

CHAPTER 3
TAXONOMY OF
ELASMOBRANCHS

3.1 Introduction: Taxonomy and Systematics

Elasmobranch, which include sharks, rays, and skates, are deemed highly vulnerable as a marine resource that is being exploited (Dulvy et al., 2017). However, there is a need to validate the fundamental taxonomic studies of these species in Indian seas in order to develop more effective management plans for their sustainable exploitation. Accurate identification of the species is crucial for effectively addressing conservation and management concerns related to Elasmobranchs at the grassroots level. This will aid in sustaining sustainable exploitation levels of these resources (Rago, 2005). Hence, it is imperative to clarify taxonomic uncertainties in order to accomplish efficient stock management. The main obstacle to creating a standardized list of Indian elasmobranchs is the intricate nature of the synonyms employed for a single shark species. Another obstacle is the scarcity of data regarding the capture trend of each species, primarily due to the challenge of recognizing them in the field. Furthermore, the taxonomy, diagnostic characteristics, bathymetric distribution, fishing methods, and biological information for various species are dispersed across multiple documents. This makes it particularly challenging for fishery biologists to obtain first-hand information on a specific species.

Several Elasmobranch species have been identified as very vulnerable to overfishing because of their K-selected life-history traits, including slow growth, late maturation, prolonged gestation periods, limited number of offspring, and longer lifespan. These biological factors affect their ability to survive, leaving them susceptible to overexploitation and having a relatively sluggish rate of regeneration to recover from depletion. Due to escalating fishing pressures in global oceans, the populations of numerous species have experienced a drop of up to 90%. Due to their status as apex predators in the ocean food chain, these species are vital for the well-being of the marine environment. Therefore, the loss of these species could have significant and widespread effects on ecosystems (Weber and Fordham, 1997; Gallagher et al., 2012). Elasmobranchs, despite their importance, are still a poorly comprehended category that necessitates immediate scientific investigation. However, due of their recognized susceptibility to fishing pressures, many nations have already implemented various measures to conserve these species. Several countries in the Arabian Sea region have recently enacted new laws that restrict shark finning, limit fishing of certain endangered

species, and establish seasonal fishing prohibitions (Karnad et al., 2020; D'Costa, 2022). Nevertheless, the implementation of these laws is neglected mostly due to a lack in capacity. Moreover, the lack of comprehensive scientific data and focused research on this specific group has resulted in a notably sluggish approach to their conservation and protection in this region, in contrast to other regions worldwide. Although extensive exploratory and synoptic surveys have been conducted in these waters, there is a significant lack of research specifically focusing on individual elasmobranch species. Recent research has resulted in the identification of numerous new species and the documentation of previously reported uncommon species through the collection of specimens. However, the data needed to assess the status of these species is still incomplete, particularly considering the current fishing pressure. Therefore, it is crucial to promptly gather the necessary data. Lacking empirical evidence, nations like India face challenges in formulating efficient strategies for the preservation and safeguarding of elasmobranch species diversity.

There is a scarcity of taxonomic research on Elasmobranchs in the Indian waters (Gupta et al., 2022). Indian waters are support to a wide variety of elasmobranch species. Day (1889) was one of the earliest to compile a list of elasmobranch diversity in Indian waters, documenting 69 species. Misra (1952) reported 52 species, Misra (1969) reported 114 species, Talwar and Kacker (1984) listed 76 species. Raje et al. (2002) identified 110 elasmobranch species, while Venkataraman et al. (2003) created a field identification handbook on sharks that included 72 species. In 2007, Raje et al. listed 84 elasmobranch species from commercial fishery. The most recent compilation by Akhilesh et al. (2014) mention the occurrence of 227 species of elasmobranchs in Indian waters. These studies, conducted over various periods, have documented between 52 and 227 species, but the actual number is likely higher due to the lack of recent, dedicated research on this group in the region.

3.2 Molecular approach to Elasmobranchs fish

DNA barcoding is widely advocated as a standard and universal method for species identification (Hebert et al., 2003a, b, 2004; Ward et al., 2005; Zemplak et al., 2009; Zhang and Hanner, 2012; Landi et al., 2014). This technique is analytically powerful, highly efficient and precisely identify biological specimens. Identifying elasmobranch fishes through mitochondrial DNA (mtDNA) analysis has become a

powerful tool for species differentiation. Heist and Gold (1999) were pioneers in this field, sequencing a 395-base pair (bp) region of mtDNA in eleven species of carcharhiniform sharks and developing species specific Restriction Fragment Length Polymorphism (RFLP) assays. Their foundational research paved the way for Greig et al. (2005), who expanded this approach by sequencing a 1.4 kilobase (kb) region of mtDNA from 93 samples, covering 35 North Atlantic shark species. Ward et al. (2008) demonstrated the accuracy of COI in species identification, providing deeper insights into the phylogenetic relationships and divergence among elasmobranch species. In India, molecular phylogenetic studies on elasmobranchs have recently gained traction, emphasizing the effectiveness of the Cytochrome Oxidase I (COI) gene for identifying sharks and rays. Integrating molecular DNA sequences into phylogenetic studies has thus enhanced our understanding of species differentiation and evolutionary history, offering a precise and reliable method for elasmobranch identification and conservation.

3.3 Deep learning Approach

Fish identification using YOLO (You Only Look Once) and other object detection techniques is crucial for various applications in marine biology, ecology, fisheries management, and conservation (Loulidi et al., 2022; Goodwin et al., 2022). The ability to accurately and efficiently detect and classify fish species in underwater environments plays a significant role in understanding aquatic ecosystems (Ouis and Akhloufi, 2023) monitoring biodiversity, assessing population dynamics, and implementing effective conservation strategies.

Traditional methods of fish identification often involve manual observation and data collection, which can be time-consuming, labour-intensive, and prone to human error. By leveraging computer vision and machine learning algorithms like YOLO, researchers can automate the process of fish detection and classification from images and video feeds, making it faster, more accurate, and less resource intensive.

The importance of fish identification using YOLO lies in its ability to:

1. Enhance Research Efficiency: Object detection algorithms like YOLO can process large volumes of images and underwater video data quickly, allowing researchers to

analyse fish populations and behaviors more efficiently than manual methods (Er et al., 2023).

2.Improve Species Monitoring and Support Conservation Efforts: Accurate species identification is essential for monitoring fish populations, tracking migration patterns, assessing the health of marine ecosystems. implementing conservation measures to protect endangered species, prevent overfishing, and preserve marine biodiversity. YOLO-based detection systems can aid in monitoring and enforcing conservation regulations (Barbedo, 2022).

3.Facilitate Data Collection: By automating the process of fish identification, YOLO enables researchers to collect large amounts of standardized data on fish species distribution, abundance, and behavior, which can inform scientific studies and management decisions (Yang et al., 2021; Kandimalla et al., 2022).

Fish identification using YOLO and other object detection technologies plays a vital role in advancing our understanding of aquatic ecosystems, supporting sustainable fisheries management, and promoting conservation efforts to safeguard marine biodiversity.

Gujarat contributes significantly to India's fisheries, accounting for 14.4% of the total fisheries landings and 10.4% of all elasmobranch landings (CMFRI, 2022). However, Gujarat's fisheries sector lacks adequate assessments by national or state agencies, resulting in deficiencies in diversity assessments, stock assessments, and effective management measures to protect elasmobranchs. This lack of scientific investigation has led to Gujarat being ranked fourth by the FAO among regions with the greatest need for research and conservation of elasmobranchs. (Dulvy et al., 2017; Nagle, 2019). Most recent research work from the region is based on fishery survey, was done by Johri et al. (2021), recorded fourteen species of sharks and seventeen species of batoids. Understanding the taxonomy and systematics of these species is critical for sustainable fisheries resource management, (Stauffer and Kocovsky, 2007) especially for vulnerable and exploited groups like elasmobranch.

The study of Elasmobranch diversity and fishery is imperative due to their significant evolutionary history, ecological roles, and susceptibility to overfishing. Taxonomic studies provide foundational knowledge for understanding their

classification and evolutionary relationships. Molecular and phylogenetic analyses offer deeper insights into their genetic diversity and adaptive traits. Additionally, incorporating advanced monitoring technologies like YOLO enhances the accuracy and efficiency of population assessments. This research aims to bridge knowledge gaps, promote sustainable fishery practices, and support the conservation of these vital marine species.

3.2 Materials and Methodology

3.2.1 Study Area

The current research work has been conducted in the coastal region of Gujarat province. It is situated on India's western coastline bounded by the vast Arabian Sea on its three sides. Among the maritime states of India, Gujarat has the longest coastline and, the continental edge in this part of the Arabian sea being farther from shore than in any other part of the country, has the widest shelf area. The state is located between 20°06' N to 24°42' N latitude and 68°10' E to 74°28' E longitude, shares a Northwestern border with Pakistan and Rajasthan, a North-Eastern border with Madhya Pradesh, and a South-Eastern border with Maharashtra. It has a 1,96,024 Km² total surface area (including Daman and Diu UT). Gujarat boasts a substantial coastline extending 1600 kilometers, providing significant access to marine resources. That accounts for 22% of the total coastline available to the country. The state's continental shelf, covering an area of 1.64 lakh square kilometers (35.3% of the country), of which 64,800 sq.km falls in the depth range 0-60 m and offers a rich habitat for marine life. Additionally, Gujarat's Exclusive Economic Zone (EEZ) spans 2.14 lakh square kilometers (9.9% of the country), allowing the state exclusive rights to explore and utilize marine resources within this area. As of the 2021-22 period, Gujarat has a total of 36,980 fishing boats actively engaged in marine fishing. The census of 2007 recorded 2.18 lakh active fishermen, indicating a substantial workforce dependent on fishing for their livelihood. The marine fish production for the state during 2021-22 was notably high, amounting to 6.88 lakh metric tons. This data underscores the importance of the fishing industry to Gujarat's economy and the significant role it plays in providing employment and contributing to the state's overall food security.

The Gujarat coast is renowned for its extensive network of fish landing centers and harbors, which are vital components of the state's vibrant fishing industry. These harbors and landing centers are strategically located along the coastline and have specific roles in the fishing and seafood trade. Among the notable fishing harbors, Veraval, Porbandar, Mangrol, Okha, and Jakhau play significant roles. Veraval stands out as one of the largest and most active harbor not only in Gujarat but also in India. It serves as a crucial hub for sorting, auctioning, and processing the daily catch, making it a pivotal point for seafood exports. Based on the high volume of fish landing, five

primary areas along the coast of Gujarat - Veraval (20.9061_ N, 70.3834_ E), Mangrol (21.1125_ N, 70.0930_ E), Porbandar (21.6392_ N, 69.5951_ E), Okha (22.4538_ N, 69.0728_ E) and Jakhau (23.2386_ N, 68.6055_ E) were chosen as sites for Data collection (Fig. 3.1).

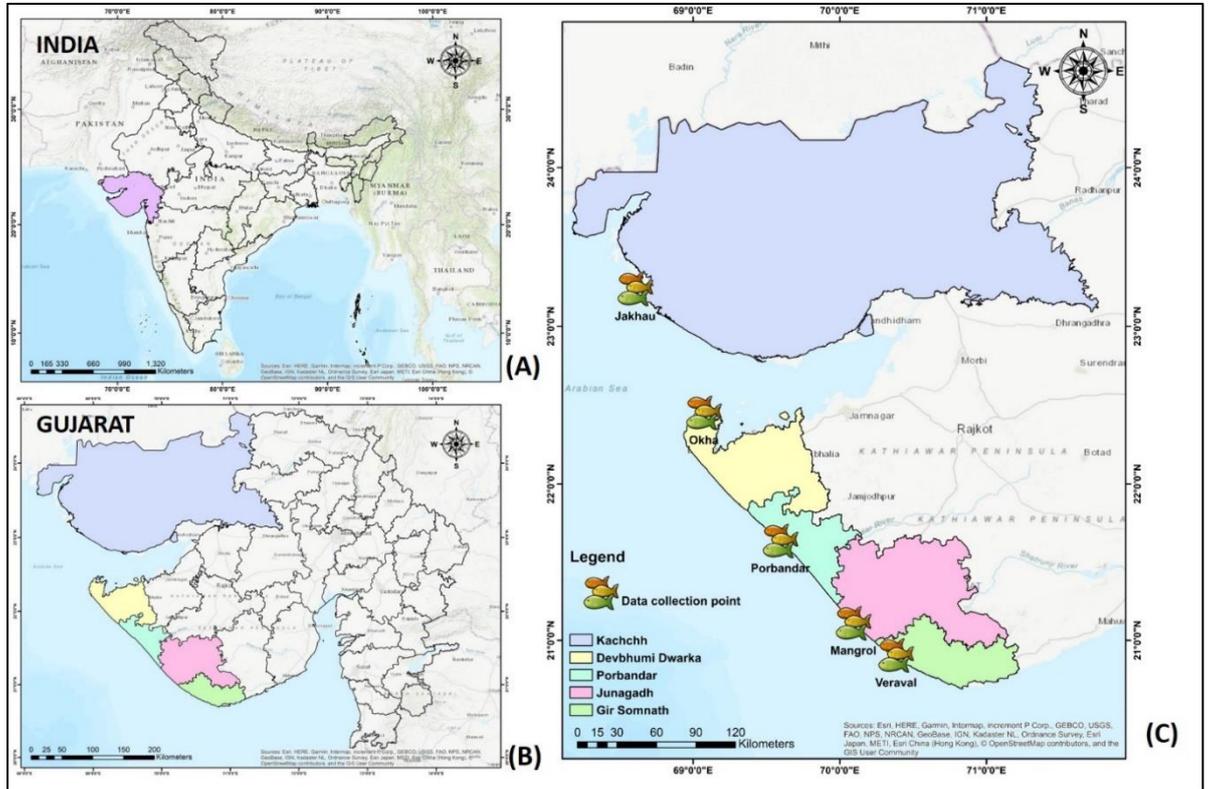


Figure 3.1: Study area map (A - India; B - Gujarat state and C - Data collection site)

3.2.2 Field sampling

During January 2021 to December 2023, field survey observations were made at commercial fishing harbours and fish landing centres along the maritime zone of Gujarat state (Fig. 3.1), India to understand the diversity in the maritime zone of Gujarat state. On field, photographs of the specimen were taken, and morphological features of specimens were examined with fine precision. Total length (TL) was measured as the distance from the snout to a point on the horizontal axis intersecting a perpendicular line extending downward from the tip of the upper caudal lobe to form a right angle.

3.2.3 Taxonomic Identification

Species identification of observed elasmobranch specimens were based on Misra (1952); Compagno (1984a, b, 2002); Smith and Heemstra (1986); Michael, (1993); Last and Stevens (1994); Carpenter and Niem (1999); Daley (2002); White et al. (2006 b); Last et al., (2008 a, b); Last and Stevens (2009); Ebert (2013); Anam and Mostarda (2012); Jabado and Ebert (2015); Last et al., (2016a, b); Kizhakudan et al., (2018) and other available authenticate literature of particular genus and species.

3.2.4 Sub-sampling and Molecular analysis

Elasmobranch fishes were separated from other fish communities and Sub-samples were collected for molecular. analysis. DNA cross contamination (this is a contamination of DNA from one sample with DNA of another sample) is always a serious issue that can compromise result from molecular analysis, to avoid cross contamination of DNA; tissue was obtained using scissor and forceps were thoroughly cleaned by soaking instruments into high concentration Ethanol (i.e. 70% or greater), 5 to 10 g of fin or gill tissue was taken as sub-sample from elasmobranch individual. Then tissue was placed in a 10 ml vial which contains 95% ethanol. After that the subsamples were kept in an icebox which contained normal ice or silica-gel pack. and transferred to the Division of Marine and Freshwater Biology, Department of Zoology, Faculty of Science, The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat with outmost care. After that the sub-samples were store at -20°C fridge for further analysis.

DNA Isolation

Genomic DNA was isolated from the tissue sample using HiPurA® DNA Purification Kit (HiMedia). Following instructions of the manufacture and eluted in 50 µl of elution buffer. Extracted DNA was checked by 0.8% agarose gel electrophoresis with ethidium bromide incorporated in 1x TBE buffer. The concentration of isolated DNA was diluted to a final concentration of 10 ng/µl using a UV spectrophotometer.

Amplification and Sequencing

Cytochrome Oxidase Subunit I (COI) gene of mitochondrial DNA (genomic DNA/mtDNA) act as universal molecular marker for species identification in molecular

biotechnology. Therefore, Cytochrome Oxidase Subunit I (COI) was selected for molecular diversity/molecular taxonomy investigation in the present study. The sequence of the COI gene was PCR amplified using the primers Fish F1 (5'- TCA ACC AAC CAC AAA GAC ATT GGC AC3') and Fish R1 (5'-TAG ACT TCT GGG TGG CCA AAG AAT CA-3') (Ward et al., 2005) in 25 µL reactions using 2X PCR TaqMixture (MBT061, Himedia) containing 10µM of each PCR primer and 1µl of template DNA. Thermal conditions consisted of initial preheat at 95°C for 3 min, denaturation 94°C for 30 s, annealing 50 °C for 30s, extension 72°C for 35 s, repeated for 29 cycles, followed by a final extension for 3 min at 72°C. PCR products were visualized in a 1.2% agarose gel. Purified amplicons were then subjected to cycle sequencing using Big Dye Terminator v3.1 chemistry and subsequently sequenced on an ABI 3500XL Genetic Analyzer following the protocol of the manufacture.

Sequence analysis

We assembled the forward and reverse DNA sequences and edited using Tracy software tool. These sequences were subjected to a Sequence match analysis using NCBI's Basic Local Alignment Search Tool (BLAST) and exported as FASTA file for further phylogenetic analysis. The sequence of this specimen has been deposited in GenBank under the assigned accession number. Sequences were aligned using ClustalW as implemented in MEGA11 (Tamura et al., 2021). Sequence was calculated using the Kimura 2 Parameter (K2P) distance model of nucleotide substitution. Neighbour-joining (NJ) trees of K2P distance were created to provide graphic representation of divergence, with 1000 bootstrap replications.

3.2.5 YOLO Object detection classification

Methodology employed for Elasmobranch identification using the YOLO V2 model with a ResNet-53 backbone, implemented in MATLAB Software. The process includes data collection, pre-processing, model configuration, training, evaluation, and deployment.

3.2.5.1 Data Collection: Image Dataset

The initial step involved compiling a comprehensive dataset of Elasmobranch images. Which is collected during the field survey. The dataset aimed to capture a wide

range of scenarios, including varying backgrounds, lighting conditions, and angles to enhance the model's robustness.

3.2.5.2 Annotation

Each image in the dataset was meticulously annotated with bounding boxes around the species image. Annotation tools such as MATLAB's Image Labeller were employed to create precise bounding box annotations. The annotation process involved drawing rectangles around each image and assigning corresponding class labels.

3.2.5.3 Data Pre-processing

Image Augmentation

To increase the variability of the training dataset and prevent overfitting, various data augmentation techniques were applied. These techniques included random rotations, scaling, translations, and horizontal flipping. This augmentation enhances the model's ability to generalize from the training data to new, unseen images.

Data Splitting

The dataset was divided into three subsets: training, validation, and test sets, with proportions of 70%, 20%, and 10%, respectively. This split ensures that the model has sufficient data to learn from while also providing adequate data for validation and testing.

3.2.5.4 Model Configuration: YOLO V2 with ResNet-53 Backbone

The YOLO V2 model was configured with ResNet-53 as the feature extraction backbone. ResNet-53 was chosen for its deep architecture and strong performance in feature extraction tasks. The layers of ResNet-53 are used to generate initial feature maps that are subsequently processed by YOLO's detection layers.

3.2.5.5 Training the Model Execution

The YOLO V2 model was trained using the specified options. The training process was monitored through MATLAB's training progress plot, which provides real-time feedback on the model's performance, including metrics such as loss and accuracy.

3.2.5.6 Model Evaluation: Performance Metrics

The model's performance was evaluated on the test set using metrics such as Accuracy Sensitivity, Specificity and F1-score. These metrics provide a comprehensive understanding of the model's accuracy and reliability in detecting and classifying sharks.

3.2.5.7 Deployment: Real-time Detection

The trained YOLO V2 model was deployed for real-time elasmobranch detection in images or video streams. This involves using a images or video reader to capture frames from a test data set, processing each frame through the YOLO detector, and displaying the annotated frames in real-time.

