets, longlines and trawl nets from coastal as well as offshore waters, however, their contribution in total shark landings of Pakistan is limited. With the exception of *Carcharhinus sorrah*, *C. altimus* and *C. limbatus*, no other sharks are caught in commercial quantities. Even contribution of these three is species not very large and only landed on few occasions in substantial quantities. Other species with noticeable landings includes *Echinorhynchus brucus*, *Carcharhinus amblyrhynchoides* and *C. plumbeus* which are occasionally landed at Karachi Fish Harbour and other landing centres along Pakistan coast but their overall contribution in total shark landings of Pakistan is insignificant.

Most of the Medium-sized used to be landed in substantially large quantities in Pakistan prior to 1999 when a large aimed shark fisheries using bottom-set gillnetting and longlining was operating in Pakistan. The dominating species of medium-sized shark in this period were *Carcharhinus altimus*, *Carcharhinus amblyrhynchos*, *C. amblyrhynchoides*, *C. limbatus*, *C. melanopterus*, *C. obscurus*, *C. plumbeus*, *C. sorrah*, *Triaenodon obesus* and *Nebrius ferrugineus*. No specimen of Pondicherry shark (*Carcharhinus hemiodon*) has been recorded from Pakistan since 1980's, although this species used to be sporadic occurrence prior to 1970's and commercially harvested by coastal gillnet and longline fisheries. It seems that this species could not survive fishing pressures and now considered to be locally extinct. According to IUCN Red List it is assessed to be Critically Endangered (CR).

Some of medium-sized shark species such as *C. melanopterus*, *Triaenodon obesus* and *Nebrius ferrugineus* used to be frequently landed at Karachi Fish Harbour and other landing centres but these have now almost disappeared in commercial landings in Pakistan. It is feared that these three species may follow the path of Pondicherry shark and may become locally extinct. No specimen of balcktip reef shark (*Carcharhinus melanopterus*) was observed in Pakistan in last 30 years, however, in 2021, an amateur diver has photographed one specimen at Churna Island, Pakistan (Moazzam and Osmany, 2021) which is only authentic record of this species in Pakistan in recent years.

Bramble shark (*Echinorhynchus brucus*) which used to be extremely rare prior to year 2000 and was known by only a few specimens, is now occasionally landed at Karachi Fish Harbour which is the main landing center for commercial trawlers in Pakistan. Shrimp trawling used to be confined to coastal areas up to a maximum depth of 50 m prior to 2000, however, now fish trawling is being done at up to depth of 180 m mainly targeting demersal fish

and shellfish species. Bramble shark being a comparatively deep dwelling on continental shelves and slopes (100–900 m) is now frequently caught by these trawlers.

Despite having no aimed fisheries in Pakistan, sharks are still caught in substantial quantities as bycatch of commercial fishing operations in Pakistan. In the absence of any management regime for medium-sized sharks in Pakistan, it is feared that many species may become locally extinct. According to IUCN Red List, two species which are included in medium-sized shark (*Carcharhinus hemiodon* and *Glyphis gangeticus*) are critically endangered (CR), four species (*Echinorhinus brucus*, *Carcharhinus amblyrhynchos*, *C. obscurus* and *C. plumbeus*) are assessed as endangered (EN), six species (*Nebrius ferrugineus*, *Carcharhinus albimarginatus*, *C. amblyrhynchoides*, *C. limbatus*, *C. melanopterus* and *Triaenodon obesus*) are rated as vulnerable (VU), two species (*Carcharhinus altimus* and *C. sorrah*) are categorized as near threatened (NT) whereas *Carcharhinus humani* is considered as data deficient (DD). The IUCN Red List assessment indicates subdued conservation status of these medium-sized shark species, however, there is a need for inclusion of the near threatened, endangered, vulnerable and near threatened on CITES appendices so as to regulate their global trade.

Considering ineffectiveness of the ban on catching sharks due to their inclusion in the Appendix-I (Protected Animal) of Sindh Wildlife Protection, Prevention, Conservation and Management Act, 2020, there is a need for putting a ban on catching, landing and marketing of all medium-sized shark species under both provincial and federal fisheries legislations. This is required to ensure that stocks of these shark species may not be depleted leading to their extinction in Pakistan.

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