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REVIEWING THE DISTRIBUTIONS, CHARACTERISTICS, LIFE CYCLE, FEEDING BEHAVIOUR AND CONSERVATION STATUS OF *SPHYRNA MOKARRAN*

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Abstract:

The ecological status and conservation issues of the great hammerhead shark (*Spyhrna mokarran*) are the concern that are discussed in this paper. In this paper, highlights about the species biology, distribution, feeding behaviour and its role as an apex predator in marine ecosystems. *Spyhrna mokarran* (*S. mokarran*) is known with its huge size, crescent-shaped dorsal in and unique cephalofoil. The area occupied by this species is in the deep oceanic regions and coastal reef area as they have the capability to travel in long distances and adapt to the temperature fluctuation. This research finds that *S. mokarran* species feed on mostly rays, cephalopods, and teleost fish. However, the pattern of their feeding behaviour will be change as its grow older. Additionally, *S. mokarran* is now list as the endangered on the IUCN Red List species all over the world, resulting from the overfishing and the market trade of their high value fins. Thus, the population of this species are fall drastically caused by overexploitation. Some of the efforts that aid in reducing and maintaining this species includes public awareness campaign, the establishment of marine protected areas (MPAs) and legal protections under CITES. The study concludes that, the act of protection of the great hammerhead sharks is vital for both of species' survival and the health of marine ecosystems in order to improve the conservation strategies and stop the species from degrade drastically throughout the whole world.

Keywords:

Conservation, Endangered, Great Hammerhead Shark, Marine, *Sphyrna Mokarran*

Introduction

Globally, hammerhead sharks (family Sphyrnidae) are found in tropical and warm temperate saltwater areas (Páez-Rosas et al., 2024). The family includes two genera, Eusphyra which is monotypic, and Sphyrna which has seven recognized species (Stevens & Lyle, 1989). Three hammerhead species which are *Eusphyra blochii*, *Sphyrna mokarran* and *Sphyrna lewini,* are reported found in the Northern Australia and often caught by commercial gill net fishers (Stevens & Lyle, 1989). The species *Sphyrna mokarran* (*S. mokarran*) is circum-tropical in the Atlantic (Boube et al., 2023; Roemer et al., 2016) and, as well as the Pacific Ocean, Indian Ocean (Stevens & Lyle, 1989), and in the Arabian Gulf (Boube et al., 2023). Occurrences of *S. mokarran* in Australia range from Western Australia; the Northern Territory, to Queensland and New South Wales (Stevens & Lyle, 1989). This species is at the top of the food chain of fish sharks in tropical and temperate regions: (Lubitz et al., 2023).

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The *S. mokarran* is the largest species of the hammerhead sharks and is an especially important species in family Sphyrnidae to the marine environment (Hammerschlag et al., 2011). Their asymptotic lengths were recorded as 264.2 cm for males and 307.8 cm for females in the northwestern Atlantic region (Hsu et al., 2021; Hsu et al., 2022), and 402.7 cm for both sexes combined in eastern Australian seas. This suggests that the *S. mokarran* may be a long-lived and slow-growing species (Hsu et al., 2021; Hsu et al., 2022). Furthermore, it can exceed 610 cm in length and resides in coastal reefs, lagoons, continental shelves, and deep oceans globally (Hsu et al., 2021; Hsu et al., 2022; Gore et al., 2024). The minimum total length (TL) recorded for *S. mokarran* was 65.9 cm (Stevens & Lyle, 1989). Aside from that, *S. mokarran* is regarded as a nomadic species that frequently migrates within coastal-pelagic and semi-oceanic regions (Roemer et al., 2016; Hsu et al., 2021), as it has been observed in both coastal and pelagic waters, undertaking extensive pelagic migrations of up to 3,000 km (Boube et al., 2023). The geographic distribution of the great hammerhead encompasses coastal mild temperate, tropical, and subtropical waters, extending from latitudes 40° N to 35° S (Hammerschlag et al., 2011), with a temperature range of 26.6°C to 28.9°C (Boube et al., 2023). Nonetheless, *S. mokarran* appeared to migrate from their native seas when temperatures exceeded the 26°C threshold (Boube et al., 2023).