3.3 Results

3.3.1 Taxonomy of Elasmobranch fishes

Class: Elasmobranchii

Order: Carcharhiniformes

Family: Carcharhinidae

1. Scoliodon laticaudus (Müller & Henle, 1838)

Common name: Spadenose shark

Plate 3.1(a)

Müller, J. and F. G. J. Henle (1838-41) Systematische Beschreibung der Plagiostomen. Veit und Comp., Berlin. i-xxii + 1-200, 60 pls. [Pp. 1-28 published in 1838, reset pp. 27-28, 29-102 in 1839, i-xxii + 103-200 in 1841.

Description:

The head is long and depressed; pointed snout elongate and tapering from the eyes. There are no hyomandibular pores, and the labial furrow is short, only present on the lower jaw. Nostrils are closer to the mouth than to the snout's tip, and the snout's length is roughly equal to or slightly more than the distance from the eye to the first gill slit. posterior margin of the first dorsal fin extending behind the origin of pelvic base, almost reaching the middle of pelvic fin. Origin of pectoral fin below or slightly in advance of the level of the fifth gill opening, outer and inner comers of pectoral fin are in advance of the origin of first dorsal fin; origin of second dorsal just above the posterior third of anal base, which is more than double that of second dorsal base and equals to its distance from the ventral. Trunk laterally compressed in the posterior region of body. Caudal fin is a broad blade-like structure with a deep notch posteriorly. Dorsal surface colour is pale greyish bronze above, dull white at sides and ventral surface.

Habitat and Distribution: This species is found in coastal waters near rocky shores, primarily near the bottom. It's distributed across the Eastern and Western Indian

Oceans, spanning from the Gulf of Oman to Myanmar and potentially reaching Thailand (Nair et al., 1974).

The status of *Scoliodon laticaudus* is listed as Near Threatened on the IUCN Red List of Threatened Species (Dulvy et al., 2021).

2. *Carcharhinus amblyrhynchoides* (Whitley, 1934)

Common name: Graceful shark

Plate 3.1(b)

Whitley, G. P. (1934) Notes on some Australian sharks. *Memoirs of the Queensland Museum* v. 10 (pt 4): 180-200, Pls. 27-29.

Description:

A stout body with a relatively short and pointed snout; the distance between the nostrils is approximately 1 to 1.2 times the length of the preoral snout. There is no interdorsal ridge. Upper labial furrows are short and hardly noticeable, and there are no distinct series of large hyomandibular pores near the mouth corner. First dorsal fin is large and triangular, with a short free rear tip, positioned over or just behind the insertions of the pectoral fins. Second dorsal fin is also fairly large and has a short free rear tip, originating over or in front of the anal fin. Pectoral fins are moderately large and falcate. Extreme rear tips of the dorsal, pelvic, pectoral, and caudal fins feature a deep dark blotch, especially noticeable on the shorter ventral caudal lobe, while the anal fin is typically uniformly pale. Dorsal surface colour is grey or grey-brown, and white or cream ventrally, highlighted by a distinct white band on the sides from the pelvic fins to the first dorsal fin.

Habitat and Distribution: this species is found both inshore and offshore, inhabiting continental and insular shelves. It can be found in mid-water at depths of at least 50 meters. Its range extends in the Indo-Pacific region from the Gulf of Aden and southwestern India, east to Papua New Guinea, north to Taiwan, and south to Australia. (Ebert et al., 2013; Jabado et al., 2017).

The status of *Carcharhinus amblyrhynchoides* is listed as Vulnerable on the IUCN Red List of Threatened Species (Simpfendorfer et al., 2021).

3. *Carcharhinus falciformis* (Bibron, 1839)

Common name: Silky shark

Plate 3.1(c)

Müller, J. and F. G. J. Henle (1839). Systematische Beschreibung der Plagiostomen. Veit und Comp., Berlin. i-xxii + 1-200, 60 pls. [Pp. 1-28 published in 1838, reset pp. 27-28, 29-102 in 1839, i-xxii + 103-200 in 1841.

Description.

Body slender, and elongated with a moderately long, flattened, and rounded snout when viewed from above(dorsal). Its upper jaw contains serrated, triangular teeth, while the lower jaw sports more slender, smooth-edged teeth. First dorsal fin is low with a moderately rounded apex, positioned well behind the pectoral fins' free rear tips. Second dorsal fin is exceptionally low, with very long free rear tip that is at least twice the height of the fin itself, situated over or behind the anal fin. Both dorsal fins and the anal fin have pronounced long free rear tips. Pectoral fins are lengthy and narrow, and there is an Interdorsal ridge present. coloration is a uniform grey to dark brown on the top and white on the ventral side, with the first dorsal fin being a consistent colour and the other fins possibly showing dusky tips.

Habitat and Distribution: The silky shark is a highly migratory species found in both coastal and oceanic waters, usually ranging from the surface to depths of 500 meters (Last and Stevens 2009). It thrives in marine environments where temperatures exceed 23°C (73°F) and has a cosmopolitan presence. Based on differences in life history, four distinct populations have been identified across world ocean basins: the northwestern Atlantic, the western and central Pacific, the eastern Pacific, and the Indian Ocean (Last and Stevens 2009, Ebert et al., 2013)

The status of *Carcharhinus falciformis* is listed as Vulnerable on the IUCN Red List of Threatened Species (Rigby et al., 2021a).

4. *Carcharhinus leucas* (Valenciennes, 1839)

Common name: Bull Shark

Plate 3.1(d)

Müller, J. and F. G. J. Henle (1838-41) Systematische Beschreibung der Plagiostomen. Veit und Comp., Berlin. i-xxii + 1-200, 60 pls. [Pp. 1-28 published in 1838, reset pp. 27-28, 29-102 in 1839, i-xxii + 103-200 in 1841.]

Description:

A stout body with a short, blunt snout, smaller than the width of its mouth, and small eyes. First dorsal fin is broad and triangular, with a height equal or less than 3.1 times that of the second dorsal fin, it originates above the inner margins of the pectoral fins. Second dorsal fin features a concave upper edge and short rear tips, originate in front of the anal fin. Large, angular pectoral fins have straight edges. There are no interdorsal ridges or distinct fin markings. Dorsal surface is grey, while the ventral surface is pale, Upper caudal fin with a thin dusky posterior margin.

Habitat and Distribution: This species is typically found inshore in turbid or brackish waters, hypersaline lagoons, bays, and canals. It is a bottom-dweller ranging from the surf line down to depths of at least 152 meters. It has a cosmopolitan distribution in tropical and subtropical waters (Ebert et al., 2013).

The status of *Carcharhinus leucas* is listed as Vulnerable on the IUCN Red List of Threatened Species (Rigby et al., 2021b).

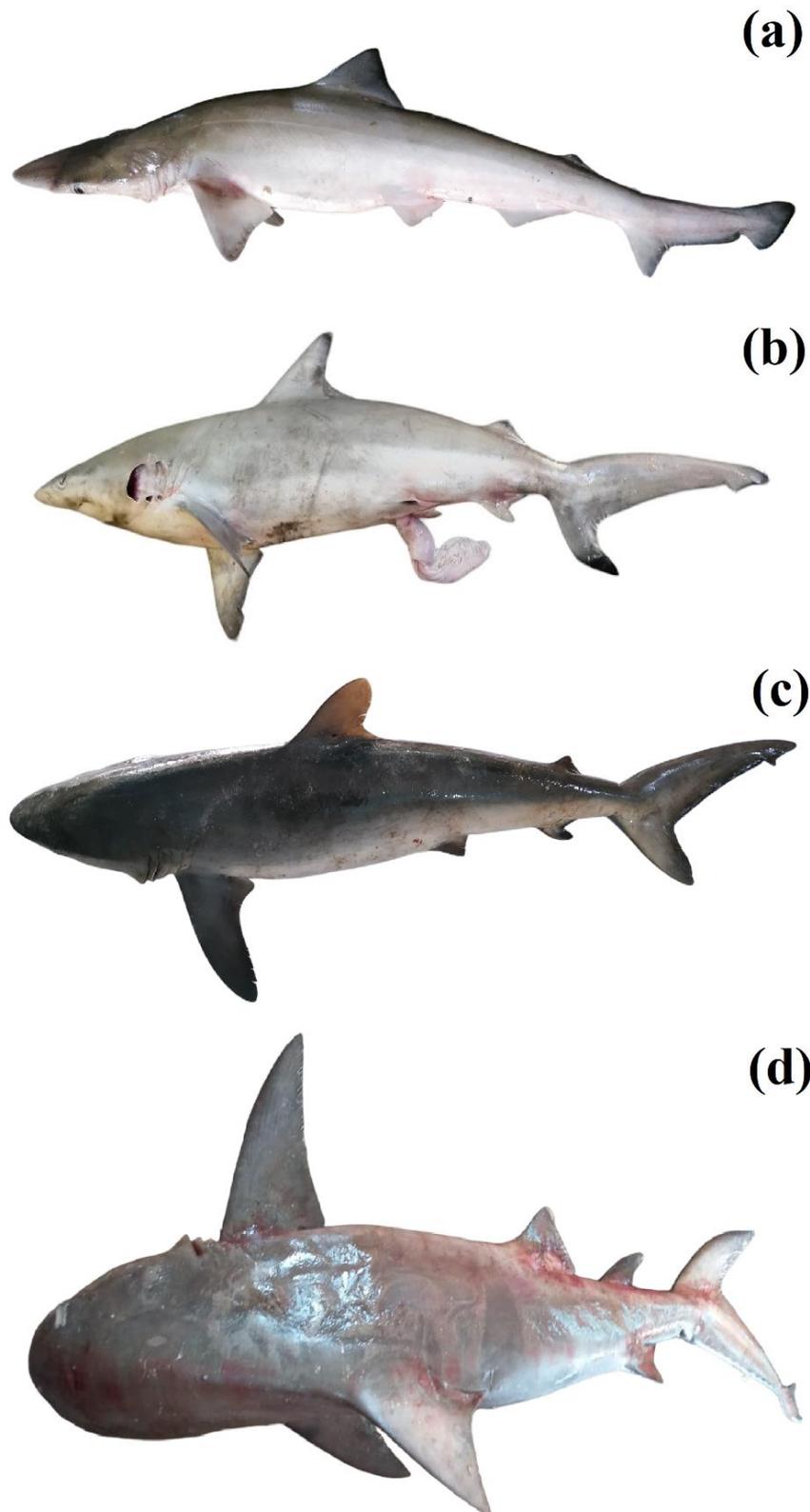


Plate 3.1: (a) *Scoliodon laticaudus*; (b) *Carcharhinus amblyrhynchooides*;
(c) *Carcharhinus falciformis*; (d) *Carcharhinus leucas*

5. *Carcharhinus limbatus* (Müller & Henle, 1839)

Common name: Blacktip Shark

Plate 3.2(a)

Müller, J. and F. G. J. Henle (1838) Systematische Beschreibung der Plagiostomen. Veit und Comp., Berlin. i-xxii + 1-200, 60 pls.

Description:

Snout is moderately long and pointed, with its length generally not exceeding the width of the mouth. The eyes are small, and the labial furrows are short and inconspicuous. a posterior mandibular notch is present. the Interdorsal distance is less than or equal to 2.2 times the height of the first dorsal fin. First dorsal fin is tall with a short rear tip, usually originate over or just behind pectoral fin insertion. Second dorsal fin is moderately large with a short rear tip, originating over or just slightly anterior to the anal fin origin. Pectoral fins are moderately large, and the pelvic fins have a distinctive black tip on their ventral surface. No Interdorsal ridge. Juveniles display prominent black tips on all fins, whereas adults typically have a plain anal fin, but the dorsal, pectoral, and lower caudal fins might show only faint black edges. Dorsal surface is grey or grey-brown, while the ventral surface is white. Black tips are commonly found on the pectoral fins, the second dorsal fin, and the lower lobe of the caudal fin, sometimes appearing on the pelvic and anal fins. Black edges are also generally present on the apex of the first dorsal fin and the lobe of the dorsal caudal fin.

Habitat and Distribution: This species is found in coastal areas along continental and insular shelves, including shallow, muddy bays and coral reef drop-offs, though it is sometimes found further offshore. It is typically found at depths of less than 30 meters but can inhabit waters down to at least 100 meters (Jabado and Ebert, 2015). This species has a cosmopolitan distribution in tropical and warm temperate oceans. (Ebert et al., 2013, Psomadakis et al., 2019).

The status of *Carcharhinus limbatus* is listed as Vulnerable on the IUCN Red List of Threatened Species (Rigby et al., 2021c).

6. *Carcharhinus macloiti* (Müller & Henle, 1838)

Common name: Hardnose shark

Plate 3.2(b)

Müller, J. and F. G. J. Henle (1838) Systematische Beschreibung der Plagiostomen. Veit und Comp., Berlin. i-xxii + 1-200, 60 pls.

Description:

A Snout is long, narrow, and either rounded or slightly pointed, featuring a highly calcified and rigid structure. Its nostrils are distinctly slanted with a wide, ovate opening. Alongside each side of the mouth, there is a noticeable row of enlarged hyomandibular pores. First dorsal fin is small with extremely long free rear tips, which are about two-thirds the length of the fin base, and its base begins either over or just behind the pectoral fins. Second dorsal fin is similarly structured with long free rear tips and starts behind the anal fin. Pectoral fins are short, moderately falcate, and pointed at the end, origin of pectoral fin below the fourth gill opening. No prominent black tip on the fins but the leading margins of the second dorsal and the upper caudal have a narrow dusky or black edge. Sometimes, the pectoral and lower caudal fins show a pale edging. There is no Interdorsal ridge on the body. Coloration includes a grey or greyish-brown dorsal side and a white belly.

Habitat and Distribution: Found inshore and offshore on continental and insular shelves. Occurs down to a depth to at least 170 m (Jabado and Ebert, 2015). Occurs from East Africa to southern Japan and the Australian east coast, that is, it ranges across the Indian Ocean and Northwest and Western Central Pacific (Jabado et al., 2017; Kumar et al., 2018).

The status of *Carcharhinus macloiti* is listed Near Threatened on the IUCN Red List of Threatened Species (Rigby et al., 2021d).

7. *Carcharhinus melanopterus* (Quoy and Gaimard, 1824)

Common name: Black tip reef shark

Plate 3.2(c)

Quoy, J. R. C. and J. P. Gaimard (1824) Description des Poissons. Chapter IX. In: Freycinet, L. de, Voyage autour du Monde...exécuté sur les corvettes de L. M. "L'Uranie" et "La Physicienne," pendant les années 1817, 1818, 1819 et 1820. Paris. 192-401.

Description:

A body is fusiform with a short, blunt snout and relatively long nasal lobes. Labial furrows are short and subtle, and there is no Interdorsal ridge. The fish features very distinct black tips on the first dorsal and lower caudal fins. Prominent black tip of first dorsal fin set off abruptly by a light band below it, the first dorsal fin is notably tall, with a width exceeding half the pre-dorsal space, originate above the pectoral fin insertions. Second dorsal fin is moderately large with a short rear tip, originate over the origin of the anal fin. Pectoral fins are large and triangular. Whereas other fins have less prominent black tips. There is also a distinctive white band on the flank. Dorsal surfaces range from yellowish-brown to grey, and the ventral surface is white.

Habitat and distribution: This species is commonly found both inshore and offshore along the continental and insular shelves near coral reefs, reef flats, and drop-offs. It inhabits waters from just a few meters deep up to depths of 50 to 100 meters (Jabado and Ebert, 2015). This is a widespread tropical species in the Indo-West Pacific and Central Pacific regions, ranging from Africa to the Central Pacific, including most islands with coral reefs (Last and Stevens. 2009).

The status of *Carcharhinus melanopterus* is listed as Vulnerable on the IUCN Red List of Threatened Species (Simpfendorfer et al., 2020).

8. *Carcharhinus sorrah* (Müller & Henle, 1839)

Common name: Spottail shark

Plate 3.2(d)

Müller, J. and F. G. J. Henle (1838) Systematische Beschreibung der Plagiostomen. Veit und Comp., Berlin. i-xxii + 1-200, 60 pls.

Description:

A snout is moderately long and pointed in dorsoventral view. Along each side of the mouth, there is a distinct longitudinal line of enlarged hyomandibular pores. Nostrils are distinctly slanted with a broad, ovate aperture. First dorsal fin is of moderate size with a short tip, positioned over the free rear tips of the pectoral fins. Second dorsal fin is smaller, featuring a long rear tip and an extremely long inner margin, starting just behind the origin of the anal fin. The pectoral fins are relatively small and curved. Interdorsal ridge present. First dorsal fin may be plain or have a slight black edge. Second dorsal fin, pectoral fins, and lower caudal fin prominently feature black tips. Dorsal side of the body is grey or grey-brown, while the ventral surface is white. Notably, there is a large black tip on the pectorals, the second dorsal fin, and the ventral caudal lobe; however, the first dorsal fin may only have a black edge at most. A prominent white band is visible on the flank.

Habitat and Distribution: This species typically resides in shallow waters and around coral reefs on both continental and insular shelves. It is found at depths ranging from the surface to a depth of 140 meters, though it is most commonly seen between 20 to 50 meters (Jabado and Ebert, 2015). This species is widely distributed across the tropical Indo-West Pacific region. Last and Stevens, 2009, Ebert et al., 2013).

The status of *Carcharhinus sorrah* is listed as Near Threatened on the IUCN Red List of Threatened Species (Simpfendorfer et al., 2021).

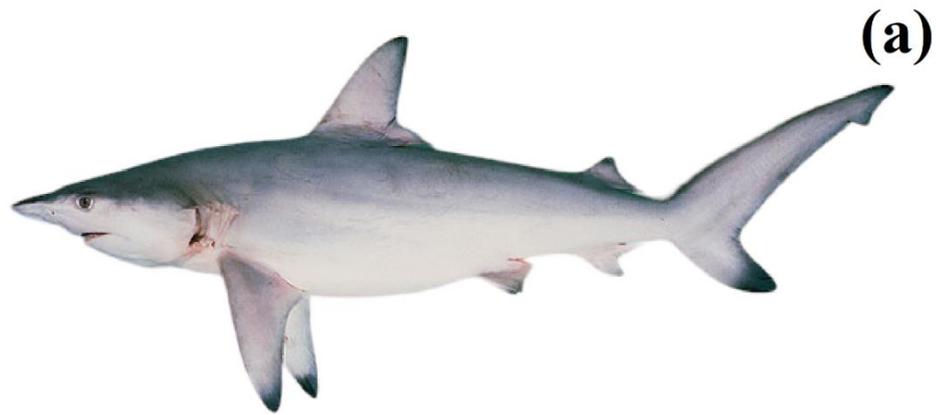


Plate 3.2: (a) *Carcharhinus limbatus* (Randall, J.E., 1997, FishBase); (b) *Carcharhinus macloti* (c) *Carcharhinus melanopterus*; (d) *Carcharhinus sorrah*

9. *Rhizoprionodon acutus* (Rüppell, 1837)

Common name: Milk shark

Plate 3.3(a)

Rüppell, W. P. E. S. (1835-38) Neue Wirbelthiere zu der Fauna von Abyssinien gehörig. Fische des Rothen Meeres. Siegmund Schmerber, Frankfurt am Main. i-ii + 1-148, Pls. 1-33. [1835:1-28, Pls. 1-7; 1836:29-52, Pls. 8-14; 1837:53-80, Pls. 15-21; 1838:81 148, Pls. 22-33.

Description:

A body shape is streamlined and relatively slender, featuring a long, narrow snout. Head is flat and broad with large eyes without a rear notch. Both upper and lower labial furrows are long, usually containing over 15 hyomandibular pores on each side near the mouth. Interdorsal ridge absent or rudimentary. Origin of the first dorsal fin varies, positioned slightly just anterior to just behind pectoral fin free rear tips. Second dorsal fin is smaller than the first, approximately one-third its height or less, originate far posterior to mid-length of anal fin base. Anal fin is larger than the second dorsal and has a slightly concave posterior margin. The preanal ridges are prominent and about as long as the anal fin base. Dorsal surface varies in colour from bronze to grey or greyish brown, tips of the pectoral, pelvic, anal, and lower caudal fins, as well as the margins of the pectoral fins, are pale; the upper lobe of the caudal fin is black edged and has a dusky tip. While the ventral surface is white.

