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SPECIES COMPOSITION, COMMERCIAL LANDINGS, DISTRIBUTION AND SOME ASPECTS OF BIOLOGY OF SHARK (CLASS PISCES) OF PAKISTAN: PELAGIC SHARKS

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ABSTRACT

Sharks are important part of coastal and offshore pelagic ecosystems and being caught mainly as bycatch of tuna gillnet fishing operations. There are 12 species of pelagic sharks caught in Pakistan which belongs to 5 families and 7 genera. Silky shark (*Carcharhinus falciformis*) is the most dominating pelagic shark followed by shortfin mako (*Isurus oxyrhinchus*) and pelagic thresher shark (*Alopias pelagicus*). Blue shark (*Prionace glauca*) is the rarest pelagic shark that is seldom caught by tuna gillnet vessels. There is general concern regarding over-exploitation of pelagic sharks globally as well as in Pakistan, as some species including scalloped hammerhead (*Sphyrna lewini*) are disappearing very fast and it is feared that they may become extinct in near future. Although most pelagic sharks are included in the Appendix-II of CITES which restricts their global trade as well as there is a ban on their catching, landing, marketing and trade has been imposed through national fisheries legislations, however, there is no effective implementation mechanism in place for ensuring these restrictions in Pakistan. Exploitation of pelagic sharks, therefore, continue unabated in Pakistan as well as some other regional countries which may lead to their disappearance from commercial catches or may ends up in regional or global extinction.

Key word: Pelagic sharks, *Alopias, Isurus, Carcharhinus, Sphyrna, Prionace, Pseudocarcharias, Eusphyra,* over-exploitation, gillnetting

INTRODUCTION

Sharks are important component of the commercial landings in Pakistan, though, at present, there is no aimed fisheries for sharks in Pakistan (Moazzam and Osmany, 2021). Sharks is mainly landed as bycatch of various fishing operations including shrimp/fish trawling, bottom set gillnetting / longlining and tuna gillnet fishing. Pelagic sharks are caught, as bycatch of tuna gillnetting in Pakistan operated in coastal and offshore waters of Pakistan. Details of pelagic gillnet fishing are given by Moazzam (2011, 2012a-d, 2017, 2018a-b), Moazzam and Nawaz (2014) and Moazzam *et al*. (2016). In Pakistan, sharks are mainly landed at Karachi Fish Harbour (Fig. 1). It is estimated that more than 80 % of the commercial shark landings is routed through Karachi Fish Harbour. Pelagic sharks have been studied in regional countries including Varghese *et al.* (2017) who studied seven pelagic sharks from Eastern Arabian Sea.

Under the national legislations, there is a blanket ban on the catching of all sharks as these are listed in the Appendix-I (Protected Animal) of Sindh Wildlife Protection, Prevention, Conservation and Management Act, 2020. In addition, almost all pelagic sharks reported from Pakistan are included in the Appendix-II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), therefore, their international trade is regulated. CITES listed species are given legal cover under Pakistan Trade Control of Wild Fauna and Flora Act, 2012 putting a ban on the export of such species.

According to International Union of Conservation of Nature's (IUCN) Red List, all species of pelagic sharks known from Pakistan are considered either endangered (EN), vulnerable (VU), near threatened (NT) or critically endangered (CR) except crocodile shark which is least concern (LC) (Moazzam and Osmany, 2021). In addition, all pelagic sharks known from Pakistan are included in the Appendix-II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS). Most pelagic sharks are also considered as highly migratory and listed Annex I of the 1982 Convention on the Law of the Sea (FAO, 1994).

It is illegal to export any species listed on Appendix-II of CITES without valid permission from the CITES management authority (Ministry of Maritime Affairs, Government of Pakistan). Similarly, 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 almost all of the pelagic shark species found in Sindh. Under Balochistan Sea fisheries Ordinance 1970

and Rule No. SO (Coord.) Fish/2-I/2013/3148-54 dated 8 September, 2016 there is a similar ban on catching, retention, marketing and trade of almost all of the pelagic sharks found in Balochistan.

In the present paper, an assessment of pelagic sharks landed at Karachi Fish Harbor is made including some aspects of biology of important shark species.

Fig. 1. Landings of pelagic sharks (dominated by shortfin mako sharks) at Karachi Fish Harbor (Photographed in 1999)

MATERIALS AND METHODS

In order to obtain information about seasonal changes in the landings and some biological aspects of pelagic shark, observations were recorded on daily basis from December 2016 to March 2020 at Karachi Fish Harbor which is the main landings of pelagic sharks in Pakistan. During this period estimated catch of sharks was recorded. In the collection of this data staff of Fishermen's Cooperative Society based in Karachi Fish Harbour have also provided support which is greatly acknowledged. The paper also looks into biological aspects of pelagic shark species including their food and feeding habits as well as information about their reproduction (mainly fecundity). The paper also describes details about management and conservation of these species.

RESULTS AND DISCUSSION

Pelagic sharks predominantly includes those species of sharks that inhabits water columns in the offshore waters and occupy the status of top predators. In Pakistan, these shark species are caught by tuna gillnets vessels that operate in the continental shelf, slope and deep oceanic areas including in the Exclusive Economic Zone (EEZ) of Pakistan and in the Area Beyond National Jurisdiction (ABNJ) as well as waters of other regional countries (Moazzam, 2012a-d). Pelagic sharks landed at Karachi Fish Harbour comprises of 12 species that belong to 5 families and 7 genera including pelagic threshers (*Alopias pelagicus*), bigeye thresher (*Alopias superciliosus*), silky shark (*Carcharhinus falciformis*), oceanic whitetip shark (*Carcharhinus longimanus*), blue shark (*Prionace glauca*), crocodile shark (*Pseudocarcharias kamoharai*), shortfin mako (*Isurus oxyrinchus*), longfin mako (*Isurus paucus*), winghead shark (*Eusphyra blochii*), scalloped hammerhead (*Sphyrna lewini*), great hammerhead (*Sphyrna mokarran*) and smooth hammerhead (*Sphyrna zygaena*). All pelagic sharks are commercially important because of their meat which is locally consumed and fins which are exported to Hong Kong.

Alopias pelagicus Nakamura, 1935
(Fig. 2-7)

Habit and Habitat: It is commonly known as pelagic thresher (Fig. 2) and is inhabitant of epipelagic zone in the inshore and oceanic waters in the tropical waters of Indian and Pacific Oceans (Fricke, *et al*., 2021; Froese and Pauly, 2021). Its occurrence in Pakistani waters was reviewed by Moazzam and Osmany (2021). Pelagic thresher is one of the important pelagic shark in Pakistan (Fig. 3) which is landed almost throughout the year.

Fig. 2. *Alopias pelagicus*

It is a large oceanic shark species attaining a maximum length of 428 cm (Weigmann, 2016). Along Pakistan coast, maximum size was recorded to be 312 cm which was landed in Karachi Fish Harbour on October, 2015. Most of specimens of *A. pelagicus* recorded from Karachi Fish Harbour, however, ranged between 130 and 180 cm.

Seasonal Distribution: Analysis of the data collected during the present study indicates that there are have two peaks of landings; the first in October to December and second during March and April. Maximum monthly landing was recorded in March 2017 when a total of 18,000 kg was landed whereas in December, 2019, monthly landing was reported to be 17,700 kg (Fig. 4). During the study period, poor landings of pelagic threshers were reported in some months when only one or two specimens were landed in the Harbour. No landings of this shark is reported during Mid-May to Mid-August because of voluntary close season observed by the fishermen engaged in pelagic fisheries, however, on rare occasions during this period a few specimens of pelagic threshers caught by coastal gillnet vessels may be landed. Temporal variation in the landings was observed during various years which may be attributed mainly to areas of operation of the tuna gillnetters which may be fishing in coastal waters where pelagic threshers are seldom caught. In some years, major part of these gillnetters operate in coastal waters whereas in others they operate in deep oceanic waters in the EEZ of Pakistan and in the ABNJ which is reflective in seasonal variations as well as year to year variations.

Fig. 3. Catch of a single haul on a tuna gillnet vessel in April 2016 dominated by *Alopias pelagicus*

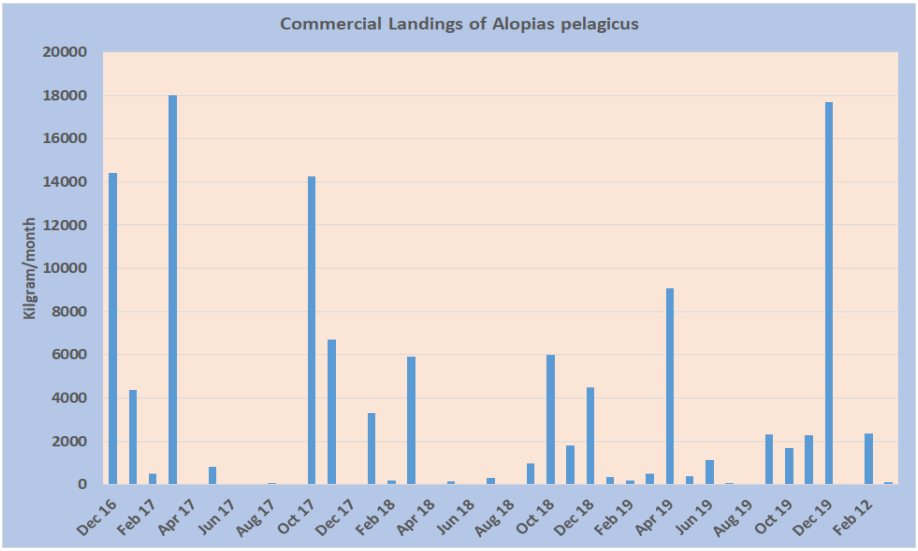

Fig. 4. Commercial landings of *Alopias pelagicus* at Karachi Fish Harbour

Biological Aspects: During the study period, stomach contents of a few specimens of *Alopias pelagicus* were examined which revealed that it feeds upon small fishes dominated by threadfin breams (*Nemipterus* spp.) and snake mackerel (*Gempylus serpens*) as well as on purpleback flying squid (*Stenouteuthis oualaniensis*). In a pelagic thresher dissected in January 2018, three intact specimens of 44 cm long Savala hairtail (*Lepturacanthus savala*) were found. Calle-Moran and Galvan-Magana (2020) and Polo-Silva *et al*. (2009) have found cephalopods including *Stenouteuthis oualaniensis* and mesopelagic fishes in the stomach content of this species. Fishes seems to be more common in the stomach contents of bigeye thresher (*A. superciliosus*) whereas cephalopods were dominating in the case of *A. pelagicus* as noted by Polo-Silva *et al.* (2009). They have also noticed that there is limited trophic overlapping between *A. superciliosus* and *A. pelagicus*, however, both species are quaternary consumer or tertiary predators.

