Study on Diversity and fishery of Class Elasmobranchii from Maritime Zone of Gujarat State

Ph.D. THESIS ABSTRACT

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Research Guide

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Class Elasmobranchii, encompassing sharks, rays, and skates, represent an ancient group of marine vertebrates that have persisted for over 400 million years since the Devonian period. Distinguished from bony fishes (Osteichthyes) by