Habitat and Distribution: this species inhabits continental and insular shelves and is typically found near the bottom up to depths of 200 meters (Jabado and Ebert, 2015), although it can occur throughout the water column. It is commonly found over sandy substrates. It has a wide range across the Indo-Pacific from South Africa to Australia and in the Eastern Atlantic from Madeira and Mauritania to Angola; it also inhabits the Mediterranean Sea (Ebert et al., 2013, Amor et al., 2016).

The status of *Rhizoprionodon acutus* is listed as Vulnerable on the IUCN Red List of Threatened Species (Rigby et al., 2020).

10. *Rhizoprionodon oligolinx* (Springer, 1964)**Common name:** Grey Sharpnose shark**Plate 3.3(b)**

Springer, V. G. (1964) A revision of the carcharhinid shark genera *Scoliodon*, *Loxodon*, and *Rhizoprionodon*. Proceedings of the United States National Museum v. 115 (no. 3493): 559-632, Pls. 1-2.

Description:

A small, slender shark is characterized by a long, narrow snout and large eyes without rear notch. Short upper and lower labial furrows with enlarged hyomandibular pores, usually between 12 to 16 on each side of the mouth. No inter-dorsal ridge. First dorsal fin origin over or just behind the inner corners of the pectoral fins, with its free rear tip generally positioned in front of the origin of the pelvic fin. Second dorsal fin is smaller than the anal fin and starts well behind the midpoint of the anal fin base, which has a slightly concave posterior margin. Preanal ridges are notably long, about equal to length of anal-fin base. Dorsal surface is bronze to greyish, Pectoral-fin posterior margins pale and upper lobe of caudal fin margins dark edged. Ventral surface is white.

Habitat and Distribution: It is inhabiting both inshore and offshore areas, on coastal and continental insular shelves (Jabado and Ebert, 2015). It is found across the Indo-west Pacific region, stretching from the Persian Gulf to northern Australia and northward to southern Japan (Ebert et al., 2013, Amor et al., 2016).

The status of *Rhizoprionodon oligolinx* is listed as Near Threatened on the IUCN Red List of Threatened Species (Rigby et al., 2021e).

11. *Glyphis gangeticus* (Müller & Henle, 1839)

Common name: Ganges shark

Plate 3.3(c)

Müller, J. and F. G. J. Henle (1838-41) Systematische Beschreibung der Plagiostomen. Veit und Comp., Berlin. i-xxii + 1-200, 60 pls. [Pp. 1-28 published in 1838, reset pp. 27-28, 29-102 in 1839, i-xxii + 103-200 in 1841.

Description:

A body is relatively stout with a short, broadly rounded snout that is much less than mouth width. Eyes are small and equipped with internal nictitating membranes, positioned dorsolaterally on the head. There are no spiracles, there are no nasoral grooves or barbels on its nostrils. Mouth is long, wide, and extends in front of the eyes. Labial furrows are very short. First dorsal fin originates from the rear end of pectoral base, while the second dorsal fin is about half the height of the first, and the anal fin features a deeply notched posterior margin. Pectoral fins are elongated and falciform, extending beneath the middle of the first dorsal fin. Upper precaudal pit longitudinal. Fins are grey with darker edges, and the posterior edge of caudal fin rather dark. Dorsal surface is grey-brown, while the ventral surface is white, with no distinctive markings.

Habitat and Distribution: Ganges Shark is euryhaline and is found in tropical rivers both in freshwater and estuarine environments, as well as in coastal areas at depths ranging from 0 to 50 meters (Grant et al., 2019). It has a patchy distribution across the Indo-West Pacific: north Indian Ocean, Indus River outside Karachi, Pakistan to Bangladesh, Myanmar, Thailand and Borneo. (Li et al., 2015; Last et al., 2010)

The status of *Glyphis gangeticus* is listed as Critically Endangered on the IUCN Red List of Threatened Species (Rigby et al., 2021f).

12. *Loxodon macrorhinus* (Müller & Henle, 1839)**Common name:** Sliteye shark**Plate 3.3(d)**

Müller, J. and F. G. J. Henle (1838-41) Systematische Beschreibung der Plagiostomen. Veit und Comp., Berlin. i-xxii + 1-200, 60 pls. [Pp. 1-28 published in 1838, reset pp. 27-28, 29-102 in 1839, i-xxii + 103-200 in 1841.

Description:

A small, slender shark, a very long, narrow, parabolic snout, which is longer than it is wide. small labial furrows, and many patches of pores open on the snout, the most conspicuous being between and in front of the level of the nostrils and behind the eyes up on to the head. There is a line of pores edging the upper lip and a line on each side above the angle of the mouth. No Interdorsal ridge. Eyes are large, marked with transverse golden bands, and have a distinct notch on their posterior edge. First dorsal fin is set noticeably behind the free rear tips of the pectoral fins. First dorsal fin origin well behind pectoral fin free rear tips, Second dorsal fin low with very long free rear tips, smaller than anal fin, its origin over anal fin insertion. Pelvic fins are pale grey with whitish posterior edges, and the pectoral fins feature subtly whitish tips and posterior edges. Preanal ridges are as long as the anal fin base. Pectoral fins same length or slightly larger than height of first dorsal fin, anal fin posterior margin slightly concave. Both the caudal and first dorsal fins display narrow dark margins, and the first dorsal fin also has a dusky tip. Dorsal surface is a bronze to greyish without a distinctive pattern, while the ventral surface is almost white.

Habitat and Distribution: It is found in shallow waters along continental and insular shelves, primarily at depths ranging from 7 to 100 meters (Jabado and Ebert, 2015). It inhabits the tropical and subtropical Indo-West Pacific region, extending from southeastern Africa to Papua New Guinea, and reaching north to southern Japan. (Ebert et al., 2013; Jabado et al., 2017)

The status of *Loxodon macrorhinus* is listed as Near Threatened on the IUCN Red List of Threatened Species (Rigby et al., 2021g).

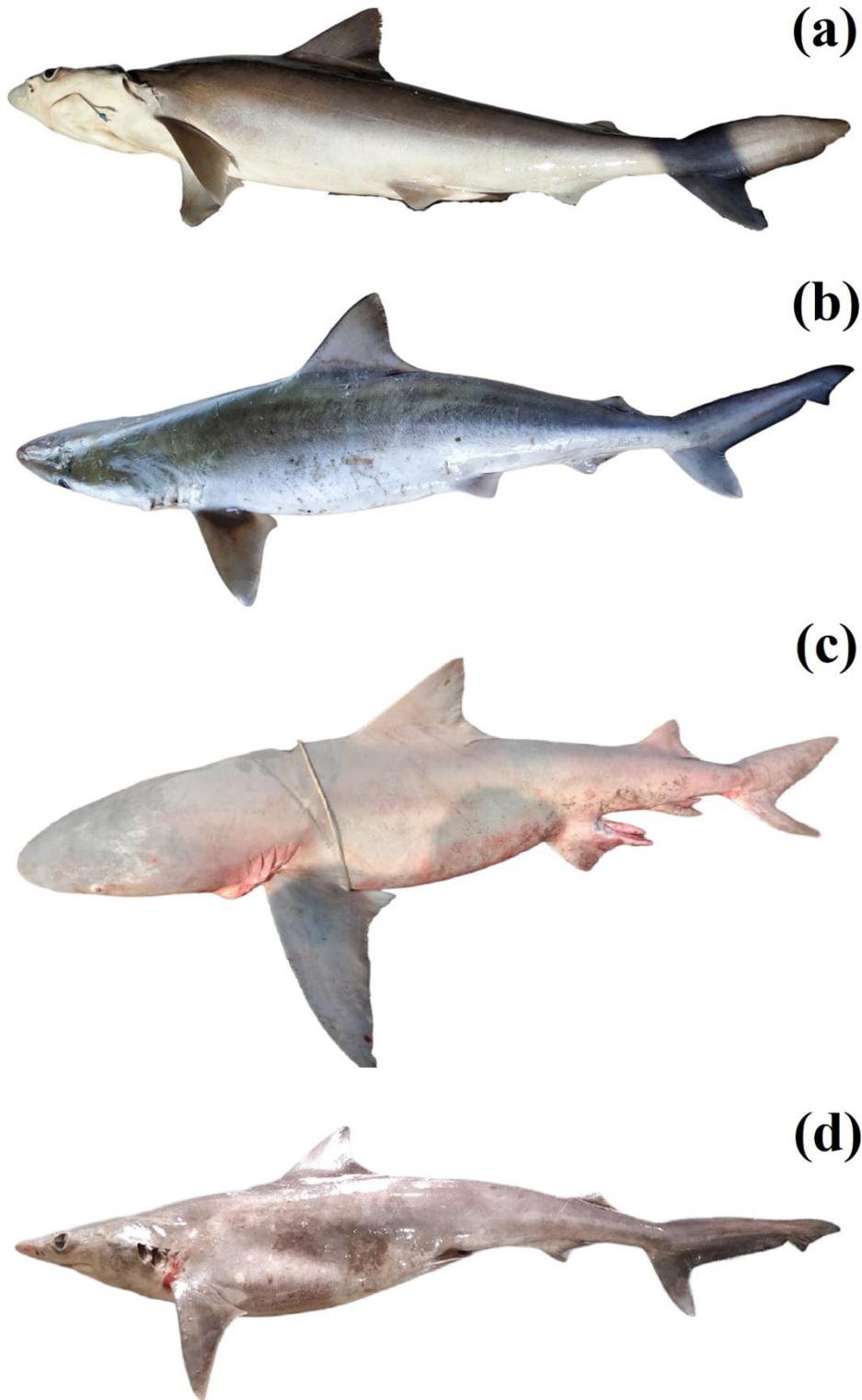


Plate 3.3: (a) *Rhizoprionodon acutus*; (b) *Rhizoprionodon oligolinx*;
(c) *Glyphis gangeticus*; (d) *Loxodon macrorhinus*

Family: Galeocerdonidae

13. *Galeocerdo cuvier* (Péron & Lesueur, 1822)

Common name: Tiger shark

Plate 3.4(a)

Lesueur, C. A. (1822) Description of a *Squalus*, of a very large size, which was taken on the coast of New-Jersey. Journal of the Academy of Natural Sciences, Philadelphia v. 2: 343-352, Pl.

Description:

A snout is short, broad, and bluntly rounded. Has a large mouth that extends well behind the eyes, with long upper labial furrows. Small, slit-like spiracles are present. Teeth are coarsely serrated, with outer edges that are deeply notched and tips that slant outward. There's a subtle rounded keel on each side of the caudal peduncle. First dorsal fin with long free rear tip which is nearly half the fin's height, originate over the pectoral fin insertions or near the inner margins. Second dorsal fin is smaller than the first, while the anal fin almost the same size as the second dorsal, has a deep notch. Upper caudal fin is sharply pointed. Body is a salty-grey on dorsal side and lighter ventrally, adorned with tiger-like stripes and blotches along the sides and back, including the high dorsal fin and the lunate-shaped upper lobe of the tail fin. markings, consisting of numerous prominent dark or brown variegated spots or vertical stripes on the body and fins, are more pronounced in juveniles and tend to fade or disappear in adults.

Habitat and Distribution: this species is found on and near continental and insular shelves, mostly in bays, lagoons, coral atolls, island passes, and estuaries. It can be found from the surface down to depths of at least 350 meters (Jabado and Ebert, 2015) and has a global distribution in tropical and warm temperate oceans (Ebert et al., 2013).

The status of *Galeocerdo cuvier* is listed as Near Threatened on the IUCN Red List of Threatened Species (Ferreira et al., 2019).

Family: Sphyrnidae

14. *Sphyrna lewini* (Griffith & Smith, 1834)

Common name: Scalloped hammerhead

Plate 3.4(b)

Griffith, E., and C. H. Smith (1834) The class Pisces, arranged by the Baron Cuvier, with supplementary additions, by Edward Griffith, F.R.S., &c. and Lieut.-Col. Charles Hamilton Smith, F.R., L.S.S., &c. &c. In: Cuvier, G: The animal kingdom, arranged in conformity with its organization, by the Baron Cuvier, member of the Institute of France, &c. &c. &c., with supplementary additions to each order, by Edward Griffith ... and others. (2nd ed.) Whittaker & Co., London. 1-680, Pls. 1-62 + 3.

Description:

A head is expanded laterally into prominent keels shaped like a hammer, with a central notch and two smaller lateral indentations. Eyes' posterior margin aligns approximately with the mouth's front. The nostrils exhibit strong prenarial grooves. First dorsal fin is tall and moderately curved, originating above or just behind the pectoral fin insertions, with its free rear tips positioned in front of the pelvic fins' origin. Second dorsal fin is small, has a free rear tip, and a subtly concave posterior margin, located directly above or slightly behind the anal fin's middle. Pelvic fin presents an almost straight posterior margin. Anal fin base is larger than that of the second dorsal fin base and features a deeply notched posterior margin, with an upper precaudal pit shaped like a 'V'. Dorsal surface is bronze or brownish grey colour, with dusky or dark tips on the pectoral fins and a dark blotch on the lower lobe of the caudal fin. Ventral surface is pale.

Habitat and Distribution: This species is found on continental and insular shelves and the adjacent deeper waters. It inhabits depths from the surface down to at least 275 meters and can be found as deep as 1000 meters (Jabado and Ebert, 2015). Juveniles primarily reside in inshore areas, estuaries, and shallow bays, while adults tend to gather offshore around seamounts. This species has a cosmopolitan distribution in tropical and warm temperate seas (Ebert et al., 2013).

The status of *Sphyrna lewini* is listed as Critically Endangered on the IUCN Red List of Threatened Species (Rigby et al., 2019a).

15. *Sphyrna zygaena* (Linnaeus, 1758)

Common name: Smooth hammerhead

Plate 3.4(c)

Linnaeus, C. (1758) Systema Naturae, Ed. X. (Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Tomus I. Editio decima, reformata.) Holmiae. v. 1: i-ii + 1-824.

Description:

A head is broad with a narrow blade. anterior margin of head broadly arched and without median indentation, while posterior margin of eyes below level of front of mouth, lateral expansion of head is almost equal or slightly bigger than its width near the eye and has a groove along almost its entire anterior edge. Prenarial grooves strongly developed, orbit closer to nares. First dorsal fin is tall, wide, and moderately falcate with a free rear tip, its originating over pectoral fin inner margins. Second dorsal fin is smaller, with a short free rear tip that does not extend to the upper caudal fin's origin; it starts just posterior the anal fin's origin. Pectoral fins are short and broad, can have dusky edges on underside. Pelvic fins have a concave posterior margin, while the anal fin is substantially larger than the second dorsal fin and has a deep notch on its posterior margin. Dorsal surface olive to dark greyish brown. No distinct fin markings, except for the dusky-tipped ventral pectoral fin. Ventral surface is white.

Habitat and Distribution: Primarily resides on continental and insular shelves. It is found from the surface to a depth of at least 200 meters, although it is most commonly seen at depths less than 20 meters (Jabado and Ebert, 2015). Its range is circum-global, occurring in temperate seas worldwide and in tropical waters in some areas (Last and Stevens, 2009; Ebert et al., 2013).

The status of *Sphyrna zygaena* is listed as Vulnerable on the IUCN Red List of Threatened Species (Rigby et al., 2019b).

Family: Triakidae

16. *Mustelus mosis* (Hemprich & Ehrenberg, 1899)

Common name: Arabian smooth hound

Plate 3.4(d)

Hemprich, F. W., & Ehrenberg, C. G. (1899). *Symbolae physicae, seu icones adhuc ineditae.. ex itineribus per Libyam, Aegyptiam, Nubiam, Dongolam, Syriam, Arabiam et Habessiniam publico institutis sumptu. studio annis MDCCCXX-MDCCCXXV redierunt. Zoologica. Berolini [Berlin](Reimer), 31.*

Description:

A body is relatively slender, featuring a short, bluntly angular snout with a broad internarial space. Eyes are placed dorsolaterally, beneath strong subocular ridges. Rostral cartilages and supraorbital crests are highly calcified. Has long labial furrows with similar upper and lower lengths. Last two gill slits are located over the bases of the pectoral fins base. An interdorsal ridge is present, and the first dorsal fin is moderately curved with free rear tips, originate behind the pectoral fin insertions. Second dorsal fin is larger than the anal fin, much far from the pelvic fin origin. Caudal fin has a semi-curved lower lobe, and the caudal peduncle without keels or precaudal pits. Tips of the second dorsal and caudal fins are black. Body colour is grey or grey brown on the dorsal side and cream white on the ventral side.

Habitat and Distribution: this species is found in deep waters from the mid-continental shelf to the upper slope and near coral reefs inshore. It resides on the ocean floor at depths ranging from 150 to 200 meters and is found throughout the Indian Ocean, including the Red Sea, Arabian Sea, and the Persian Gulf (Ebert et al., 2013).

The status of *Mustelus mosis* is listed as Near Threatened on the IUCN Red List of Threatened Species (Pollom et al., 2019).



Plate 3.4: (a) *Galeocerdo cuvier*; (b) *Sphyrna lewini*; (c) *Sphyrna zygaena*;
(d) *Mustelus mosis*

17. *Iago omanensis* (Norman, 1939)

Common name: Bigeye hound shark

Plate 3.5(a)

Norman, J. R. (1939) Fishes. The John Murray Expedition 1933-34. Scientific Reports, John Murray Expedition v. 7 (no. 1): 1-116.

Description:

A snout is moderately long and broad, and Inter-dorsal ridge present. Mouth with short labial furrows; the upper furrows being slightly longer than the lower ones. Lateral eyes with the sub-ocular ridges obsolete. Width of the longest gill slits is roughly equal to the diameter of the eyes, and the interorbital space is narrow. Trunk is hump-backed, and the gill slits are wide, width of longest being almost equal to the length of the eye. First dorsal fin is small and positioned forward, over the bases of the pectoral fin base. Second dorsal fin is a bit smaller than the first but nearly twice the size of the anal fin. Caudal fin has a small lower lobe, and both dorsal fins often have darker edges. Caudal peduncle lacks keels or precaudal pits. Body brownish or greyish ventral side and a lighter dorsal surface, without conspicuous markings. The dorsal fin margins are often darker.

Habitat and Distribution: It is found in the deep waters of the continental shelf and slope, usually residing near the bottom at depths ranging from 110 meters to at least 1000 meters (Jabado and Ebert, 2015). It is distributed across the Western Indian Ocean, including the Red Sea, Gulf of Aqaba, Gulf of Oman, to Pakistan and India (Ebert et al., 2013).

The status of *Iago omanensis* is listed as Least Concern on the IUCN Red List of Threatened Species (Dulvy et al., 2021).

Order: Orectolobiformes

Family: Hemiscyllidae

18. *Chiloscyllium arabicum* (Gubanov, 1980)

Common name: Arabian bamboo shark

Plate 3.5(b)

Gubanov, E. P. and N. A. Schleib (1980) Sharks of the Arabian Gulf. Kuwait Ministry of Public Works, Agracultural Department, Fisheries Division. 1-69.

Description:

A rounded snout with a small, transverse with barbells well in front of eyes, Eyes moderately large, the nostrils are subterminal on snout, Preoral snout is long, and the mouth is closer to eyes than snout tip, prominent pre-dorsal and Inter-dorsal ridges on back, inter-dorsal space was very long, Dorsal fins large and subangular, subequal to or larger than pelvic fins. and without concave posterior margins and projecting free rear tips. Origin of the first dorsal fin over or behind rear halves of pelvic-fin bases. Anal fin, which is low and rounded, starts slightly behind the free rear tip of the second dorsal fin. Tail is thick, and the length of the anal fin from its origin to the free rear tip is somewhat less than that of the hypural caudal lobe, which extends from the lower caudal origin to the subterminal notch. Body colour is greyish brown on the dorsal side and creamy white on the ventral side.

Habitat and Distribution: This species is native to coastal waters, typically found around coral reefs, lagoons, and rocky shores Occurs on the bottom at depths from 3 to 100 m. it is endemic to the Arabian Seas region and is common from the Gulf to Pakistan and India (Jabado and Ebert, 2015).

The status of *Chiloscyllium arabicum* is listed as Near Threatened on the IUCN Red List of Threatened Species (Moore et al., 2017).