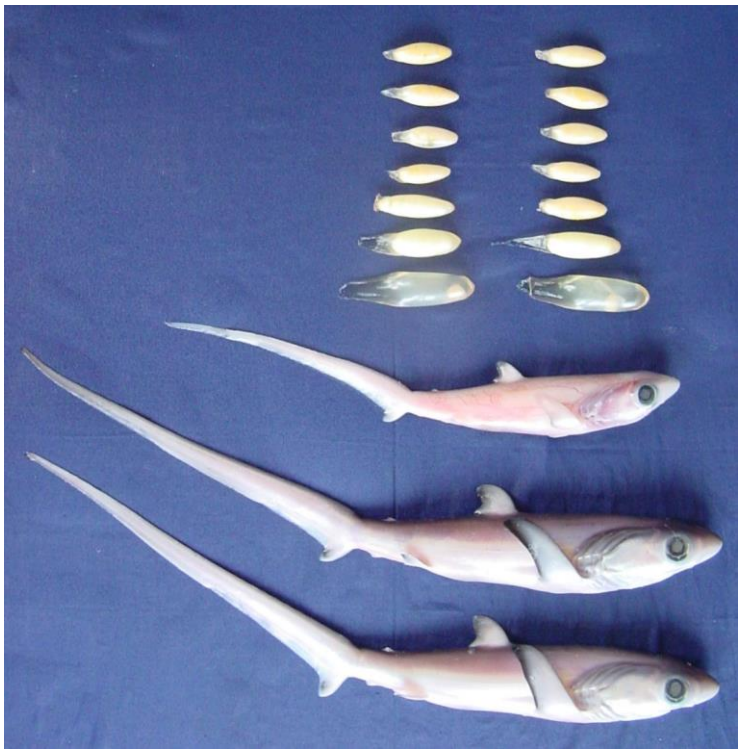

Fig. 5. Developing eggs and fetuses dissected from female pelagic thresher (*Alopias pelagicus*)

Alopias pelagicus exhibit aplacental viviparity with embryonic oophagy (Dulvy and Reynolds, 1997; Liu *et al.* 1999; Otake and Mizue, 1981). This mode of reproduction is found in genus *Alopias* like most lamniform sharks and described in detailed by Snelson *et al.* (2008). During the present study, a number of females with developing embryos were dissected (Fig. 5) which reveals, a maximum of 15 developing eggs and 3 pups in most cases. Liu *et al.*, (1999) observed 5 developed stages (2 encapsulated and 3 post hatching) in female collected from Taiwan. According to them there were 2 embryos in a litter that have length of 158 and 190 cm. Otake and Migue (1981), Compagno (1984), Liu *et al.* (1999) and Smith *et al.* (2008) reported litter size to be two.

A number of specimens of this species were observed to have ecto-parasites (Fig. 6-7). These include pandarid copepod parasite (*Pandarus cf cranchii*) fully covering cloacal region (Moazzam in press). Pelagic thresher sharks are known to visit coastal seamount where they interact with cleaner fish *Labroides dimidiatus* and *Thalassoma lunare* to control parasitic infection (Oliver *et al.,* 2011). These seamounts acts as cleaning stations and as noted by Oliver *et al.* (2011) the pelagic thresher sharks regularly visit these cleaning stations to get parasites removed by cleaner fishes. Although one of the common cleaner fish *Thalassoma lunare* is reported from Pakistan by Gomon and Randall (1984) and Zugmayer (1913) but there are no coastal seamounts or coral reefs, therefore, cleaning by wrasses or other species is not reported from Pakistan coast. Need not to mention that pelagic thresher sharks are included in highly migratory species, therefore, they may get their parasites removed at other locations in the Arabian Sea where coral reefs are present in abundance.

Fig. 6. Ecto-parasite on the body of pelagic thresher (*Alopias pelagicus*)

Fig. 7. Pandarid copepod parasite (*Pandarus cf cranchii*) fully covering cloacal region of pelagic thresher. A leech is also visible in the photo.

Marketing: Meat of pelagic thresher is locally consumed like meat of other shark species. Its meat is considered to be of better quality than that of *A. superciliosus.* This species fetches high prices in local market mainly because the species has large fins (including very long tail) which is exported to Hong Kong. Despites restrictions on international trade due to inclusion of this species in the CITES Appendix-II, the fins of this species from Pakistan

are still exported under the disguise of dried fish. In the Hong Kong fin trade market, this species was ranked 10th and 6th during 2014-15 and 1999-2000 respectively (Field *et al.*, 2017).

Specific Conservation Measures: In addition to the management and conservation measures under CITES and national legislations, Indian Ocean Tuna Commission (IOTC) has issued a Resolution No. 10/12 dealing with the conservation of thresher sharks. Under this Resolution, retention of this species on board fishing vessels, its transhipping, landing, storing, selling or offering for sale any part or its whole carcass are prohibited. The resolution requires that thresher sharks when caught and brought on board the fishing vessel be immediately released unharmed, to the extent practicable, Attempts have been to convince fishermen to release (if alive) and discard (if dead) thresher sharks but it could not be implemented effectively. A few fishermen have discarded thresher sharks initially but did not continue with this practices which is mainly because of the ineffective implementation of the concerned fisheries departments and fish harbour authorities and prevailing high prices for this fish in Pakistan.

The pelagic thresher sharks are caught by different types of fishing vessels in the Indian Ocean (IOTC, 2021). Pelagic thresher sharks are relatively long lived (more than 20 years), mature after achieving an age of 8–9 years and produce 2-3 offspring, therefore, are vulnerable to fishing pressure (IOTC, 2021). Information about its stock and other fisheries indicators are not available for this species in the Indian Ocean, therefore, there is a need for assessment of this shark species (Drew *et al*., 2015). Till some management measures are adopted, prohibition on the retention of pelagic thresher shark on-board fishing vessels in the Indian Ocean is recommended by IOTC.

Alopias superciliosus (Lowe 1841)
(Fig. 8-10)

Habit and Habitat: It is commonly known as bigeye thresher (Fig. 8) and is an inhabitant of the epipelagic zone in the inshore and oceanic waters and distributed in tropical and temperate waters in Indian, Atlantic and Pacific. (Fricke, *et al*., 2021; Froese and Pauly, 2021). Its occurrence in Pakistani waters is reviewed by Moazzam and Osmany (2021). It is one of the important pelagic shark of Pakistan which is mainly caught by tuna gillnet vessels (Fig. 9).

This shark may attain a maximum length of 488 cm (Froese and Pauly, 2020). Although along Pakistan coast maximum size was recorded to be 290 cm landed in Karachi Fish Harbour on 11 February, 2019 but most of specimens of *A. superciliosus* ranged between 120 and 295 cm.

Fig. 8. *Alopias superciliosus*

Seasonal Distribution: At Karachi Fish Harbour, its landings was observed to have two peaks; the first in October and other during April. Maximum landings of bigeye thresher shark was reported to be 2,200 kg in April 2019 whereas in October, 2019, monthly landings was reported to be 900 kg (Fig.10). Poor landings of pelagic threshers were reported in some months during the study period when only one or two specimens were landed in the Harbour. Temporal variations in the landings was observed during various months and years which may be attributed to area of operation of the tuna gillnetters, as observed in case of pelagic threshers. The landings of big-eye thresher in Karachi Fish Harbour was observed to be comparatively lower than pelagic thresher.

Biological Aspects: During the study period, stomach contents of a few specimens of *Alopias superciliosus* were examined which revealed that it feeds upon large and small sized fishes dominated by hairtail (*Lepturacanthus savala*), lancetfish (*Alepisaurus sp.*), unidentified flyingfish and snake mackerel (*Gempylus serpens*). However,

cephalopods were observed to be comparatively rare in the stomach content analysis. On contrary, Preti *et al*. (2008) have observed a few deep sea cephalopods in the stomach of *A. superciliosus* from California. Cephalopods seems to be also more common in the stomach contents of *A. pelagicus* in Ecuadorian waters as noted by Polo-Silva *et al.*, (2009). They have noticed that there is limited trophic overlapping between *A. superciliosus* and *A. pelagicus*, however, both species are secondary-tertiary predators. Bigeye thresher shark has feed on fishes, cephalopods and to lesser extent on crustaceans found in the epipelagic, mesopelagic, epibenthic and deep scattering layer (Preti *et al*., 2008). This species is also known to feed on hake, squid, scombrids, alepisaurids, clupeids, istiophorids and chondrichthyes (Fitch and Craig. 1964; Bass *et al*., 1975 and Smith *et al*., 2008).

Fig. 9. Bigeye thresher shark landings at Karachi Fish Harbour

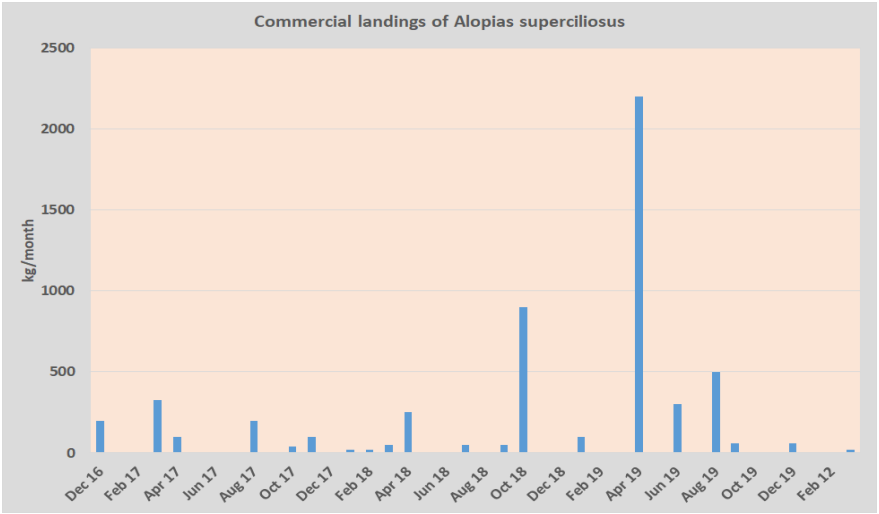

Fig.10. Commercial landings of *Alopias superciliosus* at Karachi Fish Harbour

A. superciliosus also exhibit aplacental viviparity with embryonic oophagy (Dulvy and Reynolds, 1997; Chen *et al.*, 1997; Moreno and Moron, 1992). Gruber and Compagno (1981) evidence of ovophagy by providing a photograph of an infertile, horny eggs of *A. superciliosus* which was found in the oviducts along with the embryos which tend to suggest that embryos of this species consume the yolk-filled eggs during developmental phases. During the study, a few mature female were collected that have developing eggs and fetuses in their bodies. Two embryos having lengths of 82 and 85 cm were dissected out from a female (Fig. 11). Chen *et al*. (1997) have found 6 developmental stage (3 encapsulated and 3 post-hatching). They also noted that it bears 2 embryos per litter with

their size at birth between 135 and140 cm. Similarly, Moreno and Moron (1992) also observed the litter size in bigeye thresher shark to be commonly 2 and rarely 4.

Fig. 11. Developing embryos (85, 82 cm TL) dissected from female big-eyes thresher (*Alopias superciliosus*)

A number of specimens of this species were observed to have ecto-parasites such as pandarid copepod, however, their concentration was found to sparse and of rare occurrence in *A. supercilosus* as compared to *A. pelagicus*. It is also not known whether bigeye thresher sharks also visits cleaning stations for getting rid of their parasites as reported by Oliver *et al*. (2011) for *A. pelagicus.*

Marketing: Meat of bigeye thresher is locally consumed along with meats of other shark species, however, considered to be of poorer quality as compared to meat of *A. pelagicus*. This shark fetches good prices in local market mainly because the species has large fins including very long tail. Although this species is listed on CITES Appendix-II, still its fins are exported from Pakistan to Hong Kong under the disguise of dried fish. In the order of preference, this species was ranked 10th and 6th during 2014-15 and 1999-2000 respectively in the fin trade market of Hong Kong (Field *et al.*, 2017).

Specific Conservation Measures: In addition to the management and conservation measures available under national legislations, IOTC has issued a Resolution No. 10/12 which prohibits fishing vessels operating in the Indian Ocean to retain on-board, tranship, land, store, sell any part or whole carcass of any thresher shark species. The Resolution also require this shark to be to promptly release unharmed, if caught in fishing gears. Attempts have been to convince fishermen in Pakistan to release (if alive) and discard (if dead) thresher sharks but it could not be implemented effectively. A few fishermen have discarded thresher sharks initially but did not continue this practice.

