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Diet Composition of the Shortfin Mako (*Isurus oxyrinchus* Rafinesque, 1809) off the Coast of Pakistan in the Northern Arabian Sea

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SUMMARY

The Lamnidae family, which includes the shortfin mako (*Isurus oxyrinchus* Rafinesque, 1801), is regarded as an endangered species globally. Therefore, to identify the ecological traits suitable for conservation, it is essential to investigate the feeding behavior of this species. Known locally as Auar, the shortfin mako is a common large pelagic tropical shark that is frequently caught by surface gill nets, which primarily target deep-sea tuna fish such as skipjack tuna, yellowfin tuna, and billfishes. Using the percentage of frequency (FO) approach, the stomachs of 292 shortfin mako, ranging in size from 62 cm to 312 cm (TL), were analyzed between October 2016 and May 2017. The results indicated that the majority of the diet consisted of cephalopods, accounting for 58.5%, followed by teleosts (39.7%), elasmobranchs (1.3%), and mammals (0.3%), revealing their carnivorous behaviour.

Keyword: Diet composition, Short fin mako, Arabian Sea, *Isurus oxyrinchus*

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INTRODUCTION

A neritic and oceanic species that is both epipelagic and mesopelagic, the shortfin mako is found in all tropical and warm-temperate waters up to 888 meters deep all over the world (Abascal et al., 2011; Ebert et al., 2013; Weigmann, 2016). In longline, purse seine, and gillnet fisheries, shortfin makos are often caught with other sharks like silky sharks and thresher sharks as bycatch species targeted for billfishes (families Istiophoridae and Xiphiidae) and tuna (family Scombridae).

Large and powerful, the Mako Shark, also known as the Blue Pointer, can reach a length of 12 feet and a weight of more than 1,000 pounds. Its body is smooth and streamlined, featuring big eyes, a crescent tail, and a pointed snout. Because its underside is white and its upper body is dark blue, it can blend in with the ocean's surface and ambush its prey. Makos are renowned for their extraordinary agility and speed; they can jump out of the water. Although they are the top predators in their marine environment, mako sharks can still be eaten by larger sharks like great white sharks (*Carcharodon carcharias*) and orcas. However, shortfin makos can typically avoid most predators because of their speed and agility (Animal Matchup, 2025).

With burst swimming speeds of up to 43 mph (70 km/h), the shortfin mako is recognized as the world's fastest shark (Diez et al., 2015). This highly active species is often found near the water's surface while feeding (Compagno et al., 2005). The shortfin mako, a large pelagic tropical shark belonging to the Lamnidae family, is also known as the mackerel shark (Compagno, 1984) and is locally referred to as Auar. It rarely encounters water temperatures below 16 °C (Compagno, 2001; Serena, 2005; Gorni et al., 2012).

While the shortfin mako shark will occasionally consume other sharks, porpoises, sea turtles, and seabirds, its primary diet consists of cephalopods and bony fish such as mackerel, tuna, bonito, and swordfish. They hunt by leaping vertically from below, allowing them to tear large portions of their prey's fins and flanks. This strategy provides the shortfin mako with a high chance of reaching its target before it is detected, as it swims beneath its prey to observe what is above. In the Northern Arabian Sea, the surface gillnet, aimed at deep-sea tuna species (skipjack and yellowfin tuna) and billfish, frequently catches shortfin mako, silky shark, and thresher shark, as well as dolphin fish (*Coryphaena* sp.) as bycatch. In fish environmental science, diet composition is a regular procedure. Along with other pelagic shark species, including silky shark (*Carcharhinus falciformis*), pelagic thresher (*Alopias pelagicus*), and bigeye thresher (*Alopias superciliosus*), shortfin mako (*Isurus oxyrinchus*) are fairly common in the Arabian Sea's pelagic zone. Very limited studies have been done on the composition of the shortfin mako diet. In the North Atlantic (Stillwell and Kohler, 1982), South Africa (Cliff et al., 1990), South Pacific (Stevens, 1984), and Ecuador (Calle-Morán et al., 2023), extensive studies were carried out. On rare occasions, research has been conducted in the Mediterranean Sea (Capapé, 1975), South Africa (Bass et al., 1975), and the Central Pacific (Strasburg, 1958). Although comprehensive biological data from a specific area is required for appropriate management (Mollet et al., 2000), no biological work has been performed in Pakistan. This study analyzes the diet selectivity of shortfin mako from October 2016 to May 2017 in order to determine its natural environment.