19. *Chiloscyllium griseum* (Müller & Henle, 1838)

Common name: Grey bamboo shark

Plate 3.5(c)

Müller, J. and F. G. J. Henle (1838-41) Systematische Beschreibung der Plagiostomen. Veit und Comp., Berlin. i-xxii + 1-200, 60 pls. [Pp. 1-28 published in 1838, reset pp. 27-28, 29-102 in 1839, i-xxii + 103-200 in 1841.

Description:

A slender body, long, and moderately stout. Rounded snout, a small transverse mouth with barbells positioned well in front of the eyes, no lateral ridges on trunk. Dorsal fins are rounded, subequal to or larger than the pelvic fin, and have straight posterior edges without projecting free rear tips. First dorsal fin is positioned over or slightly behind the rear tips of the pelvic fins, whereas the second dorsal fin is larger, with a base longer than that of the first dorsal fin base. Inter-dorsal space short and about the same size as length of first dorsal fin base. Anal fin is low, originating just behind the free rear tip of the second dorsal fin. Caudal fin is markedly asymmetrical, featuring a distinct subterminal notch but without a ventral lobe. Upper body colour light brown to grey-brown, while the ventral side is a cream colour.

Habitat and Distribution: This species is found inshore, around coral assemblages, rocky areas, and lagoons. It resides on the ocean floor at depths ranging from 5 to 80 meters (Jabado and Ebert, 2015). Its geographical range extends through several countries, including Pakistan, India, Sri Lanka, Malaysia, and Thailand, and it is also found in Indonesia, China, Japan, the Philippines, and Papua New Guinea (Hoq et al., 2011; Ebert et al., 2013).

The status of *Chiloscyllium griseum* is listed as Vulnerable on the IUCN Red List of Threatened Species (VanderWright et al., 2020).

Order: Lamniformes

Family: Lamnidae

20. *Isurus oxyrinchus* (Rafinesque, 1810)

Common name: Shortfin mako

Plate 3.5(d)

Rafinesque, C. S. (1810) Caratteri di alcuni nuovi generi e nuove specie di animali e piante della Sicilia, con varie osservazioni sopra i medesimi. Sanfilippo, Palermo. (Part 1 involves fishes, pp. [i-iv] 3-69, Part 2 with slightly different title, pp. ia-iva + 71-105 Pls. 1-20.

Description:

A body is elongated and spindle-shaped with a long, sharply pointed, conical snout and large black eyes. Mouth is U-shaped, positioned ventrally, and features prominently protruding, long, pointed teeth on the lower jaw that remain visible even when the mouth is closed. Teeth lack cusp lets or serrations, and the cusps of both upper and lower anterior teeth are bent backwards. First dorsal fin is large, originate just behind the pectoral fins' free rear tip, and tapers into a more angular, narrowly rounded apex. Second dorsal fin is small, originating before anal fin origin. Pectoral fins are curved and shorter than the length of the head, while the anal fin is small, starting around the midpoint of the second dorsal fin's base. Caudal fin is lunate with a prominent lateral keel extending onto it, no secondary keels on the caudal base. Dorsal surface is indigo blue, fading to lighter blue on the sides and white on the ventral side.

Habitat and Distribution: This species is found offshore but can also appear inshore in warm waters. It inhabits depths from the surface down to at least 650 meters, though it is most commonly found at depths between 100 and 150 meters (Jabado and Ebert, 2015). This species is widely distributed in the temperate and tropical waters of all oceans (Ebert et al., 2013).

The status of *Isurus oxyrinchus* is listed as Endangered on the IUCN Red List of Threatened Species (Rigby, 2019a).



(a)



(b)



(c)



(d)

Plate 3.5: (a) *Iago omanensis*; (b) *Chiloscyllium arabicum*;
(c) *Chiloscyllium griseum*; (d) *Isurus oxyrinchus*

Family: Alopiidae

21. *Alopias pelagicus* (Nakamura, 1935)

Common name: Pelagic thresher

Plate 3.6(a)

Nakamura, H. (1935) On the two species of the thresher shark from Formosan waters. Memoirs of the Faculty of Science and Agriculture, Taihoku Imperial University, Formosa v. 14 (no. 1) (Zoology no. 4): 1-6, Pls. 1-3.

Description:

A small thresher shark features a short, conical snout and moderately large eyes that do not extend onto the dorsal head surface. Head is convex with a moderately convex forehead when viewed from the lateral side. No labial furrows on mouth or deep grooves behind the eye. Origin of the first dorsal fin is closer to the rear tip of the pectoral fin than to the base of the pelvic fin. Second dorsal fin and the anal fin are very small, second dorsal fin positioned well ahead of the anal fin. Pectoral fins are long, narrow, and nearly straight, with broad rounded tips, Pelvic fin is small with a moderately concave posterior margin. Upper lobe of the caudal fin is very long and strap-like, almost equal to the length of the rest of the body, Lower lobe is short but robust. Skin colour immediately above the origins of the pectoral and pelvic fins is dark, without white patches. Dorsal surface is a dark greyish to bluish grey, often with a metallic sheen, and the ventral surface is white.

Habitat and Distribution: Found mostly offshore, but sometimes closer to shore in areas with narrow continental shelves, drop offs and seamounts. Can occur from the surface to a depth of at least 152 m (Jabado and Ebert, 2015). The species is oceanic and has a wide range in the tropical and subtropical Indo-Pacific regions (Last and Stevens, 2009; Ebert et al., 2013).

The status of *Alopias pelagicus* is listed as Endangered on the IUCN Red List of Threatened Species (Rigby et al., 2019c).

22. *Alopias superciliosus* (Lowe, 1841)

Common name: Bigeye thresher

Plate 3.6(b)

Lowe, R. T. (1841) Certain new species of Madeiran fishes ... Proceedings of the Zoological Society of London 1840 (pt. 8, no. 89): 36-39.

Description:

A body has a long, and bulbous snout with a deep horizontal groove on each side of the nape. Has very large, inverted pear-shaped eyes that extend onto the top of the head and a distinct indentation in the profile of the forehead at the origin of the head grooves that gives the head a helmeted or crested appearance. First dorsal fin is positioned more posteriorly on the back with the midpoint of its base much closer to the pelvic fin bases than to the pectoral fin base, and with its free rear tip over or slightly anterior to the pelvic origin. Second dorsal fin and the anal fin are quite small. Pectoral fins are long, narrow, and slightly curved with broadly rounded tips. Upper lobe of the caudal fin is very long and strap-like, almost quite equal to the length of the rest of the body, while the lower lobe is short. Body coloration is purplish grey or grey brown on the upper surface and sides, with a grey to white underside. Light colour of the abdomen does not extend over the pectoral fin base.

Habitat and Distribution: Found from close inshore, over continental shelves, and in the open ocean. Can occur from the surface to a depth of at least 723 m, most common at depths of over 100 m (Jabado and Ebert, 2015). Circumglobally distributed, occurs worldwide in tropical and temperate seas (Ebert et al., 2013).

The status of *Alopias superciliosus* is listed as Vulnerable on the IUCN Red List of Threatened Species (Rigby, 2019b).



(a)



(b)

Plate 3.6: (a) *Alopias pelagicus*; (b) *Alopias superciliosus*

Order: Rhinopristiformes

Family: Rhinidae

23. *Rhina ancylostomus* (Bloch & Schneider, 1801)

Common name: Bowmouth guitarfish

Plate 3.7(a)

Bloch, M. E. and J. G. Schneider (1801) *Systema Ichthyologiae Iconibus ex Illustratum*. Post obitum auctoris opus inchoatum absolvit, correxit, interpolavit Jo. Gottlob Schneider, Saxo. Berolini. Sumtibus Auctoris Impressum et Bibliopolio Sanderiano Commisum. i-lx + 1-584, Pls. 1-110.

Description:

A snout is short and broadly rounded. Eyes are positioned dorsolaterally on the head, just anterior to the spiracles. A prominent ridge lined with large thorns runs along the mid-line of the disc, and the interorbital area features two ridges adorned with clusters of small, medium, and large triangular thorns. spiracles lack skin folds on their posterior margins. Ventral mouth, with the upper jaw displaying three deep concavities and the lower jaw being strongly trilobed. Nostrils positioned anterior to the mouth, are large and very elongate, separated from each other by a distance roughly equal to their width, and they do not extend to the mouth. Two dorsally positioned fins are present, each with free rear tips. Origin of the first dorsal fin is slightly forward of the pelvic fin origins. Pectoral fins begin in front of the mouth but behind the nostrils, with their posterior tips not extending to the origin of the pelvic fins. Caudal fin is lunate, with the upper and lower lobes being nearly the same size. Dorsal surfaces range from bluish-grey to brownish, marked with numerous large white spots, including on the fins. Juveniles display black markings on the pectoral fins, which are faint or absent in adults. Dark bands are present between the eyes and spiracles. Ventral surface is white.

Habitat and Distribution: This marine species is a bottom dweller, inhabiting coastal regions and coral reefs close to shore. Its range extends across the Indo-West Pacific, from South Africa's Natal coast, Mozambique, East Africa, the Seychelles, the Red Sea, Arabia, Oman, the Persian Gulf, India, Sri Lanka, Malaysia, Indonesia (specifically

Borneo), the Philippines, New Guinea, Thailand, Vietnam, China, Taiwan, Korea, Japan, and Australia. In Australia, it is found from Exmouth Gulf in Western Australia, northward through the Northern Territory and Queensland, up to Forster in New South Wales (Last and Stevens, 2009a; Last et al., 2016).

The status of *Rhina ancylostomus* is listed as Critically Endangered on the IUCN Red List of Threatened Species (Kyne et al., 2019).

24. *Rhynchobatus laevis* (Bloch & Schneider, 1801)

Common name: Smoothnose wedge fish

Plate 3.7(b)

Bloch, M. E. and J. G. Schneider (1801) M. E. Blochii, Systema Ichthyologiae Iconibus cx Illustratum. Post obitum auctoris opus inchoatum absolvit, correxit, interpolavit Jo. Gottlob Schneider, Saxo. Berolini. Sumtibus Auctoris Impressum et Bibliopolio Sanderiano Commissum. i-lx + 1-584, Pls. 1-110.

Description:

A disc is obtusely wedge-shaped with a slightly convex front margin near the orbit, otherwise appearing nearly straight. Snout is short, broad, small, and angular, with thorns on the back and around the eyes but absent from the snout. Spiracle with two short skin folds, the outer fold being slightly taller than the inner. Thorns, which are small and blunt, are found along the dorsal mid-line, on the shoulder, beside the spiracle, and around the upper eye margin. usually, a prominent dark pectoral marking is encircled by 4-5 white spots. Area between the eyes lacks dark markings, the tip of the ventral snout is usually black, and the upper body displays multiple rows of white spots extending beyond the pectoral marking level. Dorsal fins are weakly falcate with narrowly pointed tips; first dorsal fin originates over or just ahead of the pelvic fin origin. Pectoral fin tips are angular. Caudal fin is short and deeply concave. Dorsal surface is greyish-brown with 4-5 rows of white spots along each side beneath the first dorsal fin; pre dorsal spots not reaching forward of mid-line between pectoral markings, snout sides are either pale or pinkish. large pectoral marking, often with, often

ocellated; is closely surrounded by 4-7 small white spots. ventral surface is uniformly white.

Habitat and Distribution: Found on the ocean floor, this species primarily inhabits shallow coastal areas, including bays and regions near river mouths, at depths down to 60 meters. Its range spans the Indo-West Pacific, from Oman to Japan, with primarily in the Indian Ocean (Last et al., 2016).

The status of *Rhynchobatus laevis* is listed as Critically Endangered on the IUCN Red List of Threatened Species (Kyne and Jabado, 2019).

Family: Glaucostegidae

25. *Glaucostegus granulatus* (Cuvier, 1829)

Common name: Sharp nose guitarfish

Plate 3.7(c)

Cuvier, G. (1829) *Le Règne Animal, distribué d'après son organisation, pour servir de base à l'histoire naturelle des animaux et d'introduction à l'anatomie comparée*. Edition 2. v. 2: i-xv + 1-406.

Description:

A flattened, narrowly wedge-shaped disc with a strongly depressed trunk and a very long, narrow triangular snout ending with a pointed tip; nostrils are broad and oblique, with a narrow anterior opening and nostrils are about half the width of the mouth, sub equal to the internasal width, and the anterior nasal flaps barely penetrate the internasal space. Disc is thickened centrally, and its anterior margin is almost straight, often slightly concave before the broadly rounded outer corners. Snout is acute with a bluntly pointed tip that never protrudes forward as a distinct lobe. Orbits are very small, and the rostral ridges are nearly joined along their entire length; margin of the cranium is sharply demarcated before the eyes. Spiracular folds are very short and widely separated. Skin is rough and densely covered with small denticles, more coarsely granular on the dorsal surface than on the ventral, with enlarged areas between the orbits and in a distinct band between the nape and the first dorsal fin. There is a pair

of large thorns on each shoulder and similar thorns in irregular, median rows along the midline. Has two narrowly spaced dorsal fins with rounded to bluntly pointed apices. Dorsal surface is uniformly yellowish-brown to greyish, with paler fin margins and sharply demarcated. Ventral surface is whitish, with a translucent snout and white rostral cartilage.

Habitat and Distribution: Mainly found on the benthic, ranging from coastal areas to the mid-continental shelf, at depths up to at least 120 meters. Moderately distributed throughout the northern Indian Ocean, spanning from the Arabian/Persian Gulf to Myanmar (Last et al., 2016).

The status of *Glaucostegus granulatus* is listed as Critically Endangered on the IUCN Red List of Threatened Species (Kyne et al., 2022).

26. *Glaucostegus obtusus* (Müller & Henle, 1841)

Common name: Wide nose guitarfish

Plate 3.7(d)

Müller, J., and F. G. J. Henle (1841) Systematische Beschreibung der Plagiostomen. Veit und Comp., Berlin. i-xxii + 1-200, 60 pls. [Pp. 1-28 published in 1838, reset pp. 27-28, 29-102 in 1839, i-xxii + 103-200 in 1841.

Description:

A flattened, broad, shovel-shaped disc. The snout is short and broadly triangular, while the nostrils are broad and oblique, featuring an oval opening at the front. The trunk exhibits a depressed shape, featuring a largely convex anterior margin and an outer corner that transitions from broadly rounded to abruptly angular. The snout is relatively blunt (obtuse), with a broadly rounded tip that does not extend forward as a lobe. The orbit is very small, and the rostral ridges are well separated, with the cranium margin sharply defined before the eyes. There is one small spiracular fold. Nostrils are shorter than the mouth and roughly equal to the internasal width, with anterior nasal flaps barely extending into the internasal space. On the dorsal surface, the skin is rough and covered with small denticles that are slightly enlarged and more granular than on the ventral side. Thorns are irregular in shape and often obscure, with

no prominent patch on each shoulder or greatly enlarged thorns on the snout tip and around the orbits. The tail is long, and the dorsal fins are short, with rounded apices that are close together, separated by an interspace exceedingly twice the base length of the first dorsal fin, and well separated from the pelvic fins. The dorsal side is uniformly greyish to greyish brown, with dorsal fins and paler yellowish hind margins of the pectoral and pelvic fins. The sides of the snout are whitish to translucent, sharply demarcated from the rostral ridges and the anterior part of the cranium, with the rostral ridges darker than the rest of the rostrum. The ventral surface is white, whereas the anterior snout is translucent or white.

Habitat and Distribution: Found on the benthic inshore and over inner continental and insular shelves up to about 60 meters deep. Its distribution spans from Pakistan to Thailand in the northern Indian Ocean, with its eastern boundaries remaining unclear (Last et al., 2016).

The status of *Glaucostegus obtusus* is listed as Critically Endangered on the IUCN Red List of Threatened Species (Kyne and Jabado, 2019).



(a)



(b)



(c)



(d)

Plate 3.7: (a) *Rhina ancylostomus*; (b) *Rhynchobatus laevis*;
(c) *Glaucostegus granulatus*; (d) *Glaucostegus obtusus*

Family: Rhinobatidae

27. *Rhinobatos annandalei* (Norman, 1926)

Common name: Annandale's guitarfish

Plate 3.8(a)

Norman, J. R. (1926) A synopsis of the rays of the family Rhinobatidae, with a revision of the genus *Rhinobatus*. Proceedings of the Zoological Society of London 1926 (pt 4): 941-982.

Description:

A disc is large and broadly wedge-shaped. Snout is moderate, triangular, and bluntly pointed with slightly concave margins. It has two spiracular folds and an anterior cartilage that is sickle-shaped and bilobed at the rear. Rostral ridges are somewhat separated along their length, parallel at the front, and slightly diverging at the back. Spiracle is slightly larger than the distance between the spiracles, with both folds well-developed and the outer fold being more prominent. Nostrils are oblique with sub-oval anterior openings of moderate length, and the anterior valve extends inward to the level of the inner edge of the nostril or slightly beyond. Mouth is nearly straight. First dorsal fin is a little more than twice as high as it is long. Skin is covered with minute denticles, giving it a rather smooth texture. There is a series of fairly small, closely set spines along the median line of the back, with two to four on each shoulder and several around the orbits and above the spiracles. All the spines are stronger and sharper in males. Disc is broader in females than in males. It has a stout tail that is confluent with the trunk, and the pectoral fins are expanded and attached to the head from the nostrils. Dorsal fins are relatively large, the pelvic fins are single-lobed, and the caudal fin is not bilobed; dorsal surface and fins are greyish to brownish with a symmetrical pattern of small white spots, and the disc is paler near the rostral shaft. The ventral surface is white with broad greyish-brown patches on the disc and tail, and yellowish areas around the gills, usually translucent on the snout on either side of the rostral shaft.

Habitat and distribution: Primarily benthic, found inshore on the inner continental shelf at depths up to 73 meters (Weugmann, 2016). It is distributed in the northern Indian Ocean, from Oman to India (Last et al., 2016).

The status of *Rhinobatos annandalei* is listed as Critically Endangered on the IUCN Red List of Threatened Species (Dulvy et al., 2021).

28. *Rhinobatos punctifer* (Compagno and Randall, 1987)

Common name: Spotted guitarfish

Plate 3.8(b)

Compagno, L. J. V. and J. E. Randall (1987) *Rhinobatos punctifer*, a new species of guitarfish (Rhinobatiformes: Rhinobatidae) from the Red Sea, with notes on the Red Sea batoid fauna. *Proceedings of the California Academy of Sciences (Series 4)* v. 44 (no. 14): 335-342.

Description:

A is moderately long, broad, and bluntly rounded with an angular shape, featuring a slightly concave edge near the tip, which is not expanded laterally. Rostral cartilage is broad with a uniformly wide shaft extending from the rostral node. Rostral ridges of the snout are thick, broad, and widely separated from each other along their lengths, diverging slightly at the base and converging towards the anteriorly. The eyes are large and interorbital space slightly concave. Distance from the front of the eye to the rear edge of the spiracle is about the same as the distance between the spiracles. Spiracles themselves have two strong posterior ridges.; nostrils moderately broad; anterior nasal flaps with medial folds extending onto internarial space but not medial to the excurrent apertures. Mouth is nearly straight. On the dorsal surface, enlarged denticles or thorns are obsolete, and absent on the tip of the snout and along the rostral ridges. Denticles located in the scapular region, along the back's midline, and between and behind the dorsal fins are small, blunt, and barely noticeable. There are small white spots on the head, disc, pelvic fins, and tail. Tail features lateral dermal folds starting just before the free rear tips of the pelvic fins and extending just past the lower origin of the caudal fin. First dorsal fin is slightly larger than the second, both are triangular

with slightly convex anterior margins, narrowly rounded or pointed tips, concave and nearly vertical posterior margins, and slightly pointed free rear tips. Pelvic fins have slightly convex anterior margins, narrowly rounded tips, convex posterior margins, straight inner margins, and narrowly rounded free rear tips. Caudal fin begins slightly ahead of the lower origin, has a convex dorsal margin and a broadly convex pre-ventral margin, with a broadly rounded ventral tip and an angular dorsal tip, and caudal fin without ventral lobe. Dorsal body colour is medium brown with small light spots, and the ventral side is whitish.

Habitat and distribution: This species is found along the inshore continental shelf down to depths of 70 meters (Weigmann, 2016). It is distributed throughout the Red Sea and extends to the north-western Indian Ocean, ranging from Socotra (Yemen) eastward to Pakistan, including the Persian Gulf (Bonfil and Abdallah, 2004; Last et al., 2016).