Because of low embryos production (2–4 pups every year), being long lived (more than 20 years), late maturity in 3–9 years, bigeye thresher shark are considered vulnerable to overfishing (Chen *et al*. 1997). Since no stock assessment has been done and only limited information about fishery indicators is available, therefore, it is recommended by IOTC to prohibit the retention of bigeye thresher sharks on-board.

Carcharhinus falciformis (Müller & Henle 1839)
(Fig. 12-15)

Fig. 12. *Carcharhinus falciformis*

Habit and Habitat: It is commonly known as silky shark (Fig. 12) and is an oceanodromous species which is also found in reef areas, inshore and oceanic waters. It has circumglobal distribution in tropical and subtropical waters

(Fricke, *et al*., 2021; Froese and Pauly, 2021). Its occurrence in Pakistani waters is reviewed by Moazzam (2021) and Moazzam and Osmany (2021). It is one of the commercially important shark in Pakistan landed mainly by tuna gillnet vessels (Fig. 13). Silky shark is an oceanic shark species which can attain a maximum length of 350 cm (Compagno and Niem, 1998). Although along Pakistan coast maximum size was recorded to be 179 cm landed in Karachi Fish Harbour on January 2019 but length of most of the specimens of *C. falciformis* recorded from this harbour ranged between 70 and 130 cm.

Seasonal Distribution: At Karachi Fish Harbour, it was observed to be the most common pelagic shark species occurring almost throughout the year especially during October and April. Its peak landings were recorded in December 2019 when a total of 39,800 kg was landed whereas 35,110 kg and 32,300 kg were recorded during October 2018 and January 2018 respectively (Fig. 14). Poor landings of silky sharks were reported in some months during the study period when only few specimens were landed in the Harbour such as in October 2017 when the monthly landings were only 350 kg whereas in May 2018 only 520 kg of silky shark was landed in Karachi Fish Harbour. Temporal variation in the landings was observed during various years may be attributed to area of operation of the tuna gillnetters. In some years, these gillnetters operate in coastal waters whereas in others they operate in deep oceanic waters in the EEZ of Pakistan and in the ABNJ which are known to rich areas for silky sharks.

Fig. 13. Landings of silky sharks at Karachi Fish Harbour in September 2017.

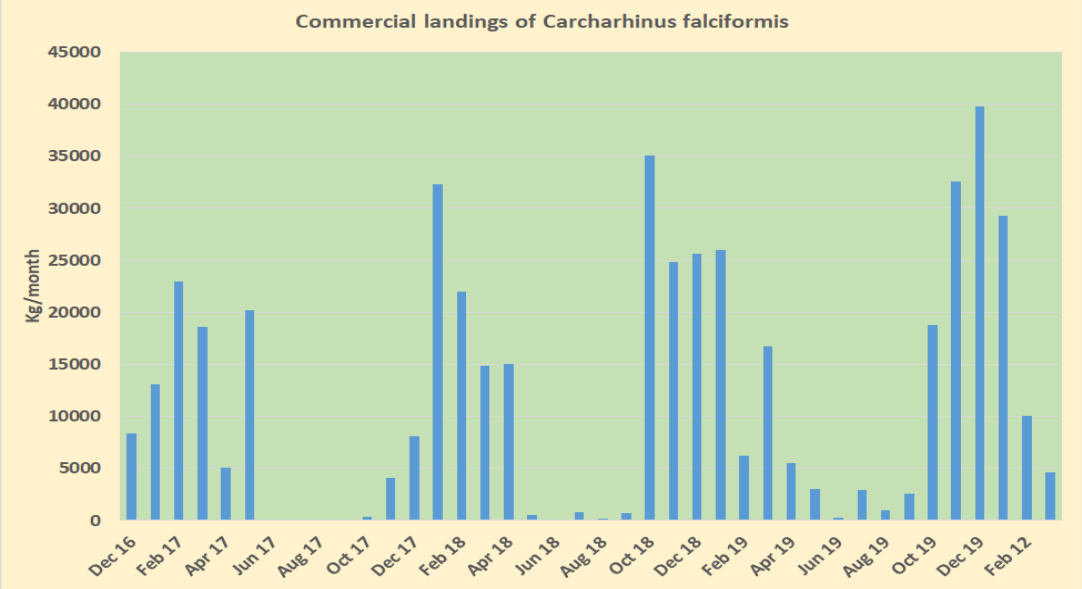

Fig. 14. Commercial landings of *Carcharhinus falciformis* at Karachi Fish Harbour

Biological Aspects: During the study period, stomach contents of a few specimens of *Carcharhinus falciformis* were examined which revealed that it feeds upon small fishes dominated by Indian mackerel (*Rastrelliger kanagurta*), small cobia (*Rachycentron canadum*) and a number of unidentified fishes. Offshore swimming crab {*Charybdis (Goniohellenus) smithii*} is one of the most dominating food of this species. They also feed on purpleback flying squid (*Stenouteuthis oualaniensis*), Indian squid (*Uroteuthis duvacelii*), needle cuttlefish (*Sepia aculeata*) and spineless cuttlefish (*Sepiella innermis*). A 135 cm silky shark was found to have a juvenile green turtle (*Chelonia mydas*) in January 2017 (Moazzam and Osmany, 2020).

Feeding habit and composition of diet have been studied by many scientists including Bonfil (2008), Cabrera-Chavez-Costa *et al*. (2010), Filmalter *et al.* (2017), Flores-Martinez, *et al*. (2017) and N'Gouan *et al*. (2021). The diet of *C. falciformis* from two areas in Baja California Sur was dominated by red crabs (*Pleuroncodes planipes*) and jumbo squids (*Dosidicus gigas*) as reported by Chávez-Costa *et al.* (2010) who considered this species to be a selective predator. Estupinan-Montano *et al.*, (2017) found yellowfin tuna (*Thunnus albacares*), tuna sp. (*Thunnus spp.*) and frigate tuna (*Auxis thazard*) as well as some squids, other fishes and turtles in the stomach of this species in the Ecuadorian waters indicating that it prefer oceanic preys. According to Duffy *et al.* (2015), *C. falciformis* is an opportunistic feeder in the eastern Pacific Ocean. N'Gouan *et al*. (2021) reported that silky sharks has epipelagic and mesopelagic feeding habit as they prey upon a wide number (33) taxa, however, *Thunnus albacares* and *Kutsuwanus pelamis* seems to be dominating prey species in waters off Ivory Coast. According to them, silky shark is considered to be a specialist predator.

Silky shark exhibits aplacental viviparity (Bonfil, 2008; Dulvy and Reynolds, 1997). According to Joung *et al*. (2008) female of this species matures between 210 and 220 cm TL at an age of 9.3 to 10.2 years whereas Grant *et al.* (2018) reported that female reaches sexual maturity at 204 cm (TL) at an age 14 years. Hoyos-Padilla *et al*. (2011) reported that females attain sexual maturity at 180 cm (TL) in Baja California Sur, Mexico. They also noted that average number of embryos in female may range between 2 and 9 (average 5). Average litter size in silky shark was reported to be 8 (range 3 to 13) by Grant *et al.* (2018) whereas according to Galvan-Tirado *et al*. (2015), the number of embryos per litter was 8-10 and noted birth size to be between 60 and 69 cm TL, According to Bonfil (2008), up to 16 (more commonly 6-12) pups are borne that have a size range of 65 to 80 cm TL. During present study a female with two full grown embryos having a size of 32.0 and 32.1 cm (TL) were obtained from Karachi Fish Harbour (Fig. 15).

Marketing: Silky shark is the most dominating pelagic shark which is contributing substantially to shark fin trade from Pakistan but no documentation of quantity being traded is available. This pelagic shark fetches good prices in local market in Pakistan mainly because of its high quality meat which is locally consumed whereas it fins are exported in dry form. Although silky shark is listed on CITES Appendix-II but its fins are still exported to Hong Kong under the disguise of dried fish. During the last two decades, silky sharks was reported to be among the most common species in the shark fin trade in Hong Kong. Cardeñosa *et al*. (2021) reported that silky shark fins of Atlantic origin are not found in the Hong Kong market and major origin of fins of silky shark seems to be from Indo-Pacific area and eastern Pacific. In the Hong Kong market, it is one of the most preferred species as it was ranked 2nd and 3rd during 2014-15 and 1999-2000 respectively (Field *et al.*, 2017).

Fig. 15. Fetuses dissected from female silky shark (*Carcharhinus falciformis*)

Specific Conservation Measures: Silky sharks are considered to be vulnerable to overfishing because these are known to long lived (over 20 years), mature relatively late (6–12 years), and have low fecundity (less than 20 pups).

Although authentic data about abundance of this species is not available, but anecdotal information suggests that silky shark abundance has declined over recent decades. Although silky shark is the most dominating pelagic shark species in Pakistan but its annual landings was believed to much higher in 1980s and 1990s. There is no quantitative stock assessment or basic fishery indicators currently available for silky shark in the Indian Ocean. Considering decreasing catch and threat to the stocks of this species, IOTC has proposed that a cautious approach may be taken by implementing some management actions for silky sharks (IOTC, 2021). There is no specific resolution of IOTC that deals with silky sharks, however, IOTC Resolution (18/07) provides a mechanisms for encouraging Indian Ocean countries to comply with reporting and recording of information about sharks including *C. falciformis*. Cardeñosa *et al*. (2021) stressed on the need for regulations for the management of silky shark stocks in the Indian Ocean which will also help in the control of trade of its fins.

Carcharhinus longimanus (Poey 1861)
(Fig. 16-17)

Habit and Habitat: It is commonly known as oceanic whitetip shark (Fig. 16) and is an oceanodromous species which has circumglobal distribution in tropical to warm temperate areas and mainly found in the deep oceanic waters but sometime coming close to shore (Fricke, *et al*., 2021; Froese and Pauly, 2021). Its occurrence in Pakistani waters is reviewed by Moazzam and Osmany (2021). It used to be among the most dominating species of pelagic sharks in Pakistan but now it is rarely found.

Fig. 16. *Carcharhinus longimanus*

This species can grow to a size of 400 cm (Bacchet *et al*., 2006). Although along Pakistan coast maximum size was recorded to be 287 cm landed in Karachi Fish Harbour on October, 2020. Most of specimens of *Carcharhinus longimanus* recorded from this harbour ranged between 80 and 150 cm.

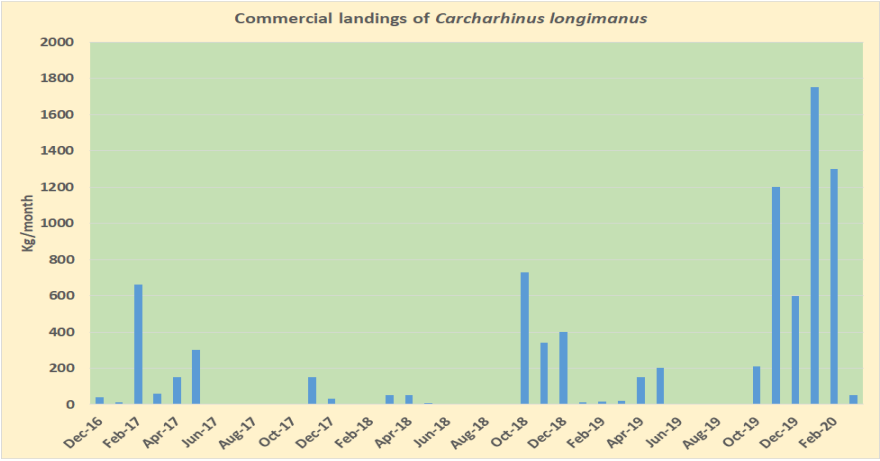

Fig.17. Commercial landings of *Carcharhinus longimanus* at Karachi Fish Harbour

Seasonal Distribution: At Karachi Fish Harbour, its maximum landings was observed during October through May (Fig. 17). During June, 2017 to September, 2018, the landings of oceanic whitetip shark was extremely low whereas

from November, 2019 to February, 2020 higher landings were recorded. During this season highest landings were recorded in January, 2020 when it touched a maximum of 1,760 kg whereas in November, 2019 and February, 2020, monthly landings were recorded as 1,200 and 1,300 kg. Highest landings during this season coincide with operation of Pakistani tuna vessels in the comparatively deeper oceanic waters in search of target species (yellowfin tuna and skipjack tuna). Oceanic whitetip shark is considered to more common in oceanic waters as compared to coastal waters.