Figure 1: Great Hammerhead, *Sphyrna mokarran*

Source: (Kok, 2022)

S. mokarran can be distinguished from its smaller congeners by its large crescent-shaped dorsal fin and broad cephalofoil that lacks a notch (Hammerschlag et al., 2011). *S. mokarran* contributes significantly towards the welfare of marine ecosystems by dealing with the number of other species, promising ecological equilibrium (Heithaus et al., 2012). However, overfishing poses severe challenges to this species, particularly for its fins, which have become unbelievably valuable in the global fin trade. According to Hsu et al. (2021), because to its large fins, this species of *S. mokarran*, along with other hammerhead species, was sold at high rates in Asian markets and ranked as the second most popular species group in the international fin trade. Furthermore, great hammerhead sharks are especially susceptible to human-induced

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stresses such as commercial (both targeted and bycatch) and recreational fisheries due to their *k*-selected life-history traits (Santos et al., 2023). They also face challenges because to heightened at-ship and post-release mortality resulting from an intensified stress response to capture (Boube et al., 2023).

S. mokarran is a species known to be very peculiar and significant in the hammerhead family. However, *S. mokarran* tends to be the least known of all other two hammerhead species which are the smooth hammerhead (*Sphyrna zygaena*) and the Scalloped Hammerhead (*Sphyrna lewini*) (Smale & Cliff, 1998). Therefore, more research and information gathering need to be conducted to understand the importance of this species to the environment and the causes that may lead to a decline in its population. Hence, the purpose of this review is to explore the distribution of individuals, life cycle and characteristics, feeding habits, and conservation status of *S. mokarran.*

Methodology

The data collection for this manuscript entailed the methodical extraction of information from electronic databases, namely Google Scholar (https://scholar.google.com/), PubMed (https://pubmed.ncbi.nlm.nih.gov/), Scopus (https://www.scopus.com/), and ResearchGate (https://www.researchgate.net) (Shaik Farid et al., 2024). The search queries utilized in these databases incorporated keywords such as Sphyrna mokarran,' 'distribution of Sphyrna mokarran,' 'health benefits of Sphyrna mokarran,' 'medical properties of Sphyrna mokarran,' 'ecology of Sphyrna mokarran,' 'commercialization of Sphyrna mokarran,' 'phytoremediation in Sphyrna mokarran,' and 'Conservation status of Sphyrna mokarran.

Literature Review

Distribution

S. mokarran has a cosmopolitan distribution (Raoult et al., 2019), primarily in tropical and warm temperate waters around the world. Bimini is one of the natural habitats to numerous great hammerhead sharks during the winter months every year (Heim et al., 2021). As summer winds down, many great hammerhead sharks migrate to the United States (Guttridge et al., 2017). *S. mokarran* are apex predators and can be found worldwide in coastal, warm waters that are 20°C or higher. They can also be found in slightly cooler or warmer waters depending on their migration and the availability of prey. In contrast to scalloped hammerhead sharks, *S. mokarran* are solitary and undertake extensive migrations exceeding 1200 km alone. (Oceana, 2023) *S. mokarran* inhabit the coastal regions and open waters of the Atlantic, Pacific, and Indian Oceans. They reside in diverse marine ecosystems, such as continental shelves, lagoons, and coral reefs. This species is located in continental shelf environments.