The status of *Rhinobatos punctifer* is listed as Near Threatened on the IUCN Red List of Threatened Species (Ebert et al., 2017).

Order: Torpediniformes

Family: Torpedinidae

29. *Torpedo sinuspersici* (Olfers, 1831)

Common name: Gulf torpedo

Plate 3.8(c)

Olfers, J. F. M. von (1831) Die Gattung *Torpedo* in ihren naturhistorischen und antiquarischen Beziehungen erläutert. Berlin. 1-35, Pls. 1-3.

Description:

A body is thick, flabby, and dorso-ventrally flattened with a rounded snout and a sub-circular disc; disc is almost as wide as it is long, broadly truncated at the front. It has small eyes and large spiracles located at the top of its head, which are rounded with a few knob-like papillae at their posterior margins. Nostrils are close together with a short, wide nasal curtain that is shorter than the internarial width; nostrils feature

prominent folds primarily around the outer margin, positioned just laterally to the mouth corners. Electric organs are powerful and originate from the branchial muscles in the head area. First dorsal fin originates in front of the pelvic fin's rear axil, slanting moderately at the front and having a posterior free lobe roughly one-third the length of its base. Second dorsal fin is smaller than the first. Caudal fin's posterior margin is straight, with slightly acute apexes, not broadly rounded. Dorsal surface is uniformly pale and dark brown with closely set light brown or pale spots that merge into thick vermiculation. Spots on margin of snout, pectoral margins are smaller than those on middle of dorsal disc, small spots are also on the pelvic fin; dorsal fins' posterior margins feature a very narrow cream-colored edge with small spots. Ventral colour is consistently creamy-white, though the disc, pelvic fin, and tail have a noticeably darker margin with spots similar to those on the dorsal side.

Habitat and Distribution: This species inhabits shallow waters in sandy regions, near coral reefs, and offshore down to depths of 200 meters. It frequently buries itself in the sand at the bottom of gullies and estuaries. It is commonly found in the western Indian Ocean and has a scattered distribution extending from South Africa to the Red Sea, Arabian Sea, Persian Gulf, Sri Lanka, and the Andaman Sea (last et al., 2016).

The status of *Torpedo sinuspersici* is listed as Data Deficient on the IUCN Red List of Threatened Species (Kyne, 2019).

Family: Narkidae

30. *Narke dipterygia* (Bloch and Schneider, 1801)

Common name: Numb ray

Plate 3.8(d)

Bloch, M. E. and J. G. Schneider (1801) M. E. Blochii, Systema Ichthyologiae Iconibus cx Illustratum. Post obitum auctoris opus inchoatum absolvit, correxit, interpolavit Jo. Gottlob Schneider, Saxo. Berolini. Sumtibus Auctoris Impressum et Bibliopolio Sanderiano Commisum. i-lx + 1-584, Pls. 1-110.

Description:

A Body is entirely naked both above and below, without dermal denticles or thorns. Disc is round, as wide as it is long, without notches or subdivisions opposite the eyes. Snout is short and rounded. Eyes are small and prominent, about half the length of the spiracles. Spiracles are large and situated close behind the eyes, with margins that are either level with or slightly raised above the disc. Mouth is small and protractile, with an oronasal groove present but no cirri. There is a shallow groove around the mouth, and the nostrils are small. There is one spineless dorsal fin, rounded along the margin and with an elongated base, positioned behind the end of the pelvic fins. Pelvic fins are large and sub-triangular, not divided into anterior and posterior lobes. There is no anal fin, and no barbed sting (stinger or stinging spine) on the dorsal surface of the tail behind the dorsal fin. Tail lacks a serrated caudal spine and is well developed, not whip-like, with a low lateral keel along its edge. The tail is slightly longer than the rest of the body. The dorsal surface is plain to reddish brown with white bars or blotches on the sides of the tail extending anteriorly to above the rear pelvic fin bases and on the rear of the pectoral disc. The ventral surface is white.

Habitat and Distribution: Primarily found in intertidal and subtidal zones, extending to offshore areas on the outer shelf and upper slope with soft bottoms, down to depths of 330 meters (Compagno and Last, 1999). Distributed in the Indo-West Pacific, including regions such as Oman and the Arabian Sea, India, Sri Lanka, Malaysia (Penang), Singapore, Indonesia (Malacca), Thailand, Vietnam, China, Taiwan Province of China, Japan, and possibly the Philippines (Menon 1961; Misra 1969; Bhatt et al., 2022).

The status of *Narke dipterygia* is listed as Vulnerable on the IUCN Red List of Threatened Species (VanderWright et al., 2021).

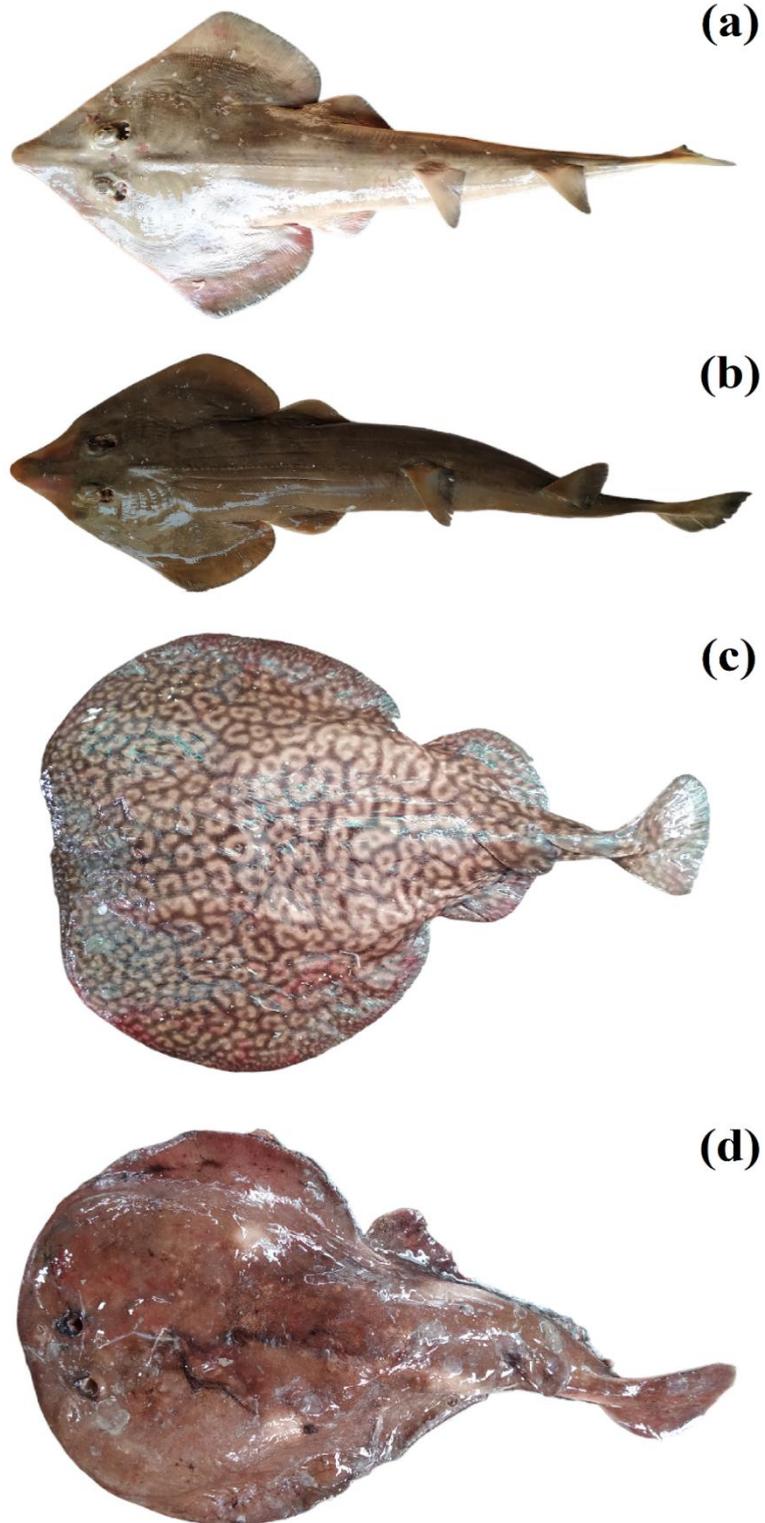


Plate 3.8: (a) *Rhinobatos annandalei*; (b) *Rhinobatos punctifer*;
(c) *Torpedo sinuspersici*; (d) *Narke dipterygia*

Order: Myliobatiformes

Family: Aetobatidae

31. *Aetobatus flagellum* (Bloch & Schneider, 1801)

Common name: Longheaded eagle ray

Plate 3.9(a)

Bloch, M. E. and J. G. Schneider (1801) M. E. Blochii, Systema Ichthyologiae Iconibus cx Illustratum. Post obitum auctoris opus inchoatum absolvit, correxit, interpolavit Jo. Gottlob Schneider, Saxo. Berolini. Sumtibus Auctoris Impressum et Bibliopolio Sanderiano Commissum. i-lx + 1-584, Pls. 1-110.

Description:

A disc is diamond-shaped, broad but relatively short, axis of greatest width of disc well posterior to scapular region, over abdominal cavity. Its thickest point is found above the scapular area and near the back of the head, and it without denticles or thorns. There is a short, bony ridge running along the midline above the scapular region. Pectoral fins are very large, resembling wings, and are narrowly triangular with a weakly falcate shape; anterior margin is basally concave, becoming slightly to moderately convex towards the end, with a narrowly rounded to subangular tip; posterior margin is moderately concave near the tip and nearly straight posteriorly, ending in a broadly rounded free rear tip; originate above the front edge of the spiracles. Head is pronounced, deep, short, and relatively narrow, extending well in front of where the pectoral fins begin. Snout is distinctly convex before the eyes and deeply concave at the origin of the rostral lobe, slightly convex ventrally. Rostral lobe is fleshy and long, narrowly parabolic from dorso-ventral view with a pointed tip. Interorbital space moderately broad. Eyes are small, nearly circular, and very slightly ventrolateral on head; orbit level or only slightly elevated above dorsal head profile. The spiracles are large, sub oval to elliptical, and located dorso-laterally posterior to orbit and above pectoral-fin origin, margins without any protuberances or folds. Nostril is narrowly oval, immediately preceded by a broad, shallow, fleshy depression that borders the front side margin of the nasal curtain; the anterior nasal fold is thin and membranous. deep

oronasal groove present. Nasal curtain is substantial, elongated, and lobed. Mouth is moderately sized and horizontal, not capable of protruding. Pelvic fins are moderately large, slender, and nearly square, with a broadly rounded free rear tip. Tail is very long, slender, and resembles a whip, tapering at the base to a stinging spine and becoming more whip-like towards the end. Base is somewhat compressed without any skin folds. Dorsal surface is consistently brown or sometimes greenish brown, without distinct markings; the tail is uniformly greyish-brown. Ventral side is mostly white, with a wide brown margin covering most of the disc. Border between the brown margin and the white underside is distinctly mottled, widest at posterior margin and narrowest at the anterior margin. The distal third of the pelvic fins is brown, the rostral lobe is predominantly white, and the anterior most margin narrowly brownish.

Habitat and Distribution: This species is benthopelagic, generally found in shallow tropical and subtropical waters worldwide. It has a patchy distribution in the Indo-West Pacific, ranging from the Western Indian Ocean, including areas from Kuwait in the Persian Gulf to Pakistan and India, and extending to the Eastern Indian Ocean from India and Sri Lanka to Indonesia (Kalimantan) and Malaysia (Sarawak) (Last et al., 2010; Last et al., 2016).

The status of *Aetobatus flagellum* is listed as Endangered on the IUCN Red List of Threatened Species (Sherman et al., 2021a).

32. *Aetobatus ocellatus* (Kuhl, 1823)

Common name: Spotted eagle ray

Plate 3.9(b)

van Hasselt, J. C. (1823) Uittreksel uit een' brief van Dr. J. C. van Hasselt, aan den Heer C. J. Temminck. *Algemeene Konst- en Letter-bode voor het Jaar I Deel* (no. 20): 315-317.

Description:

A disc is diamond-shaped, very broad, and short, featuring a moderately long, parabolic rostral lobe. Skin is smooth, and the teeth are plate-like, arranged in a single row in both jaws, with the lower jaw teeth being chevron-shaped. Nasal curtain is

deeply notched in the centre, forming a V-shape. Spiracles are large, located dorso-laterally on the head, and visible in dorsal view. Pectoral fins are expansive, wing-like, and extend above the eye level. Dorsal fin is set far back, starting behind the pelvic fin insertions, and the tail is equipped with a sting. It is very long, slender, and whip-like, tapering at the base and becoming more whip-like beyond the sting. Upper surface is dark brown or blackish, typically marked with numerous whitish spots, while the ventral surface is white with a darker front edge to the disc.

Habitat and Distribution: This species is pelagic, found both inshore and offshore along coastal and inner continental shelves, and sometimes ventures into estuaries. Its range the Indo-west and central Pacific, from South Africa to the central Pacific islands (White et al., 2010).

The status of *Aetobatus ocellatus* is listed as Vulnerable on the IUCN Red List of Threatened Species (Kyne et al., 2016).

Family: Dasyatidae

33. *Brevitrygon walga* (Müller & Henle, 1841)

Common name: Dwarf whipray

Plate 3.9(c)

Müller, J. and F. G. J. Henle (1841) Systematische Beschreibung der Plagiostomen. Veit und Comp., Berlin. i-xxii + 1-200, 60 pls. [Pp. 1-28 published in 1838, reset pp. 27-28, 29-102 in 1839, i-xxii + 103-200.

Description:

A small whipray characterized by a sub-oval disc that is slightly longer than it is wide, length usually 1-1.1 times in disc width. Pectoral fins are broadly rounded. Snout long with a broadly concave shape featuring a prominent apical lobe and strongly concave anterior margins. Eyes are small and protrude slightly. Mouth is arched, equipped with two closely situated central oral papillae, and the lower jaw also displays an arched shape with a central concavity. Nasal curtain is nearly rectangular and has a finely fringed posterior edge. Denticles located at the mid-shoulder are small, heart-

shaped, and the narrow band of denticles, extends slightly forward from the orbits and narrows at the nape. Skin outside the denticle band is smooth. Tail thorns are arranged in a median row and are spear-shaped with a convex crown, varying in size. Tail itself is relatively short and slightly depressed, with a stout and oval cross-sectional base. It features a ridge-like ventral fold and lacks a dorsal fold, appearing very slender beyond the caudal sting; fold is either rudimentary or completely absent, and there are one to three caudal stings. Tail thorns are arranged in a median row and are spear-shaped with a convex crown, varying in size. Dorsal surface is uniformly dark brown with a pale disc margin; tail, forward of the caudal sting, is dark brown above and white below, turning uniformly brownish beyond the sting. Ventral surface is white with dusky disc margins.

Habitat and Distribution: Predominantly inhabits shallow and intertidal zones, typically up to 30 meters deep, though it can occasionally be found at depths of 40 meters, favouring soft substrates. It is endemic to the Arabian Seas region, with populations in the eastern Iranian waters of the Sea of Oman and the northern parts of the Arabian Gulf/Persian Gulf (last et al., 2016).

The status of *Brevitrygon walga* is listed as Near Threatened on the IUCN Red List of Threatened Species (Simpfendorfer et al., 2017).

34. *Brevitrygon imbricata* (Bloch & Schneider, 1801)

Common name: Bengal whipray

Plate 3.9(d)

Bloch, M. E. and J. G. Schneider (1801) M. E. Blochii, Systema Ichthyologiae Iconibus cx Illustratum. Post obitum auctoris opus inchoatum absolvit, correxit, interpolavit Jo. Gottlob Schneider, Saxo. Berolini. Sumtibus Auctoris Impressum et Bibliopolio Sanderiano Commisum. i-lx + 1-584, Pls. 1-110.

Description:

A disc is as broad as it is long, with a sharply pointed snout and spiracles that are slightly larger than the eyes. Mouth's floor features two buccal processes, and the oronasal groove is pronounced. Pelvic fin is subtriangular and extends just past the rear

of the disc. Tail is stout and oval at its base, and is shorter than the disc, featuring two spines and a wide band of denticles running from the interorbital area to the base of the spine on the tail, this band narrows near the spiracles. Body colour ranges from brownish to greenish brown, with the disc's edge being pale; the underside of the disc is white with yellowish brown edges. Upper side of the tail, extending to the sting, is brownish, while the underside is white. lateral ridges are white, set against the darker colour of the tail's surface behind the sting.

Habitat and Distribution: This species is benthic on the inner continental shelf from at depths of 3–55 m (Last et al., 2016, Weigmann 2016). It occurs in the Eastern Indian and Western Central Pacific Oceans from eastern India to Sarawak, Malaysia (Last et al., 2016; Krajangdara, 2019).

The status of *Brevitrygon imbricata* is listed as Vulnerable on the IUCN Red List of Threatened Species (Sherman et al., 2021b).

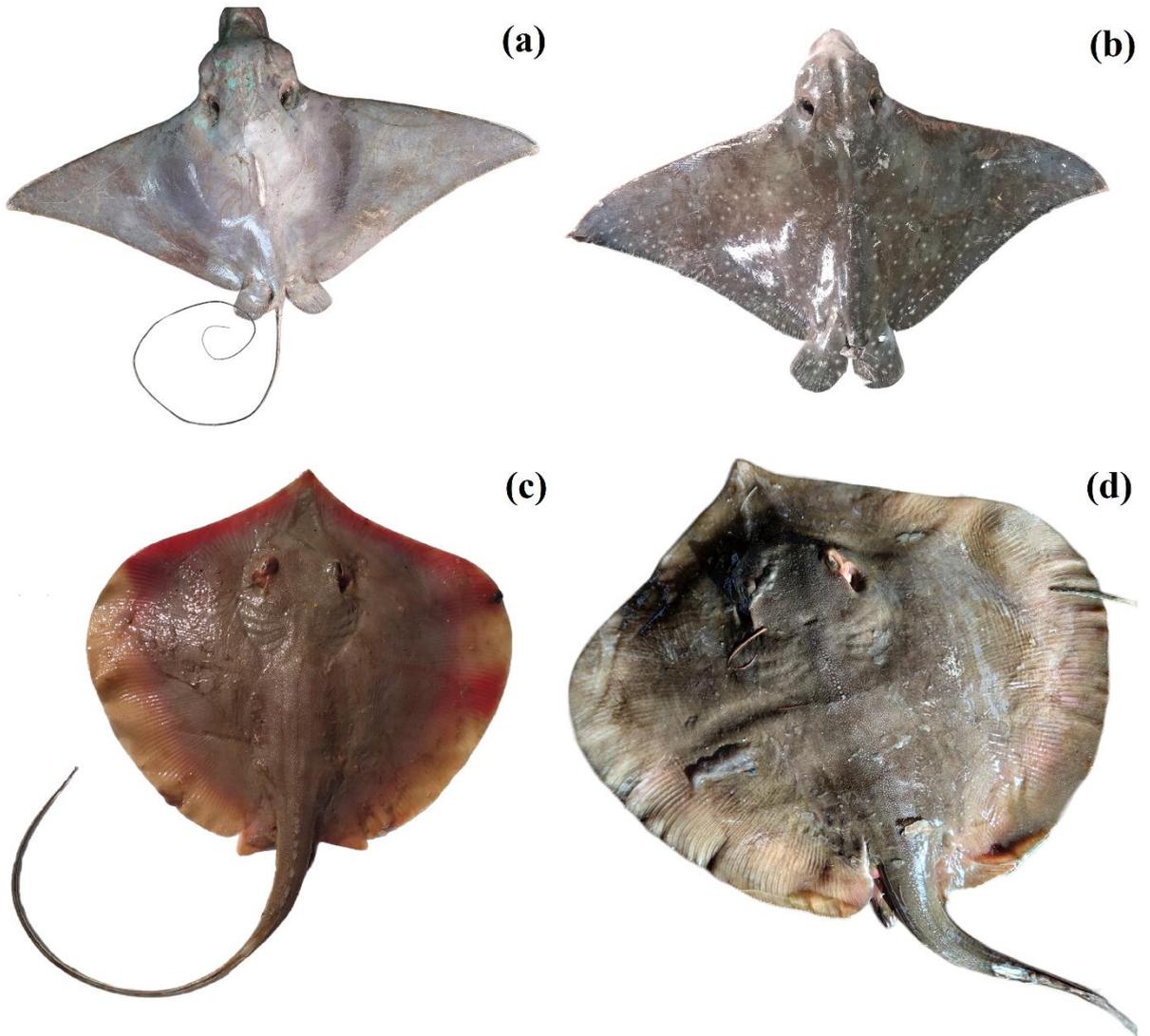


Plate 3.9: (a) *Aetobatus flagellum*; (b) *Aetobatus ocellatus*; (c) *Brevitrygon walga*;

(d) *Brevitrygon imbricata*

35. *Maculabatis arabica* (Manjaji-matsumoto & Last, 2016)

Common name: Pakistan whipray

Plate 3.10(a)

Manjaji-Matsumoto, B. M. and P. R. Last (2016) Two new whiprays, *Maculabatis arabica* sp. nov. and *M. bineeshi* sp. nov. (Myliobatiformes: Dasyatidae), from the northern Indian Ocean. *Zootaxa* 4144 (no. 3): 335-353.