Biological Aspects: During the study period, stomach contents of a few specimens of *Carcharhinus longimanus* were examined which revealed that it feeds upon bony fishes including cobia (*Rachycentron canadum*), snake mackerel (*Gempylus serpens*), sickle pomfret (*Taractichthys steindachneri*), flyingfish (unidentified), sharks (unidentified), pelagic crab {*Charybdis (Goniohellenus) smithii*} and cephalopods (unidentified). Being one of the top predators in the open waters of the tropics, oceanic white tip shark feed mostly on pelagic bony fishes, stingrays, seabirds, turtles, marine gastropods, crustaceans, cephalopods, carrion and garbage (Bonfil, *et al*., 2008, Compagno *et al*., 1984, 1989).

During the present study, no mature female that have pups or eggs were observed. According to Bonfil *et al.* (2008), oceanic whitetip sharks are viviparous with aplacental embryonic development. Size at birth was reported to be 55 and 75 cm (TL) and number of embryos in a litter range from 1 to 14 (average 6) in the Pacific Ocean (Bonfil, *et al*., 2008; Seki, *et al*.. 1998; Young and Carlson, 2020). Size in birth in average was reported to be 65-75 cm (TL) in northwestern Atlantic and 60-65 cm (TL) in off South Africa (Bass *et al*., 1975; Bonfil *et al*., 2008; Lessa *et al*., 1999).

Marketing: Oceanic whitetip shark fetches good prices in local market mainly because of its large fins which are exported in dry form. This species in listed in CITES Appendix-II, but still fins are exported from Pakistan to Hong Kong under the disguise of dried fish. It is one of the preferred species in the shark fin trade. In the Hong Kong dry shark fin market, this species was ranked 7th and 8th according to consumer preference during 2014-15 and 1999-2000 respectively (Field *et al.,* 2017). Its meat is locally consumed along with meats of other shark species.

Specific Conservation Measures: Because oceanic whitetip shark is relatively long lived, have late maturity (4–5 years) and produces few pups (less than 20 pups every two years), therefore, it is considered to be vulnerable to overfishing (D'Alberto *et al.* (2016), and Castro *et al*. (1999). In the Indian Ocean, historical data of past 20 years shows overall declines in the catch per unit effort (CPUE) of oceanic whitetip sharks (Romanov *et al*. 2008; IOTC 2015; Young and Carlson, 2020). Tolotti *et al.* (2016) reported noticeable decline in the abundance of this shark in the Indian Ocean during 2000 and 2015 compared with abundance during 1986 and1999. A similar trend is noticed in Pakistan, as its landings has drastically reduced in last 20 years. Since, the information about current population status of oceanic whitetip shark in the Indian Ocean is considered to be not reliable, therefore, there is a need for ensuring adequate data collection for this shark species (Young and Carlson, 2020).

For the management of oceanic whitetip sharks, IOTC has suggested for taking a cautious approach because studies suggest that mortality of this species is extremely high (50%) in longline fisheries in the Indian Ocean (IOTC, 2016; 2021). The information about such fishing mortality rates about other fishing gears such as purse seines and gillnets is not available but believed to be equally high. Retention onboard, transshipping, landing or storing of any part or whole carcass of oceanic whitetip sharks is prohibited in the Indian Ocean countries according to IOTC Resolution 18/07. This species is considered to be highly migratory as well as caught as bycatch of commercial tuna fisheries, therefore, management of the fisheries of the oceanic whitetip sharks is complicated.

Prionace glauca Linnaeus, 1758
(Fig. 18)

Habit and Habitat: It is the rarest pelagic shark landed at Karachi Fish Harbour. It is commonly known as blue shark (Fig. 18) and is an oceanodromous species which has circumglobal distribution in tropical to temperate areas but mainly found in oceanic waters (Fricke, *et al*., 2021; Froese and Pauly, 2021). Its occurrence in Pakistani waters is reviewed by Moazzam and Osmany (2021). It is seldom caught by tuna gillnet vessels operating in the offshore waters.

This species can grow to a maximum length of 400 cm TL (Muus and Nielsen, 1999), however, along Pakistan coast, maximum size was recorded to be 324 cm TL landed in Karachi Fish Harbour on 11 November, 2014. Most of specimens of *Prionace glauca* recorded from this harbour ranged between 170 and 210 cm.

Seasonal Distribution: At Karachi Fish Harbour, this species was observed only on 6 occasion during study period (December 2016 to March, 2020) represented by one specimen at each observation. It was observed in April-May 2017, November 2018, May 2019 and November-December 2019 only. During December 2016 to November 2018, the landings of blue shark was extremely low whereas from November 2019 to February 2020 higher landings were recorded. Variation in the landings observed during various years which may be attributed to area of operation of the tuna gillnetters. In some years, these gillnetters operate in coastal waters in some months whereas in others they operate in deep oceanic waters in the EEZ of Pakistan and in the ABNJ where blue shark may be occasionally encountered.

Fig. 18. *Prionace glauca*

Biological Aspects: No stomach contents of *Prionace glauca* were examined during the present study. Blue shark is known to feed on bony fishes (Scott and Scott, 1988)), small sharks, squids, pelagic red crabs, carrion mainly of cetaceans, sea birds and even garbage (Compagno, *et al*., 1998; Nakano and Steven, 2008).

During the study, no mature female that have pups or eggs were observed, however, the reproduction mode in blue shark is aplacental viviparity with litter size of 30-135 and birth size of pups ranging between 35 and 50 cm (Nakano and Stevens, 2008; Snelson *et al.*, 2008).

Marketing: Blue shark is seldom caught, therefore, there is no specific market for this species in Pakistan. Its fins are exported in dried form whereas its meat is locally consumed along with meats of other shark species. Despites restrictions on international trade due to inclusion of this species in CITES Appendix-II, still fins are exported to Hong Kong under the disguise of dried fish. In the shark fin trade market in the Hong Kong, this species was ranked 1st during 2014-15 and 1999-2000 in the order of preference (Field *et al.*, 2017).

Specific Conservation Measures: Blue shark is the rarest of all pelagic sharks in Pakistan, therefore, no information available on its biology, distribution or management. On the contrary, this shark species is considered one of the most studies shark species in the world (Nakano and Stevens, 2008). Blue sharks have a fecundity of 25–50 pups annually, therefore, it is considered to be the most productive among the pelagic sharks.

IOTC has issued a Resolution 18/02 on the management measures for the conservation of blue shark caught in the Indian Ocean. Blue shark are commonly caught in various fisheries in the Indian Ocean but there is no quantitative information about its stock in the Indian Ocean is currently available (IOTC, 2021). IOTC, therefore, has recommended for maintaining the prohibition on the retention of blue shark on board fishing vessels operating in the Indian Ocean.

Pseudocarcharias kamoharai (Matsubara, 1936)
(Fig. 19)

Habit and Habitat: This species is commonly known as crocodile shark (Fig. 19) which is known to occur in the oceanic water. It is an oceanodromous species that inhabits offshore waters in epi- and mesopelagic zones (Compagno, 2001; Froese and Pauly, 2021). It is included in the present study on the pelagic shark as it is caught mainly by tuna gillnetters of Pakistan that operate in the neritic and offshore areas. Crocodile shark is widely distributed in the temperate and tropical areas in Indian, Pacific and Atlantic Oceans (Fricke, *et al*., 2021; Froese and Pauly, 2021). Its occurrence in Pakistani waters is reviewed by Moazzam and Osmany (2021).

This species can grow up to maximum length of 110 cm TL (Compangno, 2001; Froese and Pauly, 2021). Although along Pakistan coast maximum recorded size was 105 cm TL that was landed in Karachi Fish Harbour on 25 February, 2009 but most of specimens of *Pseudocarcharias kamoharai* recorded from Pakistan ranged between 90 and 100 cm (TL).

Seasonal Distribution: At Karachi Fish Harbour, crocodile shark is reported only on 8 occasions during the study period. It was landed in January to April 2017 on four occasions (in January 2017, 20 specimens were landed). It was also caught in April 2018, October, 2019, December 2019 and February 2020. This species was found to be of rare occurrence in Pakistan.

Fig. 19. *Pseudocarcharias kamoharai*

Biological Aspects: During the study period stomach contents of a few specimens of *Pseudocarcharias kamoharai* were made which revealed semi-digested mesopelagic fish and Savala hairtail (*Lepturacanthus savala*). This species was reported to feed upon small fishes, shrimps and cephalopods (Compagno, 1989; Froese and Pauly, 2021).

During the study, no mature female that have pups or eggs were observed. According to Oliveira *et al*. (2010) *P. kamoharai* has an aplacental viviparity with oophagy but lack any well-defined seasonal reproductive pattern. Its fecundity was estimated to be 4 pups with the size at birth to be 41.5 to 46.1 cm TL (Lessa *et al*., 2015). According to Kindong et *al*. (2020), *P. kamoharai* has medium sized lifespan of 13 years which is much smaller than other elasmobranchs.

Marketing: Crocodile shark seems to have no demand in local market. Its fins are dried and exported along with fins of other shark species to Hong Kong.

Specific Conservation Measures: Since crocodile shark is not considered to be IOTC species, therefore, there is no specific conservation and management measures in place in the Indian Ocean. Because of rarity of occurrence, the information about distribution, biological and fisheries related to the crocodile shark is scarce (Kindong, *et al*., 2021). This species is generally ignored because of rarity of occurrence and low commercial value as therefore, however, because of low reproductive rate (4 pups in a litter), high fishing mortality in various fisheries a major decline in the population of crocodile shark was observed (Kindong *et al*., 2021). IUCN Red List ranks this species as "Least Concern" (LC) but the population of this shark may be declining in its range of distribution, therefore, adequate management measures are required to be undertaken.

Isurus oxyrinchus Rafinesque, 1810
(Fig. 20-22)

Habit and Habitat: It is commonly known as shortfin mako (Fig. 20) and widely distributed in temperate and tropical waters in Atlantic, Pacific and Indian Oceans (Fricke *et al*., 2021; Froese and Pauly, 2021). Being a pelagic shark, shortfin mako is regularly harvested by longlining, gillnetting and purse seining fisheries (Garcia-Cortes *et al*., 2021). In addition, *Isurus oxyrinchus* is also a very important target species in sport fishing in some countries (Casey and Kohler, 1992). Its occurrence in Pakistani waters is reviewed by Moazzam and Osmany (2021). It is second most dominant shark species after silky shark which is landed at Karachi Fish harbor which is mainly caught by tuna gillnet fisheries of Pakistan (Fig. 1, 21).

It is one of the large pelagic and oceanic shark that attain a maximum length of 445 cm TL (Weigmann, 2016). Although along Pakistan coast maximum size was recorded to be 402 cm TL which was landed in Karachi Fish Harbour on 6 December 2018 but most of the specimens of *I. oxyrinchus* recorded from Pakistan ranged between 75 and 280 cm TL.