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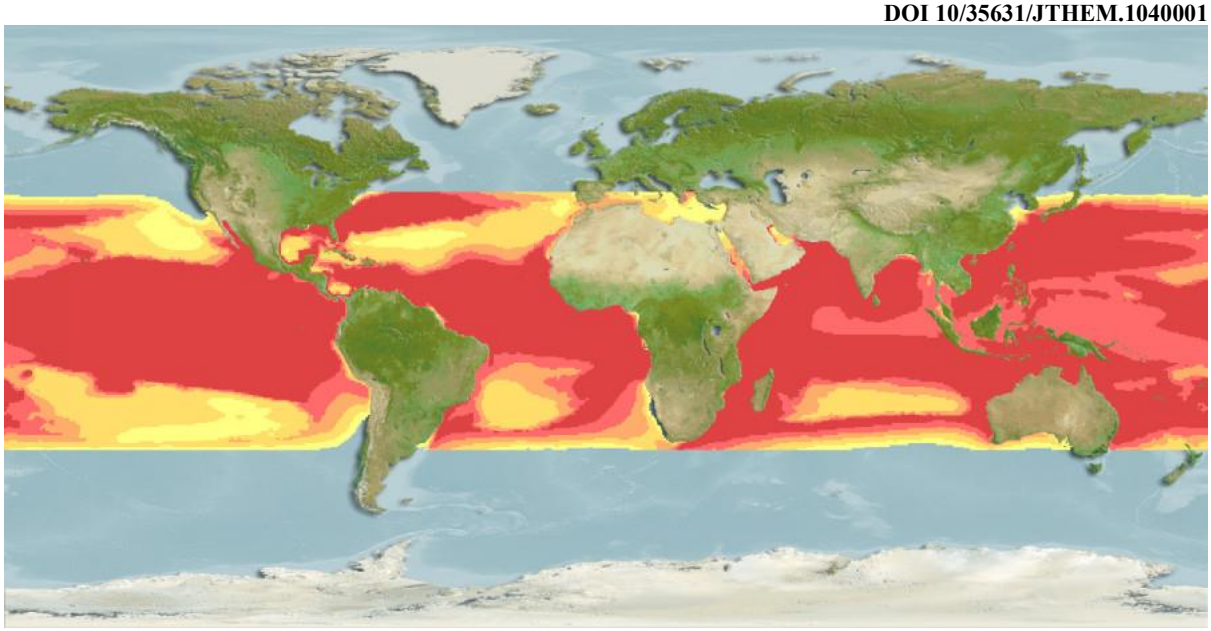

Figure 2: Native Range Map For *Sphyrna mokarran* Where Red Colour Indicates High Probabilities Of Occurrences (0.80-1.00)

Source: (AquaMaps, 2019)

Males are more inclined to travel across the ocean, whilst females typically remain in coastal regions adjacent to shallow nursery habitats (Santos et al., 2023). *S. mokarran* are recognised for their extensive migratory patterns, frequently traversing considerable distances between various environments (Lin Y et al., 2024). They often migrate seasonally in reaction to fluctuations in water temperature, approaching the beach during summer and retreating to deeper waters in winter. Moreover, the availability of prey may serve as the migratory impetus for this species, as they pursue the distribution of prey including stingrays, cephalopods (Raoult et al., 2019), bony fish (Tinari & Hammerschlag, 2021), and crabs. Another reason for migration may be for mating and breeding purposes. This may result in extensive migrations across oceanic basins. Reproduction and parturition occur in areas that offer ideal conditions for the survival of offspring. Females reproduce viviparously once every two years (Miller et al., 2014).

These sharks are located at depths from the surface to approximately 100 meters (Miller et al., 2014), while they may occasionally inhabit greater depths. The sharks inhabiting shallow coastal waters thrive in this region due to the abundant hunting grounds for their favoured prey, including stingrays, bony fish, and crabs. Great hammerhead sharks are known to inhabit the open ocean, or pelagic zones, however they are linked to coastal and shelf regions. In pelagic zones, their presence varies with depth, contingent upon prey availability and other environmental conditions. Tinari and Hammerschlag (2021) determined that the likelihood of encountering *S. mokarran* increased in deeper seas. Other shark species may also inhabit shallow seas. Temperature significantly influences their depth preferences (Heim et al., 2021), as they like warmer water, affecting their vertical (Heim et al., 2021) and horizontal motions.