MATERIAL AND METHOD

A one-year study was carried out to investigate the diet composition of shortfin mako from October 2016 to May 2017; no samples were found in the remaining months of June to September. A total of 292 stomachs of shortfin mako were obtained from the processing yard of sharks brought in by surface gillnetters operating in the offshore waters of Pakistan. Some observations were made at the same location where the sharks' stomachs were cut open with scissors, and the remains were usually brought to the Marine Fisheries Department's biological laboratory, where they were further opened with scissors, cleaned with water, and placed in a tray for additional identification. Species, or the least possible taxonomic level, was identified based on a visual assessment of the feeding rate. Selected stomachs were photographed. Dietary analysis employing basic percentage-by-number indices (Hynes, 1950; Hyslope, 1980; Bowen, 1996) was conducted using the following formula:

$$F= \frac{ni \times 100}{n}$$

Where
F= frequency of occurrence of the foodstuff in the sample;
ni= number of stomachs in which the food item is found;
n=total number of stomachs with food in the sample.

RESULT

Only 292 out of 605 stomachs containing food have been selected, while the remaining 313 empty stomachs have been excluded. In October, only two of the males' stomachs contained tuna during the months observed. Overall, cephalopods made up the largest portion at 58.5%, followed by teleosts (39.7%), elasmobranchs (1.3%), and mammals (0.3%). Figure 1 reveals carnivorous behavior. The aggregate of different food items identified in shortfin mako stomachs is provided in Table 1. It appears that the shortfin mako crushed larger animals into many parts before gulping them.

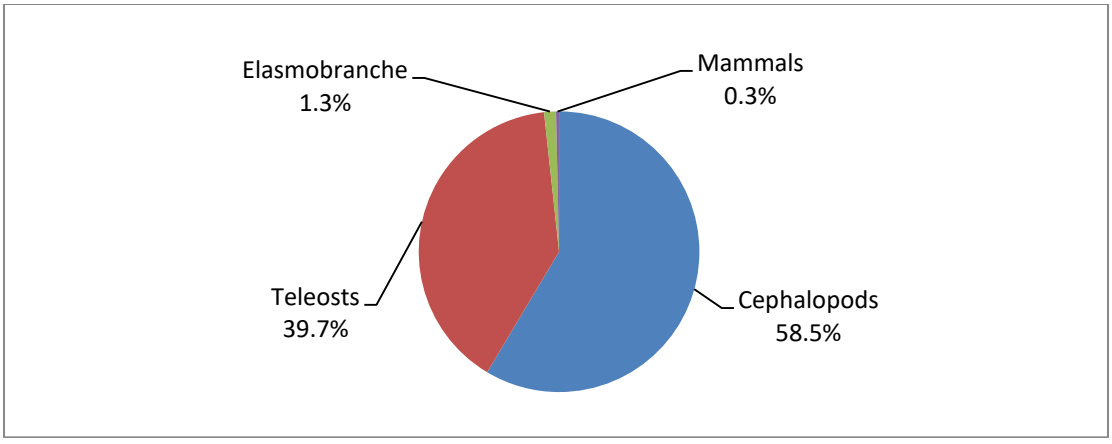

Figure 1: Percentage of diet content in groups of shortfin mako examined for a year.

CEPHALOPODS

The most dominant food item found in the stomach of shortfin mako throughout this study was cephalopods, with a combined rate of 58.5%. Figure 1 shows that purple back flying squid (*Sthenoteuthis oualaniensis*) dominated, with peak rates observed in January and February at 13.70% and 19.86%, respectively; the lowest was in October at 2.05% of the total annual diet. Table 1 indicates that the percentage of octopus was very low, found only in January at 0.3%. In this particular group, squid dominated with 99.4%, whereas octopus contributed only 0.5%. Figure 2 illustrates this distribution.