Fig. 20. *Isurus oxyrinchus*

Fig. 21. Shortfin mako sharks obtained in one haul of tuna gillnetter in 2013

Seasonal Distribution: At Karachi Fish Harbour, mako were observed to be mainly during winter months (October through April). Its maximum landings of 23,900 kg was recorded in December, 2019 whereas in December 2016, its landings was recorded to be 21,465 kg (Fig. 22). No landings of this shark is reported during Mid-May to Mid-August because of voluntary close season. Variation in landing during the years is mainly because of change in the area of operation of tuna gillnetters which operate in coastal waters in some years whereas in others they operate in deep oceanic waters in the EEZ of Pakistan and in the ABNJ where shortfin mako sharks are commonly found.

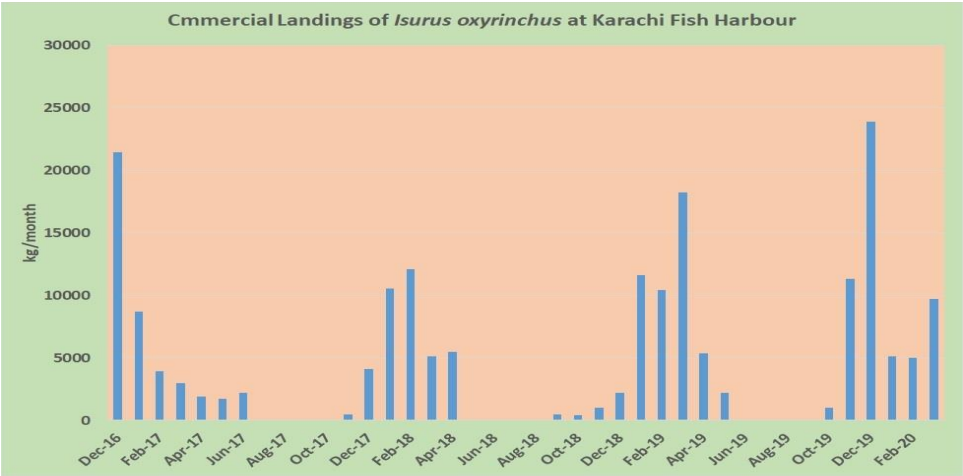

Fig. 22. Commercial landings of *Isurus oxyrinchus* at Karachi Fish Harbour

Biological Aspects: During the study period, stomach contents of a few specimens of *Isurus oxyrinchus* were examined which revealed that it feeds upon fishes dominated by threadfin breams (*Nemipterus spp.*), tuna species such as *Euthynnus affinis*/*Auxis thazard*, blue fish (*Pomatomus saltatrix*), lesser bream (*Brama dussumieri*) as well as on purpleback flying squid (*Stenouteuthis oualaniensis*), cuttlefish and pelagic crabs {*Charybdis (Goniohellenus) smithii*}. Of these purpleback flying squid seems to be the most dominating food item found in the stomach contents of shortfin mako shark. Compagno *et al*., (1989) and White *et al*. (2006) noted that mako shark feeds on bony fishes, sharks, cephalopods; billfish and small cetaceans. Its food consisted mainly of teleost fishes and cephalopods in Northwestern Atlantic and off Australia (Stillwell and Kohler, 1982; Stevens, 2008) while elasmobranch were the most common prey in Natal, South Africa (Cliff *et al*., 1990).

During the study, no mature female with pups or eggs were observed at Karachi Fish Harbour. According to Mollet *et al.* (2000), the size at birth in mako shark to be 70 cm (TL) and fecundity to be between 4 and 25 (average 12). They pointed out variations in the litter size in different parts of the world as litter size was observed to be 4 to 16 in Australia (Stevens, 1983), 9–14 in South Africa (Cliff *et al*., 1990) and 2 to 30 from the Mediterranean Sea (Sanzo, 1912). Joung and Hsu (2005) reported size at birth to be 74 cm (TL). They also observed uterine cannibalism (adelphophagy) occur occasionally most likely due to unequal embryonic growth.

Marketing: Shortfin mako fetches good prices in local market mainly because of better quality of meat as compared to other shark species. Its fin also fetches high prices and exported from Pakistan to Hong Kong in dried form. Despites restrictions on international trade as this species is listed in CITES Appendix-II, but still fins are exported to Hong Kong under the disguise of dried fish. In Hong Kong fin trade market, this species was ranked 5th and 4th in the order of preference during 2014-15 and 1999-2000 respectively (Field *et al.*, 2017).

Specific Conservation Measures: Shortfin mako is globally endangered but remained overfished in major oceans because of high demand for its meat and fins (Rosello, *et al*., 2021; Sims *et al*., 2021). There was a proposal to ban catch reduction and retention of shortfin mako shark on board in the waters of North Atlantic, but some major fishing nations blocked a catch reduction and such blocking a retention ban delays hopes for ending overfishing. Data from the Western and Central Pacific Ocean indicates that this species grows slowly and mature late (Semba *et al*., 2009). The shortfin mako is probably the fastest shark species and is known to leap out of water especially when hooked in sport fishing gear (Stevens, 2008). There is no specific resolution of IOTC that deals with shortfin mako sharks, however, IOTC Resolution (18/07) provides a mechanisms for encouraging Indian Ocean countries to comply with reporting and recording of information about shark species including shortfin mako shark. The conservation of shortfin mako is important because it is mainly caught as bycatch in some fisheries which is remained unmanaged (Cassuto and O'Brien, 2019).

Isurus paucus Guitart, 1966
(Fig. 23)

Habit and Habitat: It is one of the rarest pelagic shark (Fig. 23) landed at Karachi Fish Harbour. It is commonly known as longfin shark and is an oceanodromous species which is distribution in tropical to warm temperate areas of the world (Fricke, *et al*., 2021; Froese and Pauly, 2021). Its occurrence in Pakistani waters is reviewed by Moazzam and Osmany (2021). It is seldom caught by tuna gillnet vessels operating in the offshore waters of Pakistan.

Fig. 23. *Isurus paucus*

This species may attain a maximum length of 427 cm TL (Weigmann, 2016). Although along Pakistan coast maximum size was recorded to be 220 cm TL on Karachi Fish Harbour on 5 March, 2017, but most of specimens of *Isurus paucus* recorded from Pakistan ranged between 120 and 150 cm TL.

Seasonal Distribution: At Karachi Fish Harbour, this species was observed only on 5 occasion during study period represented by one specimen at each observation in March, 2017, December, 2018, January 2019, April, 2019 and February 2020 only.

Biological Aspects: During the study period, stomach content of one specimen of *Isurus paucus* was examined which has partially digested juvenile yellowfin tuna (*Thunnus albacares*). According to Compagno (1984) and Compagno *et al*. (1989, this species feeds mainly on fishes and cephalopods.

During the study, no mature female that have pups or eggs were observed. Longfin mako is an aplacental viviparous species that give birth to 2 pups at a time (Compagno, 1984; Dulvy and Reynolds, 1997). The information about reproduction of longfin mako shark is extremely limited, however, Martin (2008) reported a 3.3 m long female pregnant with 8 well developed embryos was caught in the Mona Passage near Puerto Rico in 1983. The pups in *I. paucus* are reported to be 97-120 cm TL (Gilmore, 1983). No evidence of sibling cannibalism is known.

Marketing: Longfin mako is seldom caught, therefore, there is no specific market for this species in Pakistan. Its fins are exported in dried form whereas its meat is locally consumed along with meats of other shark species. Despites restrictions on international trade due to inclusion of this species in CITES Appendix-II, still fins are exported to Hong Kong under the disguise of dried fish.

Specific Conservation Measures: Longfin makos are considered to be vulnerable due to its low abundance, low reproduction rate, environmental factors and fishing pressures (Mignucci-Giannoni *et al*. 2020). As population abundance trends, distribution, life history, ecology and harvest threats about *I. paucus* are not adequately available, therefore, appropriate conservation measures are required to implemented (Rigby *et al*., 2019).

There is no specific resolution of IOTC that deals with longfin mako sharks, however, IOTC Resolution (18/07) provides a mechanisms for encouraging Indian Ocean countries to comply with reporting and recording of information about shark species including longfin mako. In the absence of a stock assessment and because of limited information about its biology, there is a need to take a cautious approach by implementing any management actions.

Eusphyra blochii (Cuvier 1816)
(Fig. 24)

Habit and Habitat: Although this species is generally found in coastal water on continental shelf (Compagno, 1984), it is included in the pelagic shark as it is generally caught by tuna gillnetters that operate in the neritic areas. It is also included because it congener species occur in pelagic waters. It is the rarest shark landed at Karachi Fish Harbour and is commonly known as winghead shark (Fig.24). It is known from Indo-Pacific area extending from Persian Gulf to the Philippines, north to China, and south to Australia. (Fricke, *et al*., 2021; Froese and Pauly, 2021). Its occurrence in Pakistani waters is reviewed by Moazzam and Osmany (2021).

Fig. 24. *Eusphyra blochii*

Winghead shark is known to have a maximum length of 186 cm TL (Last and Stevens, 1994) whereas along Pakistan coast its maximum size was recorded to be 150 cm landed in Karachi Fish Harbour on 14 May, 2019 but most of the specimens of *E. blochii* recorded from Pakistan have a size range between 45 and 70 cm.

Seasonal Distribution: During study period this species was recorded on two occasion at Karachi Fish Harbour. One specimen each was landed on May, 2019 and April, 2020 only indicating rarity of occurrence of this species. In 1970s and 1980's, this species used to be seen quite often at Karachi Fish Hatbour and other landing centers along Balochistan coast but now it is an extremely rare in occurrence.

Biological Aspects: No stomach content of *Eusphyrna blochii* was examined during the study period. This species of hammerhead shark has extremely large size of the cephalofoil and have eyes placed at the ends of the cephalofoil which give this shark a wider view to facilitate in hunting (McComb, *et al*., 2009). The diet of winghead shark consists of small bony fishes, crustaceans and cephalopods (Compagno, 1998; Last and Stevens, 2009; Stevens and Lyle, 1989).

Like other pelagic sharks, this species has an aplacental viviparity (Dulvy and Reynolds, 1997). Fecundity in winhead shark is reported to range between 6 and 25 pups (Devadoss, 1988; Last and Stevens, 2009; Stevens and Lyle, 1989). Size at birth was reported to be between 32 and 45 cm TL (Compagno, 1998).

Marketing: Winghead shark is seldom caught, therefore, there is no specific market for this species in Pakistan. Its fins are exported in dried form whereas its meat is locally consumed along with meats of other shark species.

Specific Conservation Measures: The species has a patchy distribution in the range of its distribution which makes it vulnerable to fishing. The winghead shark is now rarely encountered in commercial catches of most countries where it was previously frequently reported. Based on available but limited information, it is suspected that population of winghead shark has severely declined in most Asian countries. It is assessed globally as Endangered (EN) according to IUCNRed list..

There is no specific resolution of IOTC that deals with winghead sharks, however, IOTC Resolution (18/07) provides a mechanisms for encouraging Indian Ocean countries to comply with reporting and recording of information about shark species which may include this species.

Sphyrna lewini (Griffith & Smith 1834)
(Fig. 25-28)

Habit and Habitat: This species is commonly known as scalloped hammerhead shark (Fig. 25). It is a pelagic species which occur mainly over continental shelves as well as in the deep oceanic waters. It also occur in the inshore waters in enclosed bays and estuaries (Fricke, *et al*., 2021; Froese and Pauly, 2021). It is widely distributed in coastal warm temperate and tropical waters of Indian, Atlantic and Pacific Oceans (Compagno, 1984; 1998). Its occurrence in Pakistani waters is reviewed by Moazzam and Osmany (2021). It used to be one of the most dominating pelagic sharks in Pakistan but now it is rarely caught as bycatch of pelagic fisheries (Fig. 26).) Scalloped hammerhead shark is also the most common hammerhead shark in the Indian seas (Borrell *et al*. 2011).