Characteristics And Life Cycle

With an average length of four meters and a weight of 230 kilograms, the *S. mokarran* is the biggest of the nine hammerhead species. The cephalopod, or straight hammer-shaped head with a noticeable depression in the middle, sets this species apart from other hammerheads. This

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head shape varies among different species of hammerheads but enhances their sensory capabilities and manoeuvrability. The cephalofoil provides hammerhead sharks with a wider and more efficient range for their sensory organs. Their eyes are located on the outer edges of the cephalofoil, giving them a panoramic view and better depth perception. The wide head also houses more ampullae of Lorenzini, which are specialized electroreceptive organs that help detect the electrical signals produced by prey. In addition to growing more quickly than other hammerhead species, great hammerhead sharks mature between the ages of five and nine years. Every two years, *S. mokarran* mate by internal fertilization and give birth to live offspring ranging in number from 6 to 42 pups (Miller et al., 2014). Puppies may live up to forty four years, and longer, if they are not threatened by fishermen or eaten by larger shark species.

Table 1: Taxonomy Of *S. mokarran*

Phylum	Chordata
Class	Chondrichthyes
Subclass	Elasmobranchii
Order	Carcharhiniformes
Family	Sphyrnidae
Genus	*Sphyrna*
Species	*mokarran*

S. mokarran are viviparous, meaning they give birth to live young. Females have a gestation period that can last from 9 to 11 months, depending on the species (Rigby et al., 2019). During this time, the embryos develop inside the mother's body, receiving nutrients from a yolk sac initially and later through a placental connection in some species. The birth of *S. mokarran* takes place in the spring or summer in the northern hemisphere. This species engages in mating behaviours typically during specific seasons. Males often bite females to hold onto them during copulation. This process can involve elaborate courtship rituals, including circling and chasing. Female hammerhead sharks give birth to a litter of pups, with the number of pups varying by species. For example, the great hammerhead shark can give birth to 6-42 pups, while other species may have smaller litters. The pups are born fully formed and independent, ready to fend for themselves (American Oceans, 2023). An area of mangroves was identified as a pupping and nursery ground for the *S. mokarran* species (Forselledo & Mas, 2012).

The species may have an annual reproductive cycle, with the mating season taking place between July and September, embryos reaching sizes of between three and nine cm in September, and pups of approximately 67 cm being born towards the end of August after 11 months of gestation (Forselledo et al., 2022). Studies conducted on the Australian coast have shown that the species does not appear to use coastal areas as nursing grounds (Forselledo & Mas, 2012). Individuals less than 200 cm have not been observed in other areas, and juveniles are found in this area over the course of 12 months (Forselledo et al., 2022). *S. mokarran* continue to grow and develop over several years. Their growth rate and the time it takes to reach maturity can vary by species and environmental conditions (Forselledo & Mas, 2012). Juveniles gradually move to deeper waters as they grow larger and become less vulnerable to predators. This species grows faster than other hammerhead shark species and reaches adulthood early. They also grow quickly during the first ten years of life, after which the growth rate in males slows significantly and in females to a lesser amount (Piercy et al., 2010).

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Feeding Behavior

Analyses of the contents of the stomach reveal details about a particular *S. mokarran* 's target (Smale & Cliff, 1998). Additionally, stable isotope tests can be used to determine the specific fish species' diet (Boube et al., 2023). Furthermore, descriptive observations of predation events in situ are the main source of information about *S. mokarran* s' diets and trophic ecology, indicating that they eat rays (Raoult et al., 2019). The *S. mokarran*, being an apex predator, preys on a diverse array of aquatic creatures. Sharks, or elasmobranchs, prey on seagrass, ocellated eagle rays, groupers, ariid catfishes (Stevens & Lyle, 1989), cephalopods, fish, crabs, bivalve molluscs, teleosts, rays, and stingrays. This assertion was corroborated by additional investigations indicating that *S. mokarran* seems to consume stingrays gradually (Hsu et al., 2022; Boube et al., 2023; Gore et al., 2024). The ocellated eagle ray (*Aetobatus ocellatus*) may serve as prey for the great hammerhead shark in the Central Pacific region (Boube et al., 2023). The stomach contents of the *S. mokarran*, obtained from commercial fisheries in Saudi Arabia, reveal that teleosts constituted the principal prey of this species (Hsu et al., 2022). The types of food available to them are contingent upon their habitat, and the *S. mokarran* in the northwest Atlantic Ocean is recognised for its migratory behaviour in relation to food availability (Boube et al., 2023).