Description:

A disc is rhomboidal and slightly elevated in the scapular region, with a pointed and distinct apical snout lobe that is relatively narrow. Disc's anterior edges are undulate, and interorbital space flat. Eyes are positioned laterally, are moderately large, and the orbits are slightly protruding. Spiracles are sub-rectangular, large, and positioned dorso-laterally. Nostrils are moderately elongated, slit-like, and slightly angled, featuring a faint double concavity on the outer margin. Nasal curtain resembles a skirt, is fairly narrow with an almost straight, smooth lateral edge, and the posterolateral apex rests within a broad groove; its posterior edge is very finely fringed and subtly double concave. Mouth forms a well-defined arch, with a prominent oronasal groove. Pectoral fin tips are narrowly rounded, and the posterior margin is broadly convex with a narrowly rounded free rear tip. Pelvic fins are relatively small and mostly obscured by the disc. Tail is slender, resembling a whip, tapering gradually and uniformly to the caudal sting and tail tip; the base is sub-oval and slightly depressed when viewed in cross-section. Dorsal surface of the disc is uniformly brown, while the underside is pale with broad, faintly marked, and slightly darker edges. Anterior part of the tail is light brown on the dorsal surface without white lateral spots.

Habitat and Distribution: Occurs in shallow inshore and shelf waters on muddy bottoms up to 37 m depths. It is endemic to the Arabian Seas region (manjaji-Matsumoto and Last, 2016).

The status of *Maculabatis arabica* is listed as Critically Endangered on the IUCN Red List of Threatened Species (Dulvy et al., 2017).

36. *Maculabatis bineeshi* (Manjaji-Matsumoto & Last, 2016)**Common name:** Short tail whip ray**Plate 3.10(b)**

Manjaji-Matsumoto, B. M. and P. R. Last (2016) Two new whiprays, *Maculabatis arabica* sp. nov. and *M. bineeshi* sp. nov. (Myliobatiformes: Dasyatidae), from the northern Indian Ocean. *Zootaxa* 4144 (no. 3): 335-353.

Description:

A disc is weakly rhomboidal to sub-oval, robust, and strongly elevated in the middle scapular region. Snout is moderately elongate and depressed, with a weak apical lobe. Anterior disc margin is almost straight, lateral apices broadly rounded, and the rear posterior margin widely convex. free rear tip is broadly rounded. Interorbital space flat to weakly convex. Primary suprascapular denticle is large, yellowish, and broadly ovate, usually succeeded by a smaller, subtriangular denticle. Eyes are moderately large. Spiracles are sub-rectangular and large, positioned dorso-laterally. Nostrils are moderately large, slit-like, and oblique, with the outer margin subtly double concave. Nasal curtain is skirt-shaped, relatively broad, lateral margin straight, smooth edged; postero-lateral corner lobe-like, resistible within broad groove. Posterior margin is very finely fringed and concave. Mouth arched weakly to prominently, oronasal groove prominent. Pelvic fins are moderately small and largely concealed by disc. Tail is slender and whip-like, tapering gradually and evenly towards the caudal sting, and is depressed oval in cross-section. Dorsal surface is a plain dark greenish brown, slightly lighter towards the outer disc margin; Ventral surface is white.

Habitat and Distribution: This species is benthic, residing on muddy substrates in inshore waters, from the surface to a depth of 100 meters, although it is typically found at depths shallower than 50 meters. It is endemic to the northern Indian Ocean, with a patchy distribution in Pakistan, India, northern Sri Lanka, and Bangladesh (last et al., 2016).

The status of *Maculabatis bineeshi* is listed as Critically Endangered on the IUCN Red List of Threatened Species (Sherman et al., 2021c).

37. *Maculabatis gerrardi* (Gray, 1851)

Common name: White spotted whipray

Plate 3.10(c)

Gray, J. E. (1851) List of the specimens of fish in the collection of the British Museum. Part I.--Chondropterygii. London. i-x + 1-160, Pls. 1-2.

Description:

A white spotted whip ray ranges from small to large in size, Disc slightly flattened to robust and shaped from sub-oval to rhomboidal with narrowly rounded apices. Snout is broadly angular, with small tip and is short to moderately long. Front margin of the disc is almost straight, and the apex of the pectoral fin ranges from narrowly angular to rounded. Eyes are small and slightly protruding. Nasal curtain is shaped like a skirt, and the narrow mouth with 2 to 4 oral papillae. Band of denticles is narrow, stopping short of the tail base, and variably developed mid-scapular thorns or thorns in row on nape, no other scapular thorns are present. Denticle band well developed with edge sharply defined, skin on rest of disc naked or with patchy denticles. There is no row of enlarged median thorns on the tail. Tail is long, very slender, and whip-like beyond the sting, no cutaneous fold and typically having a narrow and oval to almost circular cross-section at its base. Pelvic fins are small and mostly concealed by the disc, dorsal or ventral folds absent. Caudal sting is positioned close to the base of the tail. Dorsal surface of the disc is usually a paler greenish-grey or greyish brown with numerous white spots, while the ventral surface is white, with the tail featuring bands beyond the sting.

Habitat and Distribution: It is found inshore, on soft substrates down to depths of up to 60 meters. It's distributed from India to New Guinea, and north to Japan in the Indo-Pacific region (Last et al., 2016).

The status of *Maculabatis gerrardi* is listed as Endangered on the IUCN Red List of Threatened Species (Sherman et al., 2020a).

38. *Neotrygon indica* (Pavan-kumar, Kumar, pitale, Shen & Borsa, 2018)**Common name: Blue spotted mask ray****Plate 3.10(d)**

Pavan-Kumar, A., R. Kumar, P. Pitale, K.-N. Shen and P. Borsa (2018) *Neotrygon indica* sp. nov., the Indian-Ocean blue spotted maskray (Myliobatoidei, Dasyatidae). *Comptes Rendus Biologies* v. 341 (no. 2): [1-11] 120-130.

Description:

A disc shape is rhomboidal, wider than it is long, with a somewhat fleshy snout and a broadly angular. Spiracles are larger than the eyes, and there are short thorns line along the midline of the disc. Tail features prominent skin folds along both the dorsal and ventral sides. Usually, the dorsal surface displays distinct bluish spots and dark bands across the eyes, while the tail has striped banding. Tips of the pectoral fins are angular and narrowly rounded. Tail, broad at the base and slightly flattened, tapers off and is generally longer than the disc, usually with two stings. Coloration of the dorsal surface ranges from grey to brown and is marked with variable bluish spots. Underside is predominantly light, with a slightly darker rim around the disc and a tail characterized by alternating black and white bands; the tip of the tail is mostly light, with skin folds that are lighter at the base and darken towards the edges.

Habitat and Distribution: It is found in the Indian ocean region (Pavan-Kumar et al., 2018)

The status of *Neotrygon indica* is listed as Data Deficient on the IUCN Red List of Threatened Species (Kyne and Finucci, 2018).

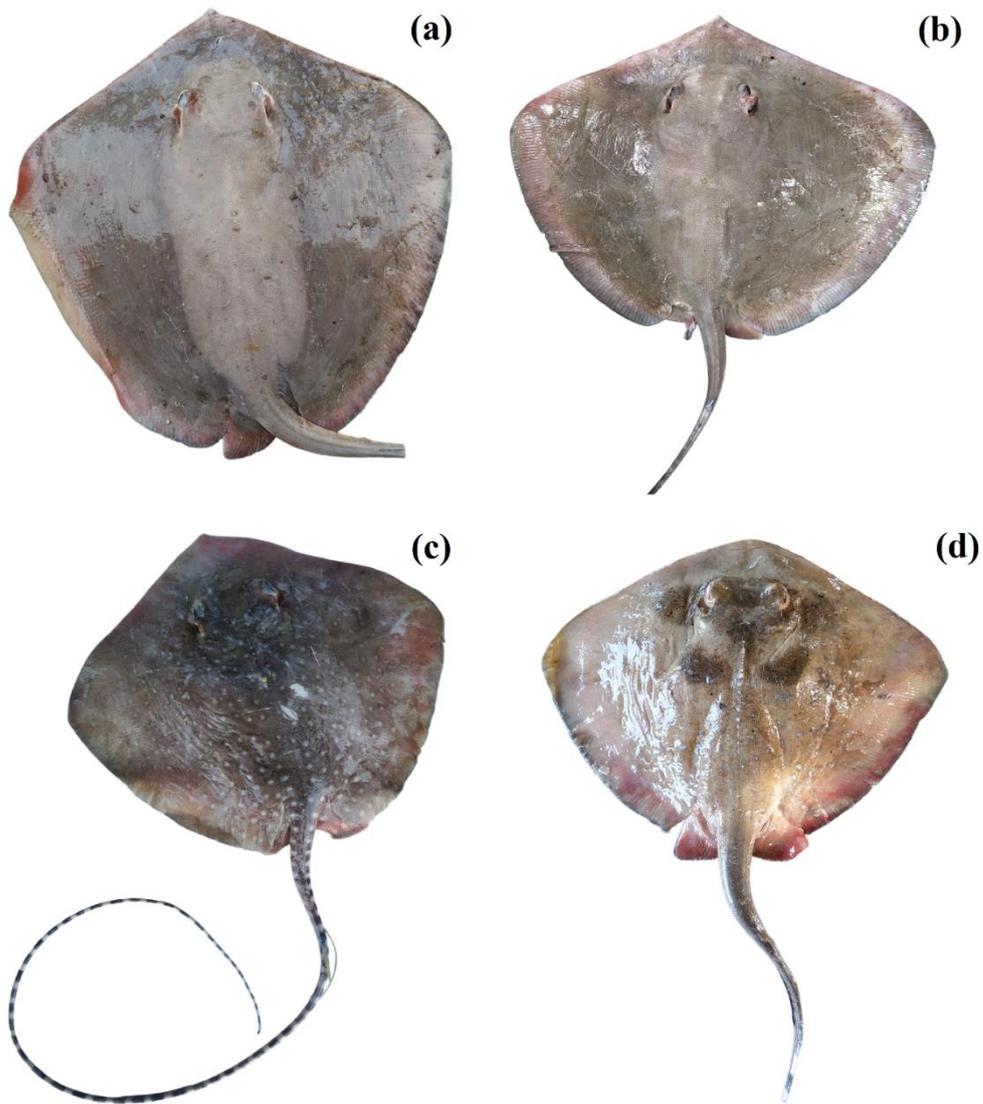


Plate 3.10: (a) *Maculabatis arabica*; (b) *Maculabatis bineeshi*;
(c) *Maculabatis gerrardi*; (d) *Neotrygon indica*

39. *Pastinachus ater* (Macleay,1883)**Common name: Broad cowtail ray****Plate 3.11(a)**

Macleay, W. (1883) Contribution to a knowledge of the fishes of New Guinea.--No. III. Proceedings of the Linnean Society of New South Wales v. 7 (pt 4): 585-598.

Description:

A disc is rhombic with angular apices and straight anterior margins. Disk much broader than long, it features a short, blunt snout with a small lobe at the tip. Tail is approximately twice the disc width or shorter, tails' base very broad and strongly depressed, that tapers gradually beyond the sting. There is a clear denticle band that becomes sparser toward the outer pectoral fin. usually, there are three to four small thorns on the back. Ventral fold is notably deep, with a height behind the sting that is 3.6 to 5.7 times greater than the adjacent tail height, while the dorsal tail fold is absent. In terms of colour, the upper surface is a uniform greyish brown to black, with the tail fold and tail tip being black. Ventral surface is white, often with a fine black edge, and the ventral tail displays black areas before the sting.

Habitat and Distribution: Occurs in inshore waters to a depth of 60 m, although it prefers shallow waters (including estuarine waters and sometimes into freshwater) and is often located in intertidal lagoons, reef flats, and reef faces (Michael, 1993, Last and Stevens, 2009). widespread in the Indo-Pacific in the Eastern and Western Indian and Western Central Pacific Oceans from Madagascar to New Caledonia and to the Philippines (Last et al., 2016).

The status of *Pastinachus ater* is listed as Vulnerable on the IUCN Red List of Threatened Species (Sherman et al., 2021d).

40. *Pastinachus sephen* (Forsskal, 1775)

Common name; Cow tail stingray

Plate 3.11(b)

Niebuhr, C. (1775) Descriptiones animalium avium, amphibiorum, piscium, insectorum, vermium; quae in itinere orientali observavit Petrus Forskål. Postmortem auctoris edidit Carsten Niebuhr. Hauniae. 1-20 + i-xxxiv + 1-164.

Description:

A disc is rhomboidal, and the trunk is very thick. Snout is broadly rounded with a blunt tip, and the anterior margin is almost straight to slightly convex. There is a wide band of flat denticles on the central disc. Apices of the pectoral fins are broadly rounded. Pelvic fins are moderately sized and also broadly rounded. Tail is very broad at the base and depressed, narrowing gradually to the sting, becoming slender and almost cylindrical beyond it. Ventral cutaneous fold is highly developed and ends abruptly around two sting lengths behind the sting tip. There is no dorsal skin fold, and the tail tip is filamentous. Dorsal surface is a uniform dark greyish brown to black, with the tail fold and tail tip being black. The ventral surface is mostly white.

Habitat and Distribution: This species inhabits the benthic zone of coastal areas, typically found over soft substrates, often near coral reefs, at depths reaching up to 60 meters. It is possibly endemic to the Arabian Seas region (last et al., 2016).

The status of *Pastinachus sephen* is listed as Near threatened on the IUCN Red List of Threatened Species (Kyne et al., 2017).

41. *Pateobatis bleekeri* (Blyth, 1860)**Common name: Bleeker's whipray****Plate 3.11(c)**

Blyth, E. (1860), The cartilaginous fishes of lower Bengal. Journal of the Asiatic Society of Bengal v. 29 (no. 1): 35-45.

Description:

A disc is oval and flat with broadly rounded apices. Anterior margin of the disc is weakly to moderately concave, and the snout is pointed. Tail has a narrow base, is subcircular in cross-section, and is slender and whip-like beyond the sting. A very broad median denticle band extends from well before the interorbit along the centre of the disc and onto the upper tail. There is a pearl thorn (more prominent in young) on the back, preceded and followed by a few slightly enlarged thorns. The tail has no thorns or skin folds. Dorsal surface is uniformly dark brown, while the ventral surface is white with a broad dark brown margin that increases in area with age.

Habitat and Distribution: This species is benthic from the surface to depths of 40 m (Last *et al.* 2016). found in the Western and Eastern Indian and Western Central Pacific Oceans from Pakistan to Malaysia (Last *et al.*, 2016, Krajangdara 2019).

The status of *Pateobatis bleekeri* is listed as Endangered on the IUCN Red List of Threatened Species (Sherman *et al.*, 2020b).

42. *Pteroplatytrygon violacea* (Bonaparte, 1832)**Common name: Pelagic stingray****Plate 3.11(d)**

Bonaparte, C. L. (1832) Iconografia delle fauna italica per le quattro classi degli animali vertebrati. Tomo III. Pesci. Roma.

Description:

A disc is broad and wedge-shaped, width much wider than disc length. Broadly rounded snout with a small central projection; from this point, the front contours of the disc extend backward bilaterally. Cranial and visceral areas are somewhat elevated, giving the body a noticeable depth compared to its relatively thin pectoral fins. Small eyes, surrounded by thick eyelids, broad interorbital space. continuous row of small thorns extending dorsally to the base of the tail sting. Nostrils are short and round, while the mouth is small, lined with numerous short, bifurcated papillae across its floor. It also has prominent labial furrows and folds, and the lower jaw is slightly convex. Nasal valves are marked by a notch projecting a short dermal flap. Pelvic fins are characterized by a straight front margin and a broadly rounded outer corner. Tail is robust at the base and has a single spine. Dorsal and ventral surface is uniformly dark brown to black, without any distinctive markings.

Habitat and distribution: This species is found in the pelagic zone (Last and Stevens, 2009) and typically inhabits waters from the surface to 100 meters depth over deep waters, although it has been recorded at depths up to 381 meters. (Mollet, 2002, Weigmann, 2016) It is widespread across the tropical and subtropical regions of the Atlantic, Indian, and Pacific Oceans (Last et al., 2016).

The status of *Pteroplatytrygon violacea* is listed as Least Concern on the IUCN Red List of Threatened Species (Kyne et al., 2019).

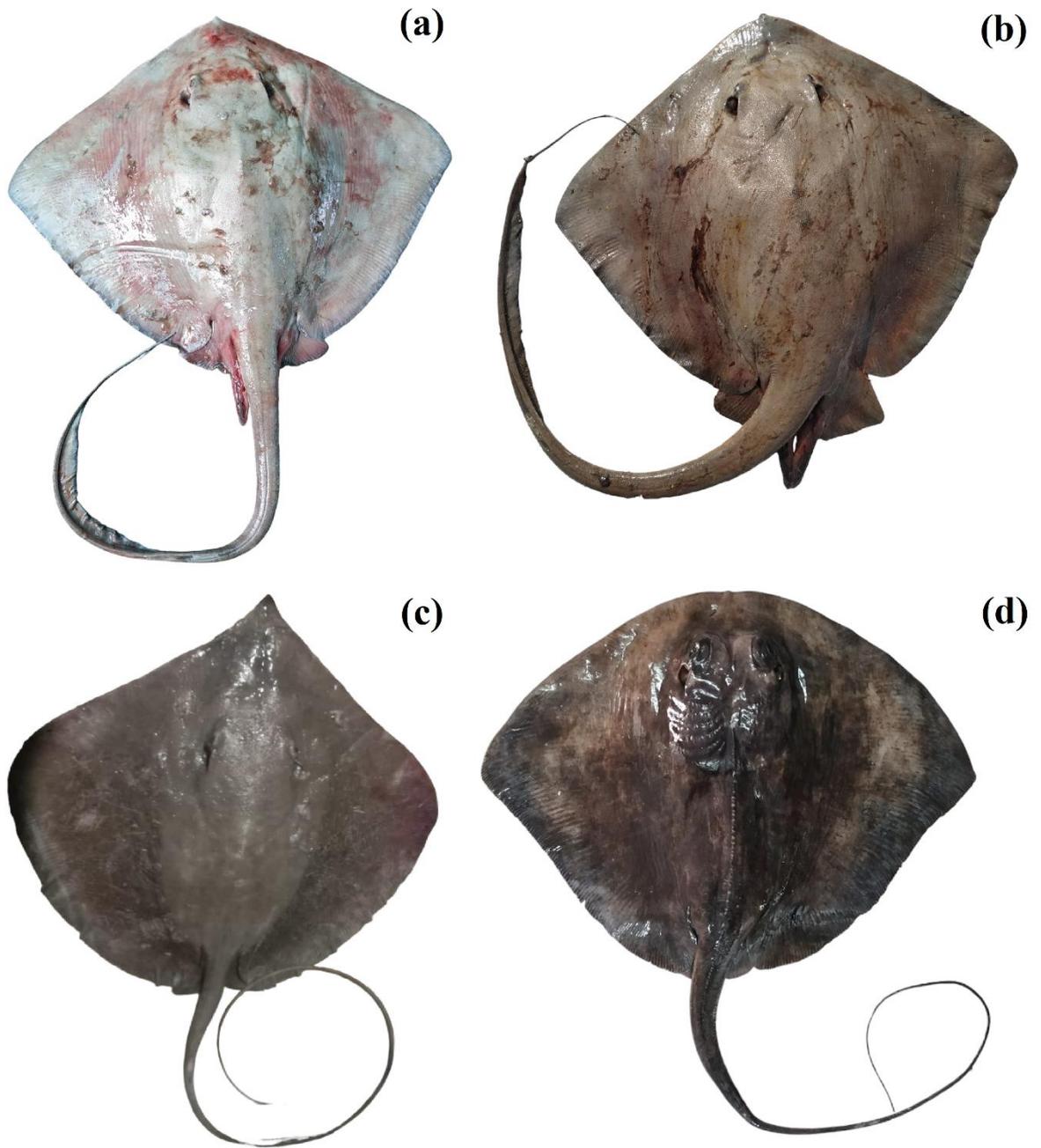


Plate 3.11: (a) *Pastinachus ater*; (b) *Pastinachus sephen*; (c) *Pateobatis bleekeri*;
(d) *Pteroplatytrygon violacea*

43. *Himantura uarnak* (Gmelin, 1789)

Common name: Reticulate whipray

Plate 3.12(a)

Gmelin, J. F. (1789) Caroli a Linné ... Systema Naturae per regna tria naturae, secundum classes, ordines, genera, species; cum characteribus, differentiis, synonymis, locis. Editio decimo tertia, aucta, reformata. 3 vols. in 9 parts. Lipsiae, 1788-93. v. 1 (pt 3): 1033-1516.