Fig. 25. *Sphyrna lewini*

This species may attain a maximum length of 430 cm TL (Froese and Pauly, 2021). Although along Pakistan coast maximum size was recorded to be 270 cm TL landed in Karachi Fish Harbour on 28 May, 2014 but most of specimens of *Sphyrna lewini* recorded from Pakistan Harbour ranged between 65 and 85 cm TL. Small specimens of scalloped hammerhead sharks are caught in coastal waters and continental shelf area by coastal gillnetters whereas larger specimens (200-400 cm TL) are mainly caught as bycatch by tuna gillnetters.

Juveniles of this hammerhead shark are mainly occur in the inshore waters but migrate to deeper water as they grow. This type of ontogenetic migration is reported from almost all the areas of its distribution including India (Borrell *et al*. 2011), Gulf of Mexico (Bonfil, 1997; Madrid *et al*., 1997), Hawaii (Duncan and Holland, 2006) and Mauritania (Ducrocq, 1998). In India the size range of *S. lewini* in the coastal waters to be 52–76 cm TL confirming that juveniles are more common in coastal waters (Borrell *et al*. 2011). Raje *et al*. (2002) reported from Kerala, India that 98% of scalloped hammerhead caught by gillnets and landed from 1990 to 1993 were juveniles (40 to 60 cm TL). According to Gallagher and Klimley (2018), scalloped hammerhead is highly migratory and can move long distances. The information about migration of this species is lacking in Pakistan, although juveniles are known to be inhabiting coastal waters over the shelf.

Fig. 26. Scalloped hammerhead shark landings at Karachi Fish Harbour in October 2019

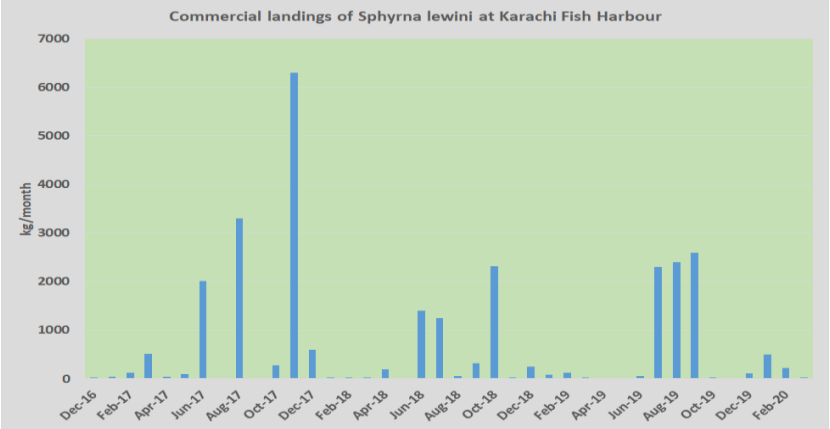

Fig.27. Commercial landings of *Sphyrna lewini* at Karachi Fish Harbour

Seasonal Distribution: At Karachi Fish Harbour, scalloped hammerhead shark is reported throughout the year with more commonly during June to December. Highest landings of 6,300 kg was recorded in November, 2017. This species used to be one of the most common landed sharks in 1970s and 1990s but it landings has decreased since 2000. Although species specific landings data is not available but during 1990 and 2000, bottom set gillnetting (with multi-monofilament) and bottom set longlining targeting sharks were used in Pakistan for catching sharks which resulted in depletion of shark stock. Scalloped hammerhead was one of the most dominating species caught in this period but now this shark is now extremely rare.

Biological Aspects: During the study period, stomach contents of a few specimens of *Sphyrna lewini* were examined which revealed that it feeds upon bony fishes including Indian mackerel (*Rastrelliger kanagurta*), shrimp scad (*Alepes djedaba*), dragonfish (*Astronesthes cyaneus*), snake mackerel (*Gempylus serpens*), rough triggerfish (*Canthidermis maculata*), Savalai ribbonfish (*Lepturacanthus savala*), shadow driftfish (*Cubiceps whiteleggii*), splitfin (*Parascombrops pellucidus*), sharks. Rays, crustaceans and cephalopods. Torres-Rojas *et al*. (2006) reported that *S. lewini* feed upon 28 species of fishes and cephalopod (*Loliolopsis diomedeae*) off the coast of Mazatlán, Mexico. Throughout its range of distribution, this species is considered to be a generalized and specialist feeder (Flores-Martınez *et al*. 2017; Gallagher and Klimley, 2018; Estupinan-Montano, *et al*., 2021c). Clarke (1971), Stevens and Lyle (1989) and Simpfendorfer and Milward (1993) reported that food of *S. lewini* consists of fish, cephalopods, and crustaceans. Since adults and juveniles occupy different habitats, therefore, the food items they consume also differs. Adults of scalloped hammerhead feed on fish, crustaceans, and cephalopods, with squid as a primary prey item (Gallagher and Klimley, 2018). Borrell *et al*. (2011) and Cabrera-Chavez and Castillo-Geniz (2000) reported that *S. lewini* is a generalist feeder with ontogenetic dietary shifts as smaller specimens fed primarily on shrimps, the mid-size animals mainly on crabs, and the largest ones primarily on bony fishes.

Stomach contents analysis of the juveniles and sub adults that were caught from coastal waters in Pakistan reveals that it feed on mantis shrimp, portunid crabs, shrimp (*Solenocera* sp.), cephalopods (*Sepia* sp.) and fishes including Japanese threadfin bream (*Nemipterus japonicas*), Savalai ribbonfish (*Lepturacanthis savala*), pompano (*Trachnotus sp*.) and a large number of unidentified teleost species. Bush (2003) noticed that juvenile *S. lewini* consumed crustacean and teleost prey in Hawaii. Crustaceans were more important than teleosts by numbers (60.77%) and *Alpheus malabaricus* appears to account for about 36% of the diet. Rojas *et al*. (2014) observed that the cephalopod (*Loliolopsis diomedeae*) and fishes of the family Carangidae are important diet of juvenile *S. lewini* whereas red crab (*Pleuroncodes planipes*) and gerreid fishes were also major prey items in the south-eastern Gulf of California.

Juvenile scalloped hammerhead occupy coastal areas, bays and shelf areas which are mainly caught by coastal gillnetters in Pakistan (Fig. 28). These juveniles is known to migrate to pelagic habitat in open ocean as they grow. Estupiñán-Montaño *et al*. (2021b) observed that with such change in habitat also results in ontogenetic changes in its diet which is evident from high consumption of coastal prey up to two years and shifting to oceanic prey after 2-4 years and a shift to high coastal prey at more than 4 years. Their study showed juveniles of scalloped hammerhead migrate from coastal to oceanic waters, and return to coastal habitats as adults in Eastern Tropical Pacific. According to them migration of *S. lewini* is potentially related to the use of coastal zones in the which is both as important feeding areas for juveniles and as feeding and breeding area for adults. Torres-Huerta *et al*. (2008) observed presence of juveniles, and gravid females in the east coast of the Gulf of California and in La Paz Bay which indicates that these areas are used as a feeding ground as well as nursery for *S. lewini.*

Fig. 28. Juvenile scalloped hammerhead caught from inner-shelf area along Pakistan landed at Karachi Fish Harbour

According to Gallagher and Klimley (2018), juvenile od scalloped hammerhead shark inhabit shallow inshore waters in the Gulf of California, where they feed upon benthic prey such as isopods, octopods (*Octopus sp*.), scorpion fish (*Scorpaena sonorae*), and neritic fish species such as grunts (*Adioryx suborbitalis*) and mackerel (*Scomber japonicus*). Along the coast of Pakistan, juveniles are found in coastal waters and bays whereas adults are largely caught in offshore waters. Large adults were not caught in coastal waters or mangrove areas along Pakistan coast which may suggest these areas may not be important feeding and breeding grounds for adults contrary to observation made by Torres-Huerta *et al*. (2008). Bejarano-Alvarez *et al.* (2021) also reported that the coastal waters off Oaxaca, Gulf of Tehuantepec, Mexico are an important nursery area for the scalloped hammerhead shark due to presence of neonates, juveniles, and pregnant females.

Estupinan-Montano *et al*. (2021c) suggested that *S. lewini* is a top predator occupying variable trophic positions over its lifetime by consuming prey in different trophic food chain performing multiple trophic roles ranging from primary piscivores to tertiary piscivores in the trophic web of the Eastern Tropical Pacific and also consume prey at lower trophic levels such as crustaceans as well as other elasmobranchs both in coastal and oceanic regions. They have also found that scalloped hammerhead shows changes in trophic position according to sex, growth, and maturity stages. Estupinan-Montano *et al*. (2021c) strews on the need to identify foraging and other essential areas for *S. lewini* which is essentially required for the management of the stocks of this species. .

Jorgensen *et al*. (2009) observed that *S. lewini* diving to a depth of the sea which has extreme hypoxic zone of the oxygen minimum layer (OML) in the lower Gulf of California. Arabian Sea is also known for a pronounced hypoxia zone for most of its parts in the offshore waters (Shenoy *et al*., 2020). Although there is no evidence of scalloped hammerhead diving to oxygen minimum zone in Pakistan or other parts of the Arabian Sea but their abundance in the area may be indicative that *S. lewini* may be foraging on the fauna inhabiting in this zone. The stomach content analysis of ta few specimens caught from offshore waters from Pakistan in January 2019 were observed to have a number of species which are found in deep waters off the shelf including Savalai ribbonfish (*Lepturacanthus savala*), shadow driftfish (*Cubiceps whiteleggii*), splitfin (*Parascombrops pellucidus*), snake mackerel (*Gempylus serpens*) and dragonfish (*Astronesthes cyaneus*) which tends to suggest that scalloped hammerhead may dive to oxygen minimum zone in the Arabian Sea for foraging.

Spaet *et al.* (2017) also provided evidence including deep diving behaviour of scalloped hammerhead shark that mesopelagic habitats in the Red Sea. They observed that besides vertical migration during night, the shark exhibited frequent excursions to mesopelagic zone during daytime. Similarly, Hoffmayer *et al*. (2013) also noted diurnal vertical migration of scalloped hammerhead in the northern Gulf of Mexico.

Sphyrna lewini is known to have an aplacental viviparity mode of reproduction (Dulvy and Reynolds, 1997). During the present study, a number of mature female were dissected which showed 18-34 pups (44 to 47 cm TL) mainly during April and June (Fig. 29). Estupiñán-Montaño *et al.* (2021a) reported that in Ecuadorian waters fecundity was 16–22 embryos (11.1–54.6 cm TL) whereas Hazin *et al*. (2001) have reported females that have between 2 and 21 embryos or pups (3 to 38 cm TL) from north western Brazil. Bejarano-Alvarez *et al.* (2021 reported 14 to 40 embryos with a size between 41 and 51 cm TL from the coastal waters off Oaxaca, Gulf of Tehuantepec, Mexico. Torres-Huerta *et al*. (2008) observed a fecundity of 32 embryos in the Gulf of California whereas the birth size was found to be between 41 and 53 cm TL. Fecundity of this species ranges from 13–23 pups in Eastern Pacific to 12–38 pups in Western Pacific and 30–40 pups in Northwest Gulf of Mexico (Cortés, 2000). The average number of pups for the North and South Atlantic were reported to 24 pups per litter and 18.5 pups per litter, respectively (Gallagher and Klimley, 2018). The number of embryos in pregnant females ranged from 14 to 41, with a mean of 25 in Indonesian waters (White *et al*., 2008). According to Duncan and Holland (2006) *S. lewini* gives birth to 13–30 pups which are born in shallow coastal nursery habitats in Hawaii nursery (Kaneohe Bay, Oahu).These studies indicates that fecundity in *S. lewini* varies with area and size of female.