According to Hsu et al. (2022), during three years of birth, the food preferences of the Arabian Gulf *S. mokarran* transitioned from teleosts to elasmobranchs. Younger *S. mokarran* may eat more teleosts; as they get larger, they become apex predators. According to the current study, newborn great hammerheads did not appear to be able to feed on other elasmobranchs; but, as the females grew older, they were able to do so, reaching the highest trophic level at two years of age. Furthermore, when a *S. mokarran*'s body size increases, so too will its trophic level. Larger-gapped fishes and sharks typically eat larger species, which tend to occur at greater levels of trophic status (Raoult et al., 2019). *S. mokarran* fed on elasmobranchs more frequently than other large, more oceanic hammerhead sharks, such the winghead shark and the scalloped, smooth hammerheads.

Adult great hammerhead sharks in eastern Australia primarily consume smaller sharks and rays, with a preference for benthic species. A 3-meter-long *S. mokarran* is said to feed on southern stingrays in the western North Atlantic Ocean near the Bahamas. According to (Raoult et al., 2019), mature *S. mokarran* are specialised predators that mostly eat benthic-associated rays and carcharhinid sharks. The great hammerhead shark is primarily a carnivore. Hsu et al. (2022) state that, the current study discovered two seagrass species in one great hammerhead stomach. Seagrass may have been accidentally consumed during their research and that *S. mokarran* do not typically eat it. Another stomach contained evidence of ingestion of seagrass and terrestrial cockroaches, suggesting that some individuals used shallower, more coastal waters for their natural habitat.

Research indicates that *S. mokarran* reside inshore, in flat, shallow water settings (less than 1.5 m) across numerous locations, while juvenile *S. mokarran* use nearshore, often extensively disturbed marine ecosystems as their rearing grounds. Moreover, the increased presence of invertebrates and demersal fish species in their digestive systems suggests that *S. mokarran* feed mostly on or near the bottom (Stevens & Lyle, 1989). Sharks typically use chemical sense and bioelectric detection through the ampullae of Lorenzini to easily seek their prey (Smale & Cliff, 1998). They use their cephalofoil to pin the stingrays to the substrate as one of their prey

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tactics. Typically, the *S. mokarran* that utilized this method is 300 cm in total length (TL) (Roemer et al., 2016).

Aside from that, *S. mokarran* can use "grasp-turning" strategies to manipulate prey in their jaws for easier ingestion by using the force exerted by the surrounding water. According to Römer et al. (2016), this kind of behaviour gives the predatory shark an edge in strategy over its victim in the vertically constrained area of a tidal flat. To optimise gill oxygen intake and facilitate recuperation from energy consumption and anaerobic acidification during food search, the *S. mokarran* would then shift its body into a strong incoming current and propel itself at a low speed to stay still for fifteen minutes. This manoeuvre could aid in the process of ingesting as the nurse shark remains trapped in the *S. mokarran*'s jaws due to the strong current.

Table 2: Significant Studies Regarding The Diets Of *S. mokarran*

Findings	Sources
S. mokarran can eat prey that have venomous spines	Compagno, 1984
A study in northern Australia found that 87.5% of the *S. mokarran*' diet consisted of fish, crustaceans, cephalopods, and other marine life, with 12.4% being empty.	Stevens and Lyle, 1989
Cephalopods, unlike other species of the *Sphyrna* genus, are not crucial food items in their diet.	Smale and Cliff, 1998
R. neglecta was found to be the primary component of *S. mokarran*'s diet during the summer, when this prey is most abundant.	Raoult et al., 2019
The analysis revealed that 83.2% of stomachs contained elasmobranchs, primarily from the superorder Batoidea, and two shark families, Scyliorhinidae and Carcharhinidae.	Cliff (1995)
S. mokarran preyed on a *Hypanus americana*.	Strong et al. (1990)
S. mokarran attacking an *Aetobatus narinari*	Chapman and Gruber (2002)
S. mokarran was observed preying on bony fish and sharks (*Ginglymostoma cirratum* and *Negaprion brevirostris*)	Roemer et al. (2016)
S. mokarran is observed preying on *Carcharhinus limbatus*	Doan and Kajiura (2020)
S. mokarran having a trophic level of 4.3.	Cortés, (1999).