Description:

A disc is wider than it is long, with a rhomboidal and flat shape. Angular snout with a sharp point tip. Mouth is narrow and undulated, while the eyes are small, protruding and abroad interorbital space. Labial furrows are weakly defined, but there are lower labial folds and papillae. Internasal flap is skirt-shaped, short, and broad, featuring a finely fringed margin. Nostrils are long and narrow, and the lower jaw is deeply concave near the symphysis. Pectoral fin apex is narrowly rounded with an almost straight anterior margin. Denticles are low, flat, and heart-shaped, forming a broad band from the interorbital area, extending across the centre of the disc and onto the tail where the density increases with size. Two prominent pearl thorns are located in the centre of the disc, but large thorns are absent from the midline of the tail and the dorsal surface of the disc, which is mostly smooth. Tail is very slender, whip-like, and significantly longer than the disc, featuring a single functional sting and a subcircular cross-section without cutaneous folds. Dorsal side displays numerous greyish-brown spots, typically circular, slightly elongated, or dumbbell-shaped, and evenly distributed. Ventral surface is completely white, and the tail has brown stripes.

Habitat and Distribution: Inshore ray occurring on soft substrates; often intertidal, but to depths of at least 50 m. Widespread in the Indo-Pacific in the Eastern and Western Indian and Western Central Pacific Oceans from South Africa to the Philippines (Last et al., 2016).

The status of *Himantura uarnak* as Endangered on the IUCN Red List of Threatened Species (Sherman et al., 2021e).

44. *Himantura undulata* (Bleeker, 1852)**Common name:** Honeycomb whipray**Plate 3.12(b)**

Bleeker, P. (1852) Bijdrage tot de kennis der Plagiostomen van den Indischen Archipel. Verhandelingen van het Bataviaasch Genootschap van Kunsten en Wetenschappen. v. 24 (art. 12): 1-92, Pls. 1-4.

Description:

A snout is angular with a sharp pointed tip, Disc is sub-oval, flat, with broadly rounded apices. Disc's profile is subtly quadrangular, Pectoral-fin apex broadly rounded. At the centre of the disc, there is a large, pearl-shaped, yellowish thorn, followed by two to three slightly smaller, similar thorns. Disc's width is approximately equal to its length, and there are no other large thorns along the midline of the disc and tail. Tail is extremely slender and elongated, dark spots up to sting and behind sting. It is several times longer than disc and has a single functional sting, is subcircular in cross-section, and without cutaneous folds. The dorsal surface displays a dense honeycomb-like pattern with thick-lined rings and reticulations, while the ventral surface is uniformly pale.

Habitat and Distribution: It is demersal inshore on soft substrates on continental and insular shelves to a depth of 70 m. Its range across the Indo-West Pacific Oceans, from eastern India to the Philippines (Last et al., 2016).

The status of *Himantura undulata* is listed as Endangered on the IUCN Red List of Threatened Species (Sherman et al., 2020c).

45. *Urogymnus granulatus* (Macleay, 1883)**Common name:** Mangrove whipray**Plate 3.12(c)**

Macleay, W. (1883) Contribution to a knowledge of the fishes of New Guinea. --No. III. Proceedings of the Linnean Society of New South Wales v. 7 (pt 4): 585-598.

Description:

A disc is thick and oval-shaped, slightly elevated in the middle of the scapular region, with its disc length being somewhat greater than its disc width. Snout is relatively short, slightly extended, and blunt with a weak apical lobe. Nostrils are narrow and slightly oblique, while the nasal curtain is small with a finely fringed posterior margin. The mouth is small, with distinct labial furrows and folds. It features numerous white spots and a granular texture on the dorsal side. Trunk of the disc is robust, and the preorbital snout is moderately short. Pectoral fin apices are thick and rounded, not angular, and free rear tips narrowly rounded. Eyes are moderately large and widely spaced; closely followed by large, dorso-laterally positioned spiracles, which are sub-rectangular to sickle-shaped. Interorbital space is broad. Fine denticles cover the mid shoulder space, extending from the interorbital area to the tail, with no large thorns present on the body. Pelvic fins are short and subtriangular; the tail is broad-based and nearly circular in cross-section. The dorsal surface is greyish to brown with small white spots, and the ventral surface is white.

Habitat and Distribution: It is commonly found in shallow inshore waters near mangroves, estuaries, sand flats, and sandy substrates, and can dwell at depths up to 85 meters. It has a patchy distribution across the Indo-Pacific region, from the Seychelles and Maldives to the Caroline and Santa Cruz Islands, as well as in Australian waters (Last and Stevens, 2009).

The status of *Urogymnus granulatus* is listed as Vulnerable on the IUCN Red List of Threatened Species (Manjaji et al., 2020)

Family: Gymnuridae

46. *Gymnura poecilura* (Shaw, 1804)

Common name: Longtail butterfly ray

Plate 3.12(d)

Shaw, G. (1803) General zoology or systematic natural history. Pisces. G. Kearsley, London, 1800-1826. Pisces in vol. 4 (1803) and vol. 5 (1804). [Series is 14 vols., 1800-1826.]. v. 4: (pt. 1) i-v + 1-186, Pls. 1-25; (pt 2), i-xiii + 187-632, Pls. 26-92.

Description:

A body is flattened, thin, and smooth on both dorsal and ventral sides, without thorns or denticles. Head is short and broad at the apex, slightly projecting/ pointed over pectorals. Front margin of the pectoral fin is gently or broadly convex near the snout, with the tips either broadly rounded or angular. Posterior margin is very broadly convex. The eyes are small, lateral, and slightly elevated, and the inter-orbital space very broad. Spiracle is small and suboval without a spiracle tentacle. Nostrils are generally distorted and broadly suboval or subcircular. Anterior nasal flap is slightly expanded, with a somewhat tubular lateral margin. Inner posterior margin is partially enclosed by the nasal curtain, which forms well developed posterior lobes. Nasal curtain is short, bilobed, and broad. Mouth is broadly angular and short. Pelvic fins are nearly subtriangular and short, with a straight to gently concave anterior margin and a slightly concave posterior margin. Pectoral fins are broad and shaped like a rhomboid, with the disc's width nearly double its length. The rear tip of the fins is narrowly rounded, and the inner margin is usually straight. There is no dorsal fin. Tail is very slender and short, tapering gradually to a blunt tip, and the base is moderately broad and slightly depressed. Disc colour ranges from uniform brown to olive green, possibly with scattered pale or light-yellow spots. Dorsal surface is uniformly pale or greyish with spots covering the entire body area, while the ventral disc is uniformly white with no markings.

Habitat and Distribution: this species is found on demersal along inshore sandy and muddy substrates at depths from 0 to 75 meters. It is widely distributed in the Indo-Pacific region, ranging from the southern Arabian Sea coasts of India to the Bay of Bengal, and from Sri Lanka to Indonesia and China (Last et al., 2010).

The status of *Gymnura poecilura* is listed as Vulnerable on the IUCN Red List of Threatened Species (Sherman et al., 2021f).

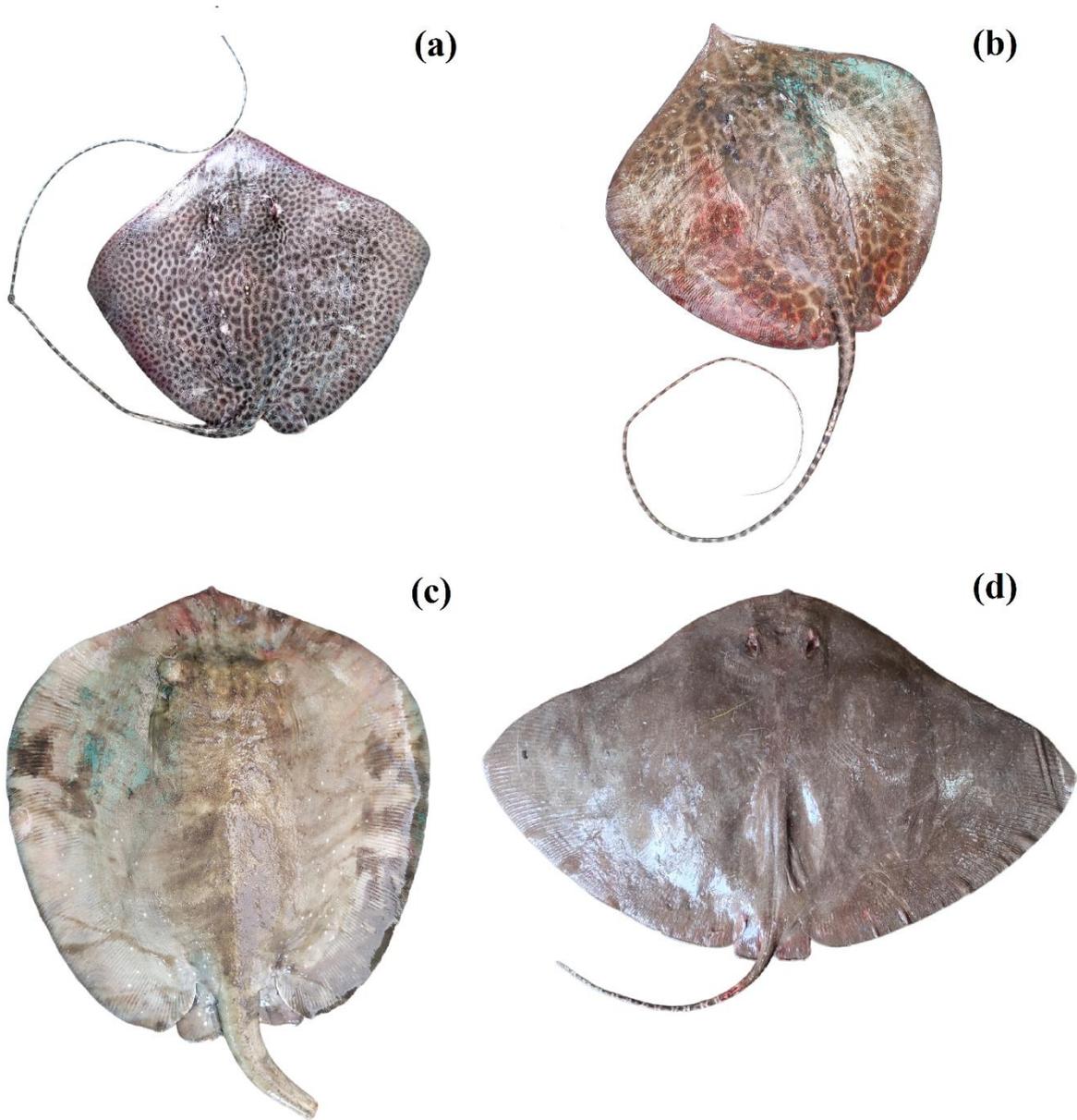


Plate 3.12: (a) *Himantura uarnak*; (b) *Himantura undulata*;
(c) *Urogymnus granulatus*; (d) *Gymnura poecilura*

Family: Mobulidae

47. *Mobula mobular* (Bonnaterre, 1788)

Common name: Giant Devil ray

Plate 3.13(a)

Bonnaterre, J. P. (1788) Tableau encyclopédique et methodique des trois règnes de la nature... Ichthyologie. Panckoucke, Paris. i-lvi + 1-215, Pls. A-B + 1-100.

Description:

A head is broad with a straight anterior margin, and the disc is elongated. Cephalic fins are well separated one from the other with the eyes and spiracles positioned on the sides. Disc's width surpasses its length, and the subterminal mouth on the head is broad and straight, featuring small teeth. Spiracles slits like, are located on the dorsal surface just behind the eyes. Pectoral fins are moderately falcate and significantly larger than both the dorsal and pelvic fins. Anterior edge of the pectoral fins is straight, while the posterior edge is concave, ending in acute tips. There is a small, serrated caudal spine and a subtle bony ridge along the dorsal midline. Dorsal fin with a distinct white tip. Tail is whip-like and very long, extending beyond the disc width, and displays a uniform coloration: dark blue on top and white on the underside.

Habitat and Distribution: It is pelagic, inhabiting coastal areas and continental shelves. It is found worldwide in both temperate and tropical waters across all oceans (Notarbartolo di sciara et al., 2017).

The status of *Mobula mobular* is listed as Endangered on the IUCN Red List of Threatened Species (Marshall et al., 2022).

48. *Mobula tarapacana* (Philippi, 1892)

Common name: Chilean devil ray

Plate 3.13(b)

Philippi, R. A. (1892) Algunos peces de Chile. Las rayas, *Callorhynchus* i *Orthogoriscus* Chilenos. Anales del Museo Nacional de Chile. Primera seccion, Zoología No. 3: 1 + 1-16 + 1, Pls. 1-6.

Description:

This large ray fish is characterized by its broad, sub-terminal mouth and a disc that is elongated and distinctly falcate, with a disc width twice that of its disc length. A mid-dorsal ridge stretches from the nuchal region to the dorsal fin. Head is flat on top, displaying a slight peak near the rear end of the anterior fontanelle, positioned halfway between the cranial width and the rostral margin. The rostrum's edge is straight, curves at the sides towards the cephalic fins' origins. Eyes are circular and prominent on the sides of its head, aligned with the rostral margin. Spiracles are elliptical, transverse slits located above the plane of the pectoral fin radials, with ends aligning with the origin and post-orbital process of the pectoral fin, respectively; the latter end is notably above the pectoral origin, with the posterior edge of the spiracle positioned one eye diameter behind the eye's posterior edge. Anterior edges of the pectoral fins are straight, curving slightly at the apex, while the posterior edges are concave distally. Free rear tip is pointed, and the inner margins are either straight or slightly convex, pointing towards the dorsal fin's base at mid-level. Dorsal fin stands out for being quite tall, with a straight anterior margin, a rounded apex, and a concave posterior edge that becomes more pronounced towards the base; free rear tip is small. Positioned forward on the body, the dorsal fin starts well in front of the pectoral axils and aligns with the middle of the pectoral fins' inner margins. Pelvic fins are wedge-shaped, with parallel anterior and inner edges approximately equal in length to the dorsal fin base. Cephalic fins' ventral edges are attached to the underside of the head at the spiracles' level, slightly behind the mouth corners. Distance from the cephalic fins' tips to the mouth corners is equal to or slightly greater than the mouth's width. Tail, shorter than the disc width, has an oval base at the dorsal fin insertion level. Tail's ventral surface is initially white near the pectoral fin base, then darkens to match the dorsal surface. Dark rims are often

visible on the margins of the pectoral and pelvic fins. Rostrum's edge is dark, fading silver grey over the nasal curtain. The cephalic fins' inner surface is silver grey with a black tip, while the outer surface is predominantly white. Black rims the eyes, and the head's side between the eye and spiracle is white, clearly demarcated from the darker head coloration along a line from mid-spiracle to the upper eye margin. Area in front of the eye on the side of the head is triangularly white. Oral valve is white, with the mouth floor and palate near the oral valve shaded grey. Dorsal surface is uniformly greenish-brown, and the dorsal fin lacks a white tip. Upper part of the ventral surface is shaded white, transitioning to grey towards the lower part.

Habitat and Distribution: Primarily oceanic but is also found in coastal waters and has a patchy circumglobally distribution and is found in tropical, subtropical, and temperate waters of the Pacific, Atlantic, and Indian Oceans (Mendonca, 2011; Lawson et al., 2017).

The status of *Mobula tarapacana* is listed as Endangered on the IUCN Red List of Threatened Species (Marshall et al., 2019).



Plate 3.13: (a) *Mobula mobula*; (b) *Mobula tarapacana*

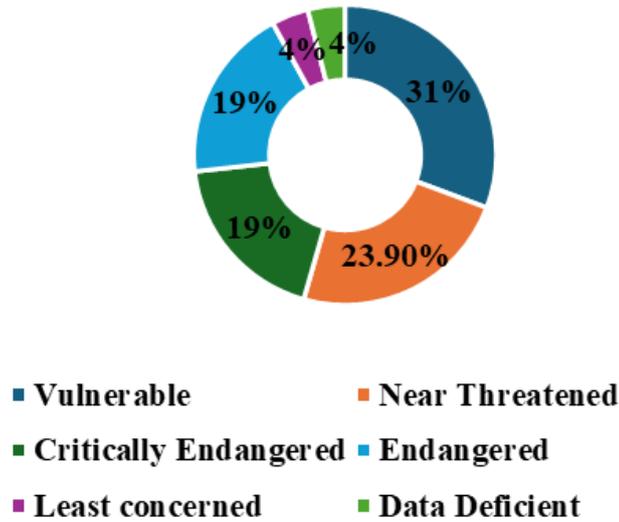


Figure 3.2: IUCN status of Elasmobranchs of Gujarat

The graph categorizes the conservation status of elasmobranch species according to the International Union for Conservation of Nature (IUCN), highlighting various levels of extinction risk. At 31%, the largest proportion of these species is classified as Vulnerable, indicating they face a risk of endangerment in the wild. Close behind, 24% of the species are Near Threatened, suggesting they are likely to become endangered in the near future. Both Critically Endangered and Endangered categories each account for 19% of the species respectively, signifying those at an extremely high risk of extinction in the future those and very likely to become extinct, respectively. Notably, only 4% of the species are classified as Least Concerned, showing they face minimal risk of extinction. Another 4% fall under Data Deficient, indicating a lack of sufficient information to make a precise assessment of their risk level (Fig. 3.2).

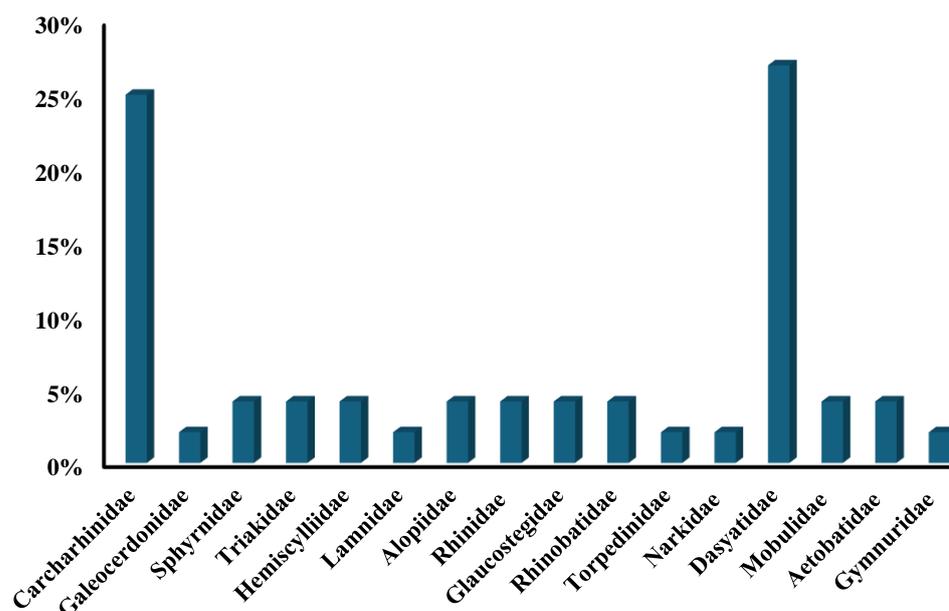


Figure 3.3: Family wise percentage contribution

The Fig. 3.3 categorizes various elasmobranch families by their contribution to the total population, highlighting significant differences in prevalence among these species. The Dasyatidae family, primarily composed of rays, constitutes the largest percentage at 27%, showing a significant presence within the elasmobranch community. Close behind, the Carcharhinidae family, which includes various species of sharks, contributes 25%. These two families are the most prominent within the data set.