Compagno, *et al.* (2005) reported that adults of scalloped hammerhead sharks are migratory in nature. They have a coastal phase in early life and also a pelagic phase as an adult. They are also known to move from pelagic phase again to coastal area for breeding (Estupiñán-Montaño *et al*., 2021b). Information about such migration is not reported from Pakistan whereas no nursery area for *S. lewini* is known from the area, however, juvenile scalloped hammerhead are occasional caught by gillnet and trawlers that operated in inner shelf along Pakistan coast but there is a need to undertake study to identify nursery area for this species.

Marketing: Scalloped hammerhead shark fetches good prices in local market mainly because of its fins which are exported to Hong Kong. Despites restrictions on international trade, as this species is included in CITES Appendix-II, but still fins are exported to Hong Kong under the disguise of dried fish. Fins of scalloped hammerhead sharks are preferred and prized by consumers as compared to fins of other shark species in the Hong Kong market

(Abercrombie *et al*. 2005). Meat of scalloped hammerhead is locally consumed along with meats of other shark species.

Specific Conservation Measures: Commercial fishing is considered to be the greatest threat to the population of *Sphyrna lewini* in Pakistan and other area of its global distribution (Baum *et al*. 2007; Gallagher and Klimley, 2018). Clarke *et al*. (2006b) estimated that about 1.3–2.7 million scalloped hammerhead shark (also including smooth hammerhead shark) end up in the shark fin trade globally annually. Like other sharks, scalloped hammerhead sharks are highly vulnerable to pelagic longline and bottom longline mainly as bycatch (Gallagher and Klimley, 2018). This species is also harvested as bycatch in other fisheries such as trawls, driftnets, purse-seines. Its stocks also seriously impacted due to artisanal fisheries which is mainly undertaken in coastal area resulting in mortality of juveniles which inhabit coastal waters (Baum, *et al.,* 2007). Although no species related landings data for shark species is available in Pakistan but major decrease in catches of scalloped hammerhead shark was noticed after 1999.

Fig. 29. Developing embryos dissected out of a female *Sphyrna lewini*

Scalloped hammerhead sharks are extremely vulnerable to various fishing operations including gillnet fisheries in coastal and offshore waters. This species is known to be long lived (over 30 years) and have low fecundity (less than 31 pups each year), therefore, it is considered to be vulnerable to overfishing. There is no stock assessment or fishery indicators currently available for scalloped hammerhead shark from the Indian Ocean. In a study carried out in Indonesia, Chodrijah and Setyadji (2015) noticed that due to substantially lower mean size and presence of more immature scalloped hammerhead sharks in the Eastern Indian Ocean which may seriously impact the sustainability of its stock.

Even in the absence of the information about its stocks in the Indian Ocean, there is a need to take a cautious approach by implementing management actions for scalloped hammerhead sharks. There is no specific resolution of IOTC that deals with scalloped hammerhead shark, however, IOTC Resolution 18/07 provides a mechanisms exist for encouraging Indian Ocean countries to comply with their recording and reporting requirements for various shark species including *Sphyrna lewini*.

Scalloped hammerhead is considered to be one of most endangered shark in the area of its distribution because of uncontrolled fishing especially juveniles are being caught as bycatch in most global fisheries. Although size frequency data has not been collected and analyzed during the present study, however, juveniles are still abundantly caught by gillnet fisheries, as bycatch, in both coastal and offshore waters of Pakistan. It is explicitly known to fishermen that quantity of scalloped hammerhead shark caught by gillnet vessels has substantially decreased in last 20 years.

In the regional countries including India, hammerhead shark has been overexploited mainly as bycatch of many fisheries in India (Thomas *et al*., 2021). They, therefore, recommended to ensure sustainable fisheries for this species through fishery-independent monitoring including tag and release to monitor movement of hammerhead sharks and identifying the area and season of breeding and nursery aggregations of the species through exploratory surveys. Thomas *et al*. (2021) also suggested involvement the stakeholders through a participatory approach for management and conservation of scalloped hammerhead shark and for undertaking species-specific management

measures including establishment of protected areas in spawning sites of scalloped hammerhead shark. They urged for strict implementation of gear regulations to protect juvenile fish, maintain spawning stocks and control the sizes of fish caught.

Simeon *et al.* (2021) studies exploitation of *Sphyrna lewini* in Indonesian waters and suggested for taking strict management measures for its conservation. In Pakistan, also rigorous management regime for conservation of scalloped hammerhead has to be developed and implemented. Scalloped hammerhead exhibit slow rates of growth and late age at maturity, therefore, there is a need for a re-assessment of the relative resilience of this globally threatened shark species because of high level of fishing mortality (Drew *et al*., 2015). According to Gallagher and Klimley (2018) and Gulak *et al*. (2015) it is now well established that hammerhead sharks are more sensitive to capture than other shark species therefore require strict management measures for its sustainability. According to White *et al*. (2008) the removal of large numbers of this apex predator (scalloped hammerhead shark) in the Indonesian waters may be affecting the trophic structure in such waters. Similar trophic cascade may be prevailing in other parts of the world where scalloped hammerhead shark is overfished or their stocks are serious depleted. The scalloped hammerhead is the first shark to be protected by the U.S. Endangered Species Act, 2014 citing four of the six distinct population segments as threatened (Indo-West Pacific, and Central/Southwest Atlantic) or endangered (Eastern Atlantic and Eastern Pacific). Pakistani population of *S. lewini* being a part of Indo-Pacific population, therefore, threatened and immediate management measures are warranted.

Sphyrna mokarran Ruppell, 1837
(Fig. 30-31)

Habit and Habitat: This species is commonly known as great hammerhead shark (Fig. 30) and is a pelagic and oceanic shark that is found close inshore as well as in the offshore waters over the continental shelves (Compagno 1984; Froese and Pauly, 2021). This species is considered to be primarily a coastal species, but known to migrate to offshore pelagic habitats (Queiroz *et al*. 2016; Graham, *et al*,. 2016; Hammerschlag, *et a*l., 2011; Harry, *et al*., 2011; Morgan and Carlson, 2010). Its occurrence in Pakistani waters is reviewed by Moazzam and Osmany (2021). It used to be one of the important pelagic sharks in the commercial fisheries of Pakistan but now it is rarely found in pelagic shark fisheries.

Fig. 30. *Sphyrna mokarran*

This species is known to attain a maximum length of 610 cm TL (Froese and Pauly, 2021). Although along Pakistan coast maximum size was recorded to be 362 cm TL landed in Karachi Fish Harbour on 18 October 2007 but most of the specimens of *Sphyrna mokarran* recorded from Pakistan ranged between 83 and 230 cm TL.

Seasonal Distribution: At Karachi Fish Harbour, great hammerhead shark is reported to have no specific pattern but seems to be rarely encountered during winter months (Fig. 31). During the study period, it was observed to be occurring on seven occasions mainly in October. Nevertheless this species used to be among one of the most common sharks observed during in 1970s and 1990s but it landings has decreased since 2000 and reached an ebb during last five years.

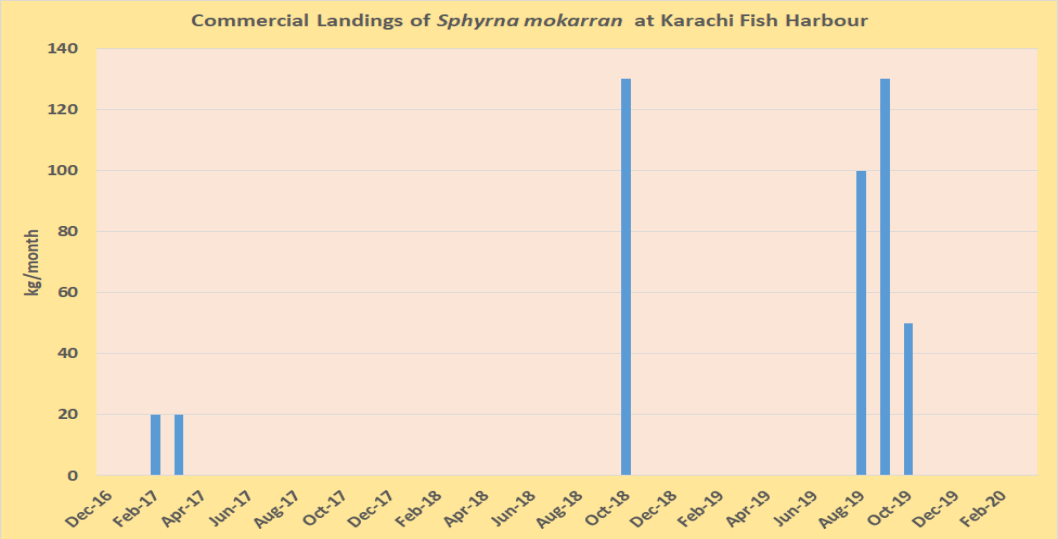

Fig. 31. Commercial landings of *Sphyrna mokarran* at Karachi Fish Harbour

Biological Aspects: During the study period, no analysis of stomach contents of *Sphyrna mokarran* was done. This species is known to feed mainly upon bony fishes (groupers and sea catfishes), chondrichthyes (stingrays and other batoids), but also preys on crabs, squid, other sharks, and lobsters (Compagno, 1984; 1998; Froese and Pauly, 2021). Stevens and Lyle (1989) observed that teleosts to be the main food item followed by crustacean by *S. mokarran*. According to Raoult *et al*. (2019) large *S. mokarran* are apex predators mainly feeding on sharks and rays such as Australian cownose rays (*Rhinoperon neglecta*) as its diet in the off eastern Australia however, teleosts, cephalopods and crustaceans were not observed to be the significant components of great hammerhead shark diets.

Strong *et al.* (1990) reported that this species may occupy inshore habitats where it may feed on stingrays such as southern stingray (*Dasyatis americana*) in east of North Bimini Island, Bahamas. In addition, Chapman and Gruber (2002) reported predation by a great hammerhead on a spotted eagle ray (*Aetobatus narinari*) in south of South Bimini Island, Bahamas. Unlike other shark species, cephalopods are not an important prey item for this species (Smale and Cliff 1998). Interestingly, Roemer *et al*. (2016) reported this species to be an opportunistic feeder in shallow tidal flats.

During the study, no mature female that have pups or developing embryos were observed. However, the species is known to be aplancental viviparous species (Dulvy and Reynolds, 1997). *Sphyrna mokarran* is believed to give birth in the offshore waters (Harry *et al*., 2011). However, Baker *et al*. (2017) observed two S. *mokarran* neonates in near shore habitat of South Carolina and the northern Gulf of Mexico coast of Florida which tends to indicate that *S. mokarran* may pupped elsewhere and its neonates subsequently moved into near shore areas after parturition.

The litter size ranges from 6 to 55 pups measuring 50–70 cm TL at birth. Stevens and Lyle (1989) reported size at birth to be 65 cm (TL) with a litter size of 15 for great hammered shark. According to Cortés (2000) and Cortés *et al*. (2015), the average fecundity of greater hammerhead shark is 15 pups in both the Atlantic and Eastern Indian Ocean with a maximum of 33 pups. The young differ from the adults in having a rounded frontal margin on the head (Rigby *et al*. 2019).

Marketing: Great hammerhead shark fetches good prices in local market mainly because of its high priced fins. This species is listed on CITES Appendix-II, but its fins are still exported from Pakistan to Hong Kong under the disguise of dried fish. As compare to other shark species including other hammerhead species, fins of *Sphyrna mokarran* are preferred and prized by consumers in Hong Kong fin trade markets (Abercrombie *et al*. 2005). In the Hong Kong fin trade market, this species was ranked in the order of preference 7th and 9th during 2014-15 and 1999-2000, respectively (Field *et al.*, 2017). Its meat is locally consumed along with meats of other shark species.