Factors Contributing To The Loss Of Species

S. mokarran inhabits warm waters and is frequently encountered in global fisheries that target tuna, swordfish, and other species, as well as in coastal gillnet and artisanal fishing. Due to its highly migratory nature, conservation of this species is a critical issue (Chin et al., 2017). They are classified as Endangered on the IUCN Red List and have become extinct in several regions where they once flourished, including the Gulf of California (Pérez-Jiménez, 2014). Although there is no dedicated fishery for *S. mokarran* in the northwest Atlantic Ocean, they are often inadvertently captured in longline fishing operations. Unfortunately, many sharks do not survive after being caught, even if released to the wilds (Gulak et al., 2015; Ellis et al., 2016). Anthropogenic activities pose a serious threat to *S. mokarran*. Zeeberg et al (2006) stated that

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they are captured for their meat and fins and often get unintentionally caught in commercial and recreational fishing gear and beach nets. These dangers are exacerbated by their slow reproduction rates, late maturity, and slow growth (Piercy et al., 2010; O'Connell et al., 2015).

Despite not being commonly sought after, their substantial fins hold significant value in the global shark fin trade, especially in Asia, where *Sphyrna spp*. fins are esteemed for their quality (Abercrombie et al., 2005). In Hong Kong, the largest fin trade market globally, *S. mokarran* constitute approximately 1.5% of the total fins traded each year, amounting to over 375,000 sharks or about 21,000 metric tonnes of biomass (Clarke et al., 2006). Despite efforts to improve catch reporting, many great hammerhead catches go unrecorded, and records often do not distinguish between *Sphyrna spp*. or other shark species. This under-reporting, combined with heavy exploitation, has led to significant population declines. In Belize, extensive fishing during the 1980s and 1990s led to a reduction in the population and size of hammerhead sharks, resulting in their relocation to barrier reefs and the cessation of the local shark fishery (Kyne et al., 2012; Denham et al., 2007). In the Northwest Atlantic, *S. mokarran* have one of the highest discard mortality rates, with over 90% at-vessel mortality documented in the U.S. bottom longline fishery (Denham et al., 2010). Their diminished reproductive rate exacerbates their susceptibility to over-exploitation, with research indicating significant population decreases (Ferretti et al., 2008). Hammerhead shark populations in the Atlantic, including *S. mokarran*, have diminished by over 89% from 1986 to 2000 (Myers et al., 2007), potentially resulting in substantial ecosystem-level consequences.

Fishing pressures are considerable on the east coast of Australia, where *S. mokarran* constitute around 10% of the elasmobranch biomass captured in inshore gillnet fisheries inside the Great Barrier Reef World Heritage Area (GBRWHA) (Harry et al., 2011). These sharks are additionally captured in mid-shelf longline fisheries and by offshore pelagic longline fisheries (Macbeth et al., 2009). Moreover, trawl and recreational fisheries affect these species, and illicit, unreported, and unregulated (IUU) fishing transpires off northern Australia (Field et al., 2009). The absence of essential life-history data impedes the global management of *S. mokarran.* The significant demand for their fins, which are among the most prized shark fins, indicates ongoing depletion at present fishing rates, corroborated by an 80% rise in reported global hammerhead catches from 2000 to 2007 (Lack & Sant, 2009). As a result, *S. mokarran* is classified as Endangered by the IUCN (Baum et al., 2007; Denham et al., 2007).