TELEOSTS

The second dominant group of food items constituted 39.7% of the total diet (Figure 1). In this specific group, digested fish accounted for 37.6%, digested tunas and similar species for 36.7%, Bluefish (*Pomatomus saltatrix*) for 6.84%, Frigate tuna (*Auxis thazard*) for 5.13%, Skipjack tuna (*Katsuwonus pelamis*) for 3.42%, Swordfish (*Xiphias gladius*) for 1.17%, Filefish (*Aluterus monoceros*) for 1.71%, Yellow

streaked snapper (*Lutjanus lemniscatus*) for 1.71%, Longtail tuna (*Thunnus tonggol*) for 1.71%, Eel (Muraenesocidae sp.) for 1.71%, Billfish (Istiophoridae sp.) for 0.85%, and Lesser bream (*Brama dussumieri*) for 0.85% (Figure 3).

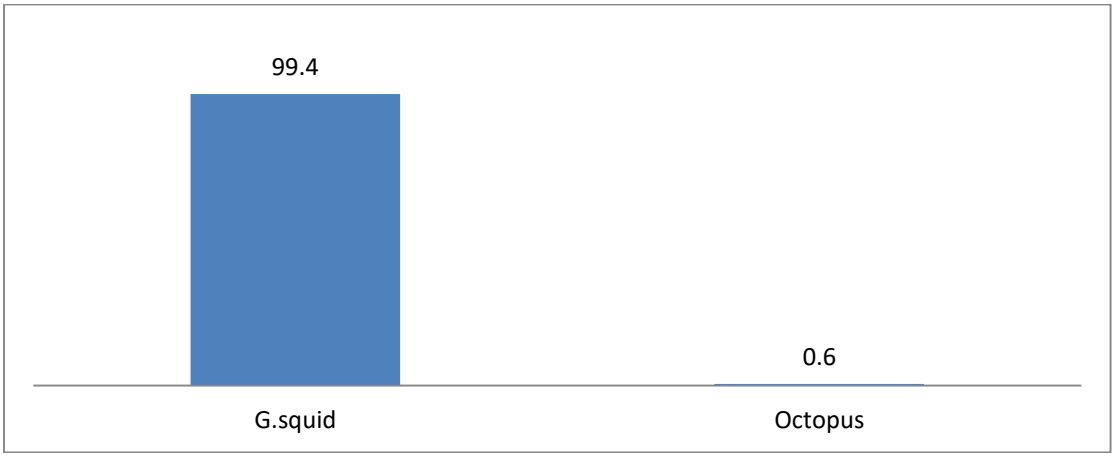

Figure 2: Percentage of cephalopods of one year study of shortfin mako.

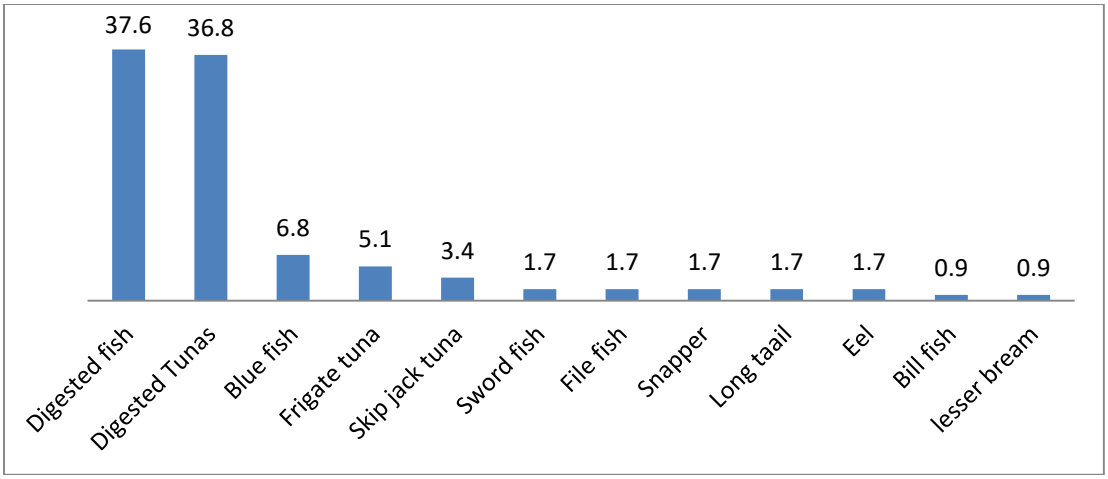

Figure 3: Percentage of teleosts of one year study of shortfin mako.