Other families represented in smaller proportions include the Galeocerdonidae, Lamnidae, Torpedinidae, Narkidae, and Gymnuridae, each contributing 2.08%. Meanwhile, families such as the Sphyrnidae, Triakidae, Hemiscylliidae, Alopiidae, Rhinidae, Glaucostegidae, Rhinobatidae, Mobulidae, Aetobatidae, and Gymnuridae are moderately represented, each accounting for 4.17% of the total elasmobranch population. This graph effectively outlines the varying levels of representation among different elasmobranch families in the studied population.

3.3.2 Phylogenetics

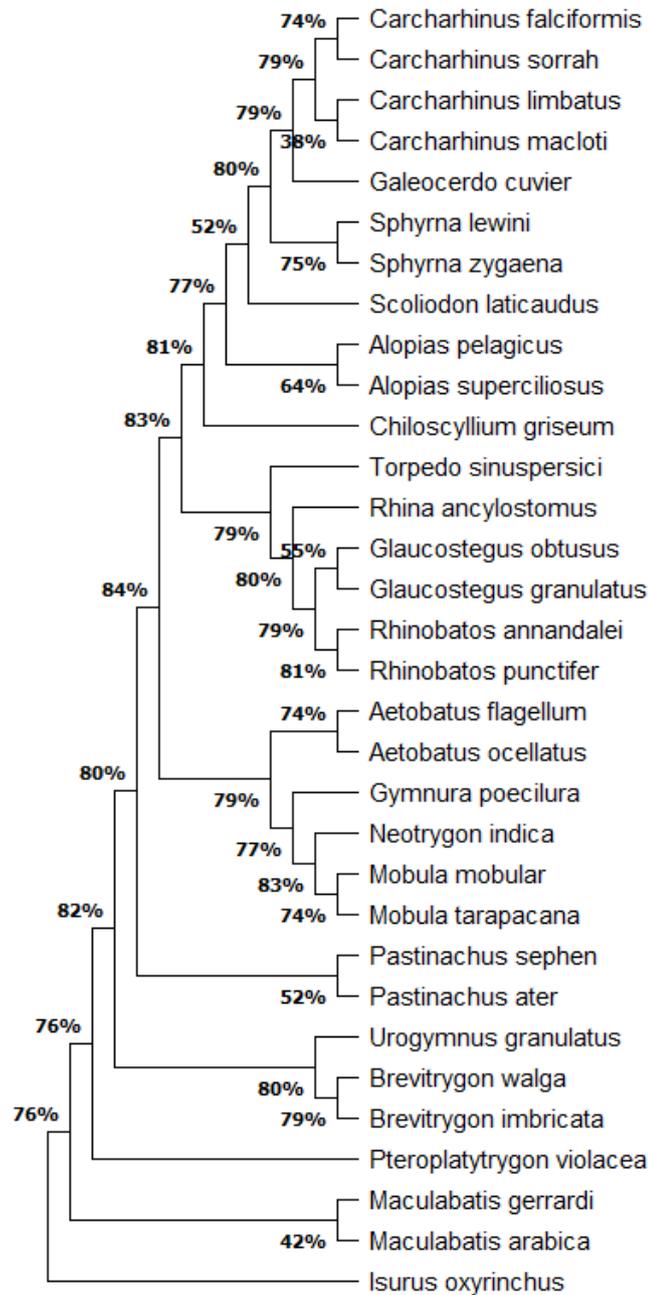


Figure 3.4: Phylogenetic tree of Elasmobranch fishes

The elucidation of elasmobranch phylogeny, as depicted in the current study, provides a nuanced understanding of the evolutionary relationships among various sharks rays and skates (Fig. 3.4). In this phylogenetic representation, each node signifies a common ancestor, with the branches reflecting the evolutionary divergence among species. The percentages adjacent to these nodes represent bootstrap values,

quantifying the confidence levels of the phylogenetic inferences based on the genetic data analysed. These values are crucial for assessing the robustness of the evolutionary pathways proposed.

3.3.3 Identification of elasmobranchs through YOLO

To identify Elasmobranch fish species from images, utilizing a training image dataset that was collected during the field visits. This dataset is used to train models that can analyse and interpret the images to identify different fish species. Once trained, the models generate various performance metrics such as Accuracy, Sensitivity, Specificity, and F1 score to evaluate their effectiveness (FIG). Additionally, the models predict the presence of fish in the images and mark them with bounding boxes to visually highlight the identified species (Fig. 3.5).

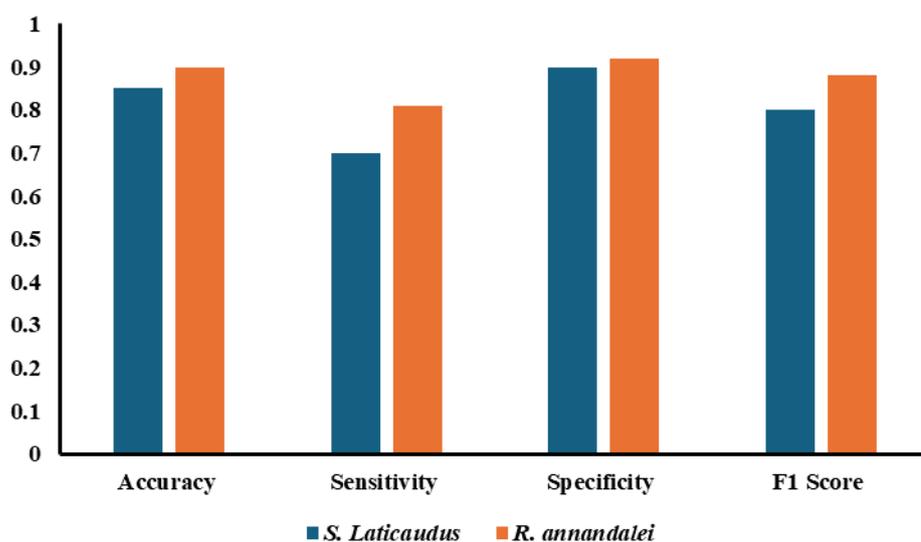


Figure 3.5: Model performance metrics



Figure 3.6: Bounding box prediction of *R. annandalei*



Figure 3.7: Bounding box prediction of *S. laticaudus*

A model performance is considered accepted and reliable if the scores of Accuracy, Sensitivity, Specificity, and F1 score are more than 0.8 (Chicco et al., 2020)

Accuracy: Both species show high accuracy. This suggests that the model correctly identifies a high percentage of both positive and negative instances (Fig. 3.5). Accuracy above 0.8 is generally considered good in ecological research, especially when distinguishing between similar species.

Sensitivity (Recall): Sensitivity of *S. Laticaudus* and *R. annandalei* indicates that the model is reasonably good (Fig. 3.5) at identifying true positives. This means it successfully detects the presence of these species most of the time, which is particularly important in conservation efforts where missing a rare species can have significant ecological impacts.

Specificity: The specificity of *S. Laticaudus* and *R. annandalei* are excellent. High specificity (Fig. 3.5) means the model is very effective at correctly identifying negatives, reducing the risk of false positives. This is essential in studies where false identification can lead to misdirected resources or incorrect ecological assessments.

F1 Score: The F1 scores are particularly good because the F1 score balances the precision and recall, providing a more holistic view of model performance. An F1 score closer to 1 suggests a very effective model, and scores above 0.8 are typically considered strong results in machine learning applications (Chicco et al., 2020) (Fig. 3.5).

Overall, these results are suggesting that the model is performing well in identifying these species with a high degree of reliability. Such metrics would support its use in practical applications like monitoring biodiversity, where accurate species identification is crucial for data-driven decision-making in conservation strategies. This performance is also comparable to other studies in wildlife detection and identification, which often target similar levels of accuracy and specificity.

3.4 Discussion

Accurate classification is essential in taxonomy since it serves as the foundation for various other fields in the study of living organisms. In the past decade, there has been a significant resurgence in the field of Elasmobranch taxonomy, with the formal description of over 180 new species (White and Last, 2012). Elasmobranchs consist of sharks, skates, and rays. A scientific investigation has shown the presence of 1282 distinct species classified under the taxonomic category of Chondrichthyes, which are distributed worldwide. (Serena et al., 2020). Prior research has documented the presence of 1266 elasmobranch species, categorized into 54 families. This includes 537 species of sharks and 689 species of batoids (Ebert et al., 2013; Last et al., 2016a; Nelson et al., 2016; Scharpf and Lazara, 2019; Roskov et al., 2020).

The study of elasmobranch taxonomy has had a crucial impact on conservation and management efforts in recent years, since it has led to the discovery of numerous new species and the clarification of the taxonomic status of many endangered species. Nevertheless, Elasmobranch taxonomy undergoes frequent changes in nomenclature, making it an ongoing and evolving field (Weigmann, 2016). Generally, there have been two dominant classification methods for elasmobranchs (Naylor et al., 2005; Nelson, 2006). Based with the initial classification, batoids, which include saw sharks and angel sharks, are categorized as a sibling group. These sharks are characterized by their dorsoventral flattened body. The species mentioned are classified into the superorder Squalimorphii, together with squaliformes and Hexanchiformes, as stated by Compagno et al. (2005). In contrast to the previous classification, the second type of classification distinguishes rays or batoids from sharks Selachii (Naylor et al., 2005) based on molecular data (Heinicke et al., 2009; Naylor et al., 2012). The precise sequence of orders and families is primarily determined by Nelson et al. (2016). The taxonomy of elasmobranchs has been a subject of ongoing controversy and uncertainty for many years, particularly about the classification of several species and genera (Compagno et al., 2005; Ebert et al., 2013). Conversely, molecular methods have provided significant assistance to taxonomists in detecting cryptic taxa and species combinations. Prior to their use, it is crucial to thoroughly evaluate the limitations of these molecular tools and address any issues regarding their integration with classical taxonomy.

In the present study, 48 species of elasmobranchs were recorded from the Gujarat. Elasmobranchs belonging to 6 Orders, 16 Families, 29 Genera and 48 species were identified from the study area. The elasmobranchs recorded comprised of 22 sharks coming under 3 orders, 7 families and 12 genera: 8 skates belonging to 2 orders, 5 families, and 6 genera and 18 Rays belonging to 1 order, 4 families and 11 genera. Earlier study on elasmobranchs diversity have reported 31 species of elasmobranchs which belonged to 7 orders, 13 families and 19 genera along Gujarat Coast India (Johri et al., 2021)

Day (1878) documented a total of 67 elasmobranch species in Indian seas, including 41 species of sharks (including sawfishes), 19 species of rays, and 7 species of skates. Misra (1952) later documented a total of 78 elasmobranch species in the Indian waters, comprising 51 sharks, 20 rays, and 7 skates. Out of these, 76 species were identified as commercially significant. Furthermore, earlier research has shown a total of 76 elasmobranchs that hold significant commercial value in the Indian oceans (Talwar and Kacker, 1984). Compagno (1984) subsequently documented 55 shark species found in the Indian Ocean. However, the presence of 10 of these species within the Indian Exclusive Economic Zone (EEZ) still requires verification.

The absence of a thorough and precise taxonomic reference for elasmobranchs has resulted in significant ambiguity in the nomenclature system. Another worry arises from the inconsistent and improper adoption of species names by different researchers, as well as the challenge of accurately recognizing numerous exploited or vulnerable elasmobranch species in the Indian oceans.

Nair et al. (2002) documented a total of 110 elasmobranch species in the Indian oceans, based on the classification system established by Compagno (1984). This included 70 species of sharks, 32 species of rays, and 8 species of skates. This study identified 34 species that were not previously described by Talwar and Kacker (1984). Raje et al. (2002) documented the presence of 110 elasmobranch species in Indian waters, with the majority of them being collected at depths of up to 200 meters (Raje et al., 2002). Nevertheless, the true number is likely to be more due to the absence of current efforts to revalidate the species within this particular group from the region. Subsequently, Raje et al. (2007) conducted a revision of the list, specifically focusing on the fishery of the Indian oceans, and narrowed it down to 84 species of

elasmobranchs, as documented in their atlas. This highlights the necessity for further studies to assess the variety of species. Consequently, the presence of confusion and inconsistencies in identifying species hinders the ability to determine the status of elasmobranchs in the Indian coast. This is crucial for conserving the biodiversity of this fragile group of marine species.

In the present study no new species could be encountered of the 48 species of elasmobranchs obtained from the study area, 6 species were first time reported along Gujarat coast India. The species included *Glyphis gangeticus*, *Sphyrna zygaena*, *Alopias superciliosus*, *Pastinachus ater*, *Himantura undulata* and *Urogymnus granulatus*.

3.4.1 DNA Barcoding

DNA barcoding is a widely suggested molecular technique for species identification. It involves sequencing nucleotide sequences from a standardized gene region, known as DNA barcodes, to diagnose species. In addition, a network of supplemental information supports these DNA barcode reference records, enabling independent assessment of barcode sequences (Ratnasingham et al., 2007). DNA barcodes are used for identification by considering the fact that genetic differences within a species are typically smaller than the differences between different species, known as the "barcoding gap" (Meyer et al., 2005). Elasmobranch species identification by DNA barcoding can be done utilizing entire specimens or body sections from dried or fresh materials (Dudgeon et al., 2012). Prior research on identifying shark species has relied on multiplex polymerase chain reaction (PCR) assays that use distinct primers for each species (Shivji et al., 2002; Abercrombie et al., 2005; Shivji et al., 2005; Clarke et al., 2006; Magnussen et al., 2007). Sequence analysis is a different method for identifying molecular species in Elasmobranchs, as described by Greig et al. (2005) and Quattro et al. (2006). DNA barcoding has effectively differentiated numerous shark species found in Australian seas, as demonstrated by studies conducted by Hebert et al., (2003a) and (2003b), as well as Holmes et al., (2009) and Ward et al., (2008). Ward et al. (2005) and Holmes et al. (2009) conducted first research using molecular data to identify elasmobranchs, which included the identification of potential new species and species that are at a high risk of extinction. Furthermore, the molecular data of sharks, rays, and skates were examined to investigate their diversity (Coulson

et al., 2011; Cerutti-Pereyra et al., 2012). Phylogenetic tree based on neighbour joining (NJ) analysis and its cladistic array revealed independent array of selected congeners with 100% bootstrap support.

Isurus oxyrinchus is positioned distinctly, indicating a potentially divergent evolutionary path from the more derived elasmobranch groups. This placement suggests that *I. oxyrinchus* may represent one of the more ancient lineages within this clade, highlighting its evolutionary significance. Heist et al., (1996) highlighted *I. oxyrinchus* has a distinct genetic lineage and evolutionary trajectory compared to other elasmobranchs. The close association between *Galeocerdo cuvier* and *Sphyrna lewini* suggests a relatively recent common ancestry, which may reflect similar ecological adaptations or geographic distributions that have influenced their evolutionary history. This phylogenetic relationship is supported by the DNA sequence-based analysis conducted by Naylor et al. (2012), who explored global elasmobranch diversity and provided a framework for understanding the molecular phylogenetics of sharks and rays.

The close genetic relationships among *Carcharhinus falciformis*, *Carcharhinus sorrah*, and *Carcharhinus limbatus* are evidenced by high bootstrap values, suggesting a recent common ancestry (Naylor et al., 2012). These relationships are further corroborated by the detailed species descriptions and morphological data provided by Compagno et al., (2005), which highlight the shared physical traits across the genus *Carcharhinus*. The ecological roles and patterns of movement detailed in Heupel et al., (2010) provide insight into behavioural traits that may influence genetic structure and diversity within these shark species. Such ecological data are essential for understanding the mechanisms behind the phylogenetic patterns observed.

Alopias pelagicus is very closely related to *Alopias superciliosus*, with a very high degree of genetic similarity. It implies a recent common ancestry relative to other species in the tree. Cardenosa et al. (2014) highlighted that, there are differences between populations across the Atlantic and Indo-Pacific, the differentiation within the Indo-Pacific is less pronounced, indicating a higher genetic similarity or connectivity among these populations. This suggests a closer evolutionary relationship and possibly a shared recent ancestry between these species within this region.

The species morphologically identified as *R. annandalei* displayed close similarities with *R. punctifer*. Both species, which co-occur in the Indian Ocean's Arabian Sea region, differ in their body spots, which are smaller and more widely spread on the latter and have a comparatively narrower disc and fewer thorns on the midline (Compagno and Randall, 1987). The taxonomy of the Northern Indian Ocean Rhinobatos, which includes *R. annandalei*, *R. lionotus*, and *R. punctifer*, presented one of the most difficult nomenclatural issues, in which *R. punctifer* and *R. annandalei* are the most mistaken species for one another (Last et al., 2019). The misidentification of *R. punctifer*, an Oman-based species, as *R. annandalei* by Randall and Compagno (1995) appears to have contributed to the latter's subsequent and repeated misidentification (Last et al., 2019). It was previously believed that *R. punctifer*, a species with very variable colours, was unrecorded. Last et al. (2019) re-established the identities and morphological variations of *R. annandalei*, *R. lionotus*, and *R. punctifer* in the Northern Indian Ocean.

The evolutionary kinship between *Rhina ancylostoma* and *Glaucostegus obtusus* is highlighted by their close grouping in phylogenetic analyses. This is indicative of a conserved evolutionary history within this subset of the Batoidea, an insight that gains further empirical support from the work of Aschliman et al. (2012). Their research into the body plan convergence across various rays and skates, including members of the Batoidea superorder, provides a comprehensive molecular and morphological framework that elucidates the phylogenetic relationships among these species.

Tree showing (Fig. 3.4) high genetic similarity between *Mobula mobular* and *Mobula tarapacana*. This support suggests a close evolutionary relationship and possibly similar ecological niches or evolutionary histories. However, Banjarsari et al., (2023) stated that *Mobula mobular* is closer to *Mobula thrustoni* than *Mobula tarapacana*. This indicates a genetic relationship between *Mobula mobular* and *Mobula thrustoni*, which aligns with the idea of a close evolutionary relationship between *Mobula* species. The species of family Dasyatidae, Aetobatidae and Gymnuridae are shown to have a close similarity, which indicates that they are closely related (Lim et al., 2015) because they all are belonging to order Myliobatiformes

The diverse array of findings from molecular and morphological studies underscores the intricate evolutionary relationships and genetic structures within the Elasmobranchii, particularly among sharks and rays. DNA barcoding, a molecular technique suggested by Ratnasingham et al. (2007), has proven essential in delineating species boundaries and uncovering the cryptic diversity within this group. This approach not only enhances our understanding of their taxonomy but also aids in conservation efforts by identifying and characterizing species at risk of extinction.

3.4.2 YOLO

The high performance of the YOLO v2 model in identifying species, demonstrates its robust capability in marine biodiversity monitoring, the effectiveness of the YOLO v2 model in accurately identifying these species from photographic data not only enhances the efficiency of species cataloguing and monitoring but also reduces the time and potential errors associated with manual identification methods. This reliable identification process is crucial in marine environments, helping to inform better conservation tactics and management decisions aimed at preserving biodiversity. Such technological advancements are integral to advancing ecological studies, providing critical data that supports the sustainability and protection of various marine species.

The YOLO v2 model, recently introduced in current study and currently in its pilot phase, has not yet been practically applied in the field. As a cutting-edge tool in the initial stages of development, it operates on a relatively small dataset, highlighting the need for more comprehensive and high-quality data to enhance its training procedures. The ongoing training process underscores the necessity to enrich the model's learning with diverse and extensive data inputs. This preliminary work serves as a foundational step towards evaluating the model's potential applications and effectiveness in real-world scenarios, particularly in environments that require precise and accurate biodiversity monitoring. As such, further development and refinement are essential to fully realize the model's capabilities in practical conservation efforts.