Table 3: Significant Studies Regarding The Loss Of *S. mokarran*

Findings	Sources
S. mokarran is one of species that are known as species of concern	Chin et al., 2017
S. mokarran is ensnared in fishing apparatus (longlines, gillnets, trammel nets, and trawls) in regions characterised by thin continental shelf.	White et al. 2006, Camhi et al. 2008, Lack and Meere 2009, Diop and Dossa 2011, Miller et al. 2014
S. mokarran is frequently sought for its fins.	Dent and Clarke 2015, Fields et al. 2018
It is probable that catches of *S. mokarran* in pelagic and domestic fisheries are under-reported.	Dent and Clarke 2015
S. mokarran is traded for the fins	CITES 2013

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The fins of *S. mokarran* are a crucial element of the fin trade and are among the favoured species for culinary purposes.	Dent and Clarke 2015, Fields et al. 2018
S. mokarran and other species accounted for 4% of fin imported in Hong Kong (2014)	Fields *et al.* 2018
Clients seek the flesh, liver oil, skin, cartilage, and jaws of *S. mokarran.*	White et al. 2006, Lack and Meere 2009, Miller et al. 2014, Glaus et al. 2015

Conservation Status

The International Union for the Conservation of Nature (IUCN) Red List designates the *S. mokarran* as 'Endangered,' indicating a worldwide decline in its population (Chin et al., 2017). This status indicates a critically elevated risk of extinction in the wild, mostly due to overfishing (Guttridge et al., 2022), bycatch, habitat degradation (Gore et al., 2024), and the illicit shark fin trade (Pacoureau et al., 2021). The quick decrease in population signifies that prompt and efficient conservation measures are essential. *S. mokarran* have experienced some of the most pronounced decreases, as evidenced by research conducted by Baum and Blanchard (2010) and Ferretti et al. (2008) that underscore their swift reduction in numbers. Recognition of the significant peril facing *S. mokarran* is increasing among scientists, policymakers, and the public, despite the complexities of conservation initiatives (Gallagher et al., 2014). Multiple legislative frameworks have been established to safeguard *S. mokarran*. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) categorises the *S. mokarran* in Appendix II, restricting its international trade to prevent endangering the species' survival. Numerous nations have implemented specific legislation to save this species, including the United States, which has incorporated *S. mokarran* into its Endangered Species Act, so restricting its capture and trade.

Moreover, conservation initiatives for *S. mokarran* encompass scientific research, habitat preservation, and awareness campaigns. Marine protected zones (MPAs) are crucial for offering secure environments where these sharks can reproduce and flourish free from fishing pressures. Establishing and managing Marine Protected Areas in vital habitats is essential for the recovery of the great hammerhead shark. Recent findings indicate that banning their capture in US seas could safeguard over 90% of their primary habitat in the Northwestern Atlantic, notwithstanding the intricacy of their alternating utilisation of coastal and pelagic zones (Graham et al., 2016). Research activities, including as satellite tagging and tracking projects, are essential for comprehending the behaviour, migratory patterns, and reproductive biology of *S. mokarran*, hence guiding the establishment of more effective protected areas and laws. Recent biotelemetry applications have enhanced our comprehension of the range of great hammerhead sharks, especially in the western Atlantic Ocean (Guttridge et al., 2017). Research has revealed extensive migrations, seasonal habitation, and site fidelity in *S. mokarran* monitored in Florida and the Bahamas. Public awareness and educational initiatives are essential for securing support for conservation efforts. By emphasising the ecological significance of *S. mokarran* and the challenges it encounters, these ads can influence consumer behaviour, including diminishing the demand for shark fins and promoting sustainable seafood options.

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Notwithstanding these endeavours, considerable obstacles persist in the conservation of *S. mokarran*. Overfishing remains a significant problem because to the substantial demand for shark fins. The inadvertent capture of non-target species through bycatch further intensifies their population collapse. Hammerhead species exhibit greater sensitivity to capture compared to other sharks, adversely affecting catch-and-release fisheries and bycatch mitigation initiatives in pelagic longline fishing (Gulak et al., 2015; Drymon & Wells, 2017). Mitigating the capture of hammerhead sharks in diverse fishing environments is difficult; nonetheless, progress has been achieved in bycatch reduction technologies targeting hammerhead sharks (O'Connell et al., 2015). The *S. mokarran* is endangered due to significant bycatch mortality and a slow reproductive rate, rendering it susceptible to over-exploitation (Denham et al., 2007). Recent catches in the Mexican Pacific originate from oceanic waters in the Central and Southern regions. The effective execution of current laws and regulations is essential, as illegal fishing continues due to inadequate monitoring and enforcement. International collaboration is essential since the migratory behaviour of *S. mokarran* implies that lenient legislation in one area can jeopardise conservation initiatives in another.