ELASMOBRANCHS

Only the head portion of the pelagic thresher shark (*Alopias pelagicus*) was found, that was the only elasmobranch that constituted 1.3% of the whole diet (Figure 1). It was observed in the months of January and February, with 0.68% for each month (Table 1).

MAMMALS

Few parts of any dolphin (family Delphinidae) were found, which constituted 0.3% of the whole diet (Figure 1) in the month of February (Table 1).

SEASONAL VARIATION OF DIET COMPOSITION IN SHORTFIN MAKO

Seasonal variation has also been observed in shortfin mako. In autumn, only tunas (Scombridae sp.) were observed among teleosts, making up 56%, including 44% purple back flying squid (*Sthenoteuthis oualaniensis*) (Figure 4). In winter, multiple groups were observed, with the most dominant cephalopods at 68%, followed by teleosts at 29%, elasmobranchs at 2%, and mammals at 1% (Figure 5). In spring, teleosts dominated with 53%, while cephalopods accounted for 47% (Figure 6). No specimens were observed in the summer season.

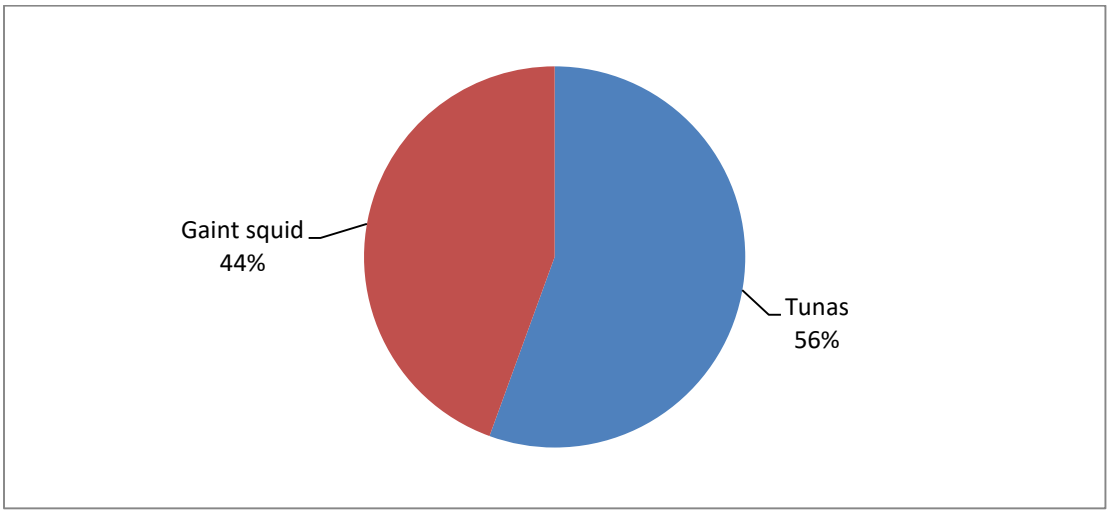

Figure 4: Percentage of diet composition of various groups in autumn of shortfin mako.

Table 1: Combined percentage (%) of various food stuff in the stomach of shortfin mako (*I. oxyrinchus*) from October 2016 to May 2017.

Name	Oct 2016	Nov 2016	Dec 2016	Jan 2017	Feb 2017	Mar 2017	Apr 2017	May 2017
Purple back flying squid	2.05	3.42	4.79	13.70	19.86	6.16	2.74	5.48
Octopus				0.34				
Pelagic shark				0.68	0.68			
Digested fish			1.71	3.08	3.77	0.68	1.37	4.11
Tunas	2.05	4.79	0.34	0.68	0.68	1.37		4.79
Skip jack tuna				1.37				
Long tail tuna						0.68		
Sword fish				0.68				
File fish					0.68			
Snapper						0.68		
Frigate tuna						0.68		1.37
Mammals					0.34			
Bill fish				0.34				
Eel				0.68				
Blue fish					2.74			
Lesser bream					0.34			