Specific Conservation Measures: Populations of great hammerhead sharks have drastically declined in the world oceans (Baum *et al*. 2003; Shepherd and Myers 2005; Myers *et al*. 2007; Ferretti *et al*. 2008; Hammerschlag *et al*. 2011). In the Atlantic alone, stocks of *Sphyrna mokarran*, have declined over 89% between 1986 and 2000 (Myers *et al*. 2007). In Pakistan, great hammerhead used to of frequent occurrence during 1980's and 1990's but since then,

it has become extremely rare. In the coastal waters in the Southwest Indian Ocean, catches of great hammerheads also declined by 89% which is attributed to be as a result of illegal longline operations targeting hammerheads during 1978 and 2003 (Dudley and Simpfendorfer, 2006; Gallagher and Kimley, 2018). Due to its highly migratory nature, low fecundity, late age of sexual maturity and slow growth *Sphyrna mokarran* is considered highly prone to overexploitation.

Although no species related data for shark species including great hammerhead shark is available in Pakistan but major decrease in catches of this species was noticed after 1999 indicating that its stocks are depleted mainly due to overfishing. Despite the absence of stock assessment information in the Indian Ocean, there is a need to take a cautious approach by implementing management actions for great hammerhead sharks. There is no specific resolution of IOTC that deals with great hammerhead shark. According to IOTC Resolution 18/07 a mechanisms exist for encouraging Indian Ocean countries to comply with their recording and reporting requirements for various species including great hammerhead sharks. Experiments have been conducted to avoid the catching of hammerhead under various fishing methods and some advances in bycatch reduction devices with a specific focus on hammerhead sharks were made (O'Connell *et al*. 2015), however, implementation on these methods is undeniably challenging,

Sphyrna zygaena Linnaeus, 1758
(Fig. 32)

Habit and Habitat: This species is commonly known as smooth hammerhead shark (Fig. 32). It is known to inhabit pelagic-oceanic environment. Being oceanodromous it is found in the inshore and offshore water over continental shelves (Compagno 1984; Froese and Pauly, 2021; Gallagher and Kimley, 2018). It is known to have a widespread distribution in temperate and tropical waters of the Atlantic, Indian and Pacific Oceans as well as Mediterranean and Red Sea (Compagno, 1984; 1998). Its juveniles are predominantly found in the coastal waters whereas adults are found more commonly in the offshore waters (Smale 1991). Its occurrence in Pakistani waters is reviewed by Moazzam and Osmany (2021). It used to be one of the common sharks in the commercial fisheries of Pakistan but now it is rarely found in pelagic shark fisheries.

Fig. 32. *Sphyrna zygaena*

This species has maximum length of 500 cm TL (Froese and Pauly, 2021). Although along Pakistan coast maximum size was recorded to be 285 cm TL landed in Karachi Fish Harbour on 02 October 2019, however, most of specimens of *Sphyrna zygaena* recorded from Pakistan ranged between 120 and 180 cm TL.

Seasonal Distribution: At Karachi Fish Harbour, smooth hammerhead shark is reported only on four occasions during the study period. A few specimens were landed in December, 2016, March, 2017, October, 2018 and October, 2019. This species used to be among one of the common landed sharks in 1970s and 1990s but its landing has decreased since 2000 and now substantially reduced.

Biological Aspects: During the study period, no stomach contents of *Sphyrna zygaena* was analyzed. This species is considered to be a top predators in the marine food webs (Cortés, 1999). It is known to feed on small elasmobranchs, bony fishes, cephalopods, and to a lesser extent crustaceans (Compagno, 1984; 1998; Froese and Pauly, 2021). In some areas, stingrays are its favored prey and comprise a majority of its diet (Strong *et al.,* 1990)

which is evident from venomous barbs of stingrays that are often found lodged in and around the mouths of this shark. Strong, *et al*. (1990) reported one specimen of smooth hammerhead shark that have 95 such spines. In northern Europe, the smooth hammerhead feeds on herring and sea bass whereas in North America, this species devour on Spanish mackerel and menhaden (Smale, 1991). In the offshore waters of South Africa, smooth hammerheads were reported to feed on squid such as *Loligo vulgaris* and small schooling fish (pilchard) as well as small sharks and rays (Fowler *et al*., 2005). Off Australia, squid are the most important prey, followed by bony fish (Fowler *et al*., 2005; Smale, 1991) whereas in the off southern Africa, stomach content analysis of this shark indicates that neritic and oceanic cephalopods composed 55.81% and 21.31% wet mass of prey respectively (Smale and Cliff (1998). Similarly in the Southern Atlantic, smooth hammerheads appear to primarily feed on cephalopods (Bornatowski, *et al*., 2014), however, Gonzalez-Pestana, *et al*. (2017) suggested an ontogenetic shift in diet and habitat in smooth hammerhead sharks.

During the study, no mature female that have pups or eggs were observed. This species is known to have aplacental viviparous mode of reproduction (Dulvy and Reynolds, 1997). According to Cortés (2000), Ebert, 2003. Last and Stevens, 1994 and Gallagher and Kimley (2018) fecundity in smooth hammerhead is relatively high (20–50 pups per litter). Each of the pup measures 50–61 cm TL (Compagno, 1998).

Marketing: Smooth hammerhead shark fetches good prices in local market mainly because of its fins which are exported from Pakistan in dry form to Hong Kong. This species in listed on CITES Appendix-II but its fins are still exported to Hong Kong under the disguise of dried fish. According to Abercrombie *et al*. (2005) this shark is the most common hammerhead in the catches off western South America and its fins are exported to Hong Kong whereas Carr *et al*. (2013) and Sebastian *et al*. (2008) reported that it is also fished heavily for shark fin in Galapagos Islands. Its meat is locally consumed in Pakistan along with meats of other shark species.

Fins of smooth hammerhead sharks are considered to be high values due to their large size and high fin-ray count, therefore, like other hammerhead shark, it is a preferred shark species, in fin trade market in Hong Kong (Rose, 1996). In an analysis of the trade data from the Hong Kong fin market, Clarke *et al*. (2006a) estimated that 4–5% of all fins annually traded were from *S. zygaena* (and/or *S. lewini*). Which in terms of quantity would be about 49,000 and 90,000 m. tons. Such quantities of fins can be obtained from 1.3 and 2.7 million individual smooth hammerhead sharks (Clarke *et al*. 2006b). This indicates that scale of harvesting of hammerhead sharks required for producing such quantities of fins. In Hong Kong fin trade market, this species was ranked 4th and 2nd in the order of preference during 2014-15 and 1999-2000, respectively (Field *et al.,* 2017).

Specific Conservation Measures: There is no quantitative stock assessment or basic fishery indicators currently available for smooth hammerhead shark in the Indian Ocean. Gallagher and Kimley (2018) reported that smooth hammerheads were caught in directed fisheries in other areas of the world including USA, Brazil, Spain, Taiwan, off Australia, Africa and the Philippines but there a serious lacunae in the data specific to smooth hammerhead abundance worldwide. Jiao *et al*. (2011) illustrated consistent patterns of population decline for the smooth hammerhead with a collapse beginning in the early 1990s. Although no data for shark species including smooth hammerhead shark is available in Pakistan but major decrease in catches of this species was noticed since 1999 and now it is seldom caught in pelagic fisheries of Pakistan.

Despite the absence of stock assessment information, there is a need to take a cautious approach by implementing management actions for smooth hammerhead sharks. IOTC Resolution 18/07 provides a mechanisms exist for encouraging Indian Ocean countries to comply with their recording and reporting requirements for various species including smooth hammerhead shark.

CONCLUSIONS

Pelagic sharks are important component of the marine ecosystems of offshore waters over continental shelf, slope and deep oceanic waters. These sharks are usually top predators in the pelagic food chain and play important role as oceanic production dynamics. In Pakistan, pelagic sharks are caught by a large fleet of gillnetters that operate in coastal waters (over continental shelf), in the EEZ, in the ABNJ and sometimes fishing in the waters of other countries like Yemen and Somalia (Moazzam, 2011, 2012a-d). There are 12 species of pelagic sharks that are caught as bycatch and landed by the tuna gillnet vessels in Pakistan. Meat of pelagic sharks is locally consumed and fins are dried and exported to Hong Kong. Although most of the pelagic shark species are listed on Appendix-II of the CITES, therefore, it is illegal to export these fins without valid permission from the national CITES management authority (Ministry of Maritime Affairs in case of Pakistan) but still fins of pelagic sharks find its way into Hong Kong shark fin market in the disguise of dried fish.

Of the 12 species of pelagic sharks, crocodile shark (*Pseudocarcharias kamoharai*) is one species which is seldom included in pelagic sharks, however, in Pakistan, it is caught only by pelagic gillnets vessels that operate in the offshore waters of Pakistan, therefore, included in the present study. Similarly winghead shark (*Eusphyra blochii*) is generally found in shallow water on continental shelf but it is included in the pelagic shark as it is generally caught by tuna gillnetters that operate in the neritic areas. It is also included because it congener species occur in pelagic waters.

Silky shark (*Carcharhinus falciformis*) was observed to be the most common species found mainly during October to April whereas blue shark (*Prionace glauca*) which is seldom caught by tuna gillnet vessels from Pakistan. There is ban on catching, retention, marketing and trade of almost all pelagic sharks including silky, oceanic whitetip, thresher and hammerhead sharks under the provincial (Sindh and Balochistan) fisheries legislations, however, implementation on these laws is not effectively made. Invariably these species are landed on all major fish landing centers. It may be added that among pelagic sharks, crocodile shark, shortfin mako and longfin mako are not protected under any national legislations of Pakistan. Although mako sharks (both shortfin and longfin) are now (as of 2019) included in the CITES list of species placed in Appendix-II, therefore, legal protection against export (of their fins) is available under Pakistan Trade Control of Wild Fauna and Flora Act, 2012.

Limited information about crocodile shark is available but this species seems to be of rare occurrence throughout its area of distribution. Though not targeted, this species is being caught frequently in the fishing gears, therefore, there is a need to have a management regime for its conservation. Presently this species is considered to be Least Concern (LC) according to IUCN Red List, but there is a need for a reevaluation considering that it is being caught as bycatch of various fisheries and number are seriously declining.

All pelagic species were observed to be top predator of the pelagic oceanic ecosystem and their conisderable removal through target fisheries as well as bycatch (like in Pakistan) may disturb ecological functioning and may lead to trophic cascade in some areas. In Pakistan, there was an aimed shark fisheries during 1990's which led to collapse of shark landings by 1999. During this period most species that grow to large sizes have disappeared or their numbers were reduced substantially. This was especially noticeable in case of oceanic whitetip, mako and hammerhead sharks as their landings have substially declined and their stocks have not yet recovered. Although the ancedotal infrmation about their species-wise landings is not avaiable and present catches are not adequately recorded but still there are evidences that landings of pelagic sharks has considerable reduced in last two decades. The impact of this reduction in the number of these top predators on the open-ocean ecosystem along Pakistan coast is not known.

Fecundity in most pelagic sharks is low as they produce a few pups except hammerhead sharks which are prolific and can produce up to 41 pups. Owing to lecithotropic and aplacental vivipary with oophagy and uterine cannibalism and resultant low reproductive rate, most pelagic sharks are prone to overexploitation. As most of the species are highly migratory in nature, management at global, regional and national levels are necessairly required for conservation of pelagic sharks. There is a need to identify pupping areas for pelagic sharks as well as areas which are nursery ground for sharks like hammerheads located in coastal areas which will ensure protection of juveniles which are prone of fishing operations in coastal waters. The need for creation of awareness among fishermen communities for protection of sharks cannot be overemphasized as control of overfishing can be effectively implemented if fishermen are engaged in such efforts.

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