Preserving *S. mokarran* is essential for the species and the overall vitality of marine ecosystems. *S. mokarran*, as apex predators, are essential for sustaining marine ecological equilibrium by controlling prey populations, averting the overgrazing of seagrass beds and coral reefs, and enhancing overall ecosystem health and resilience. Conserving *S. mokarran* has substantial ramifications for biodiversity, as the loss of a principal predator may trigger cascading effects that influence several other species. Preserving them is essential for maintaining the stability and diversity of the marine ecosystem; the conservation status of *S. mokarran* necessitates immediate attention and action. Despite considerable progress achieved by legal safeguards, research, and public awareness, the ongoing reduction highlights the necessity for improved and coordinated conservation initiatives. By mitigating threats and enhancing conservation efforts, we can ensure the future of the *S. mokarran* and safeguard the waters for subsequent generations.

The conservation of marine species is vital not only for ecological integrity but also for economic, social, and scientific progress. It is a fundamental component of global environmental sustainability. Maintaining high water quality is thus essential to protect marine biodiversity, ensure sustainable fisheries, and preserve the overall integrity of ocean ecosystems in the face of environmental stress and climate change (Kamaruddin et al., 2022a). Furthermore, Geographic Information System (GIS) can be used to help identify critical habitats, assess threats, and support decision-making processes for effective conservation planning (Kamaruddin et al., 2018). GIS also aids in analysing the impact of human activities, such as fishing, shipping, coastal development, and pollution (Kamaruddin et al., 2020b). It can also support the development of spatially explicit models to predict how marine ecosystems will respond to environmental changes, such as climate change and ocean acidification (Kamaruddin et al., 2022)

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Figure 3: Baby Hammerheads Sold In A Market In Malaysia
Source: (Then, 2019)

Conclusion

The great hammerhead shark, also known as *Sphyrna mokarran (S. mokarran)*, is a rare and ecologically significant species in the Sphyrnidae family. It is known for its size and distinctive cephalofoil features and is often found in tropical and warm-water temperatures. However, *S. mokarran* is facing severe degradation due to overfishing, bycatch, and habitat deterioration. The species' slow growth, low reproduction rates, and late maturity make it vulnerable to extinction. Efforts to protect the species include national legislation and international legal safeguards like CITES listing. However, *S. mokarran* is now listed as endangered on the IUCN Red List, requiring urgent global action. Future research could include temperature monitoring to better understand its impact on the species.

Recommendation

In ensuring the long-term conservation of *S. mokarran* populations, a multifaceted approach is required, encompassing international cooperation, local enforcement, scientific research, and public engagement. Strengthening international protections through mechanisms such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is essential, particularly to regulate and monitor the trade of shark fins. Expanding marine protected areas (MPAs), especially in regions that encompass critical habitats such as migratory corridors, breeding grounds, and nursery areas, would further safeguard essential life stages of *S. mokarran*. These MPAs should include no-take zones to mitigate direct human exploitation. Additionally, implementing sustainable fishing practices including the prohibition of shark finning and the adoption of selective gear like circle hooks can significantly reduce bycatch. Investing in genetic studies and satellite telemetry can enhance understanding of population dynamics and movement patterns, providing data critical for effective management strategies.

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Furthermore, promoting shark ecotourism and public education initiatives can foster greater awareness and appreciation of *S. mokarran*, encouraging local communities to participate in conservation efforts. Finally, the development and enforcement of national legislation, including species-specific conservation plans and stricter penalties for illegal trade, are vital components of a comprehensive protection strategy. Collectively, these measures can contribute to reversing the population decline of *S. mokarran* and ensuring their ecological role within marine ecosystems is maintained.

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