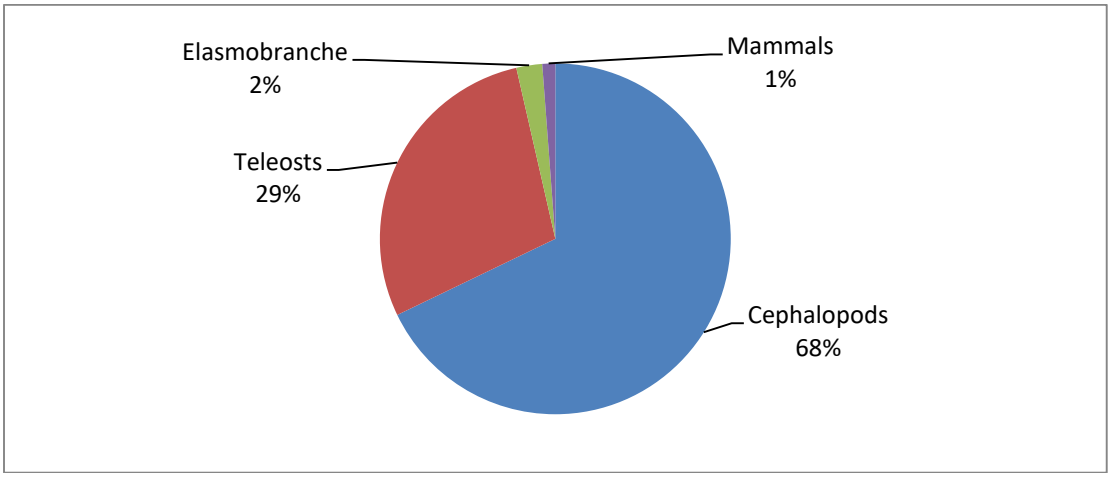

Figure 5: Percentage of diet composition of various groups in winter of shortfin mako.

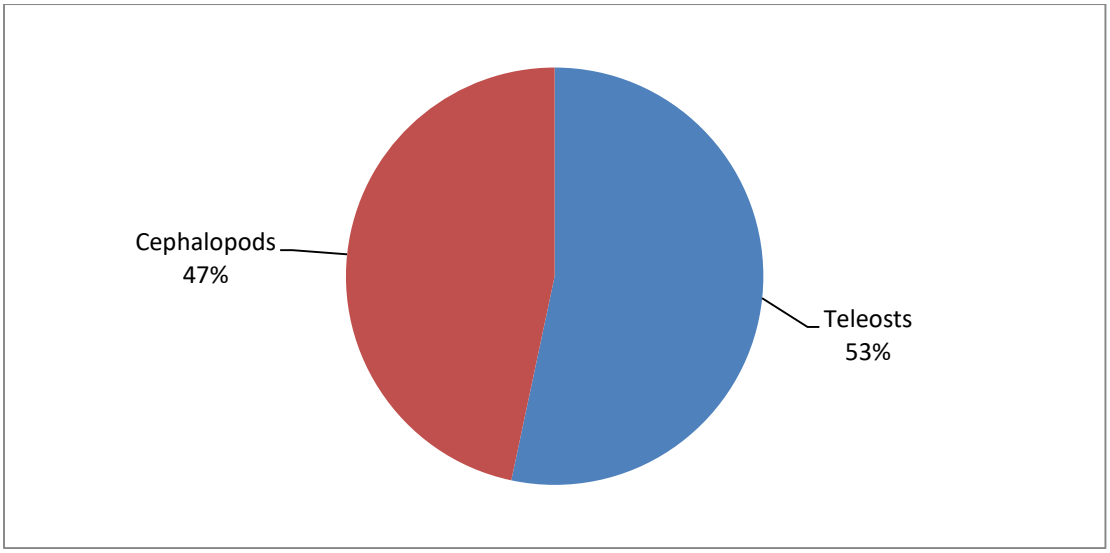

Figure 6: Percentage of diet composition of various groups in spring of shortfin mako.

DISCUSSION

Every animal requires energy to perform various body functions, and this energy is obtained from the food found in the animal's surroundings. Food items discovered in the stomach show where living things search for nourishment. Few fish species, like tunas, the great white shark, and the shortfin mako, have a specific blood vessel arrangement known as a countercurrent exchanger that allows them to sustain a body temperature higher than the surrounding water. This adaptation provides them with the main benefit of hunting in cold water by allowing them to travel more rapidly and efficiently (Oceana, 2025). The fast speed of the mako and its selection of food give it behavior similar to that of the great white shark (Klimley, 1994). Shortfin makos greater than 3m have inner teeth that are significantly broader and flatter compared to

smaller makos, which allows them to prey successfully upon species like dolphins, swordfish, and other sharks (Martin, 2003). Therefore, this species has significant bite ability (Shimada, 2002).

Figure 7: Monthly various food item of one year study of Shortfin mako.

Study of the diet composition of this predator is very important as it provides basic steps to maintain an ecosystem for establishing the fishery to prevent the stock of this species. Various studies have been conducted in many parts of the world, describing results that show species preferred teleosts, cephalopods, and other groups such as crustaceans, elasmobranchs, mammals, and turtles, which were found in lesser quantities. The nutritional composition of fish indicates that they are carnivores that need a high-protein diet to survive. In North Atlantic studies, it is confirmed that this pelagic predator feeds mainly on large bony fishes such as tuna and swordfish,

including sharks, marine mammals, and sea turtles. Studies show that in the size range over 67 cm, bony fishes constituted 67%, with bluefish (*Pomatomus saltatrix*) making up 77.5% of the diet by volume. Cephalopods accounted for 15%. The diet composition in both sexes was the same. The average weight of the stomach was 10% of the body weight (Stillwell and Kohler, 1982). After a few years, another study conducted in the same region showed bluefish made up 71.2% of the total diet (Wood et al., 2009).

In New South Wales, a study of sport fishing observed that shortfin mako sharks feed mainly on teleosts, including other elasmobranchs, pelagic cephalopods, and marine mammals (Stevens, 1984). Similar observations were made in California (Preti et al., 2012), but they are opportunistic in that they may switch between prey groups depending on availability (MacNeil et al., 2005). In South Africa, elasmobranchs were found in 60.2 percent of stomachs that contained food. Cetacean remains, probably those of a dolphin, were found in a single stomach (Cliff et al., 1990).

In the Mediterranean Sea, crustaceans were abundant, likely due to their overall prevalence in the region (Sbrana et al., 2003). In the Eastern North Atlantic, specifically along the southwestern coast of Portugal, teleosts constituted 87% of the diet, with cephalopods also present, while elasmobranchs were found in low quantities (Maia et al., 2006). In the southeastern Pacific, the diet of the shortfin mako shark included 17 prey items. Teleost fishes were the most significant prey, making up 86.9% of the Index of Relative Importance (IIR), followed by cephalopods at 12.3% IIR. Other prey types, including elasmobranch fishes, marine birds, and marine mammals, occurred with low frequency (<1% IIR) (Lopez et al., 2009).

A study in Brazil demonstrated that the shortfin mako shark exhibits an ichthyophagous feeding habit, as revealed by a Bayesian analysis of its diet. The most dominant items were teleosts, followed by cephalopod mollusks, crustaceans, and other less significant items. The low quantity of crustaceans and other items indicates their minimal importance (Gorni et al., 2012), which aligns with findings from various studies around the world (Stillwell and Kohler, 1982; Vaske-Junior and Rincon-Filho, 1998; Cortes, 1999).

In Australia, large pelagic fish and cephalopods were dominant in the 121 stomachs of juvenile and sub-adult makos sampled in the southern area (Rogers et al., 2012). In the easternSouth Pacific Ocean, the most dominant food item of this species was teleosts at 86.32% and cephalopods at 12.32% (Lopez et al., 2012). In the southwestern Atlantic, Brazil, cephalopod mollusks likewise dominated the shortfin mako diet, and the Teuthida order, which is primarily made up of Ommastrephidae, accounted for 30.4% of the IRI (Gomi et al., 2013). In South Africa, Cape Agulhas, elasmobranchs were the most common prey item in coastal samples at 63.5% (Groeneveld et al., 2014). In the Pacific Ocean, the ommastrephid squid, *Dosidicus gigas* (42.57%), and *Sthenoteuthis oualaniensis* (21.04%) were the most common prey. Fish belonging to the Hemiramphidae family came in second (11.85%) (Calle et al., 2023).

In the west coast of Baja California Sur, Mexico, *Dosidicus gigas, Prionotus albirostris*, and *Scomber japonicus* were the preferred food items of this species (Velasco et al. 2024). Various studies have been conducted in many parts of the

world, describing results that show species preferred teleosts in the Atlantic Ocean, abundant crustaceans in the Mediterranean Sea, elasmobranchs in South Africa, and other groups such as cephalopods, crustaceans, elasmobranchs, mammals, birds, and turtles, which were also found, albeit in lesser quantities. A one-year study of food items shows that pelagic animals were frequently found in the stomach of the Shortfin Mako (Figure 7), and larger animals were divided into many parts with the help of teeth. Mako sharks are perfect for grabbing and destroying fish and squid because of their huge, dagger-like, needle-shaped hook-like teeth that are sharp-edged and lack cusps or serrations (Figure 8). The protein of prey animals is digested with the specific activity of three digestive enzymes: pancreatic trypsin and gastric pepsin, which are higher in Shortfin Mako compared to other sharks (Newton et al. 2015).

Figure 8: Jaw of Shortfin mako.

The results of the present study are comparable to findings from various parts of the world, showing that cephalopods and teleosts dominate the diet, comprising 58.5% and 39.7% respectively. Other groups, such as elasmobranchs and mammals, are present in much smaller quantities, at 1.3% and 0.3%. It appears that species tend to prey on animals that are readily available in their environment, favoring those with soft, smooth tissues. The purple-back flying squid is particularly abundant in the Arabian Sea (Tribune, 2017). Despite the common presence of Smith's swimming crab (*Carybdis smithii*) in the area, which is frequently found in the stomachs of silky sharks (*C. falciformis*) (Osmany et al., 2022) alongside the purple-back flying squid, no specimens of this crab were found in the diet of the shortfin mako. We studied three out of four seasons, observing that in autumn, tunas were dominant along with a

significant presence of purple-back flying squid (Figure 4). In winter, a diverse diet was noted, with cephalopods being the most dominant and a sufficient amount of teleosts, while elasmobranchs and mammals were less represented (Figure 5). In spring, teleosts were the predominant group, with slightly fewer cephalopods (Figure 6). No specimens were found during the summer, likely due to the rough seas of the monsoon, which limit fishing activities. According to the current research and other studies conducted worldwide, the shortfin mako is an opportunistic feeder that consumes any available prey within its reach.

CITES Appendix II includes the shortfin mako shark *(Isurus oxyrinchus)* to regulate global trade and ensure its survival. This species is currently classified as Endangered (EN) by the IUCN, having been uplisted from Vulnerable (VU) in 2019 and Near Threatened (NT) in 2007 (Rigby et al., 2019). To enhance our understanding of mako sharks, it is essential to conduct strategic studies and share information, including data on their biology, distribution, and population status. The removal of top predators can negatively impact entire trophic levels (Cortes, 1999; Kitchell et al., 1999; Essington et al., 2002; Rogers et al., 2012). Therefore, this study will contribute valuable insights for maintaining a suitable environment and management plan for the shortfin mako shark.

CONCLUSION OF THE STUDY

During study period between October 2016 and May 2017, 292 out of 605 stomachs containing food were examined, cephalopods dominated with 58.5%, followed by teleosts 30.7%, elasmobranchs 1.3%, and mammals 0.3%. Purple back flying squid (*Sthenoteuthis oualaniensis)* dominated in cephalopods, tunas dominated in teleosts, the pelagic thresher shark (*Alopias pelagicus*) a single represents in elasmobranchs, and a piece of the dolphin was found in mammals. Teleosts were slightly more common than cephalopods in autumn, accounting for 56% and 44%. Most dominant food items was cephalopods in the winter 68%, whereas teleosts dominated in the spring with 53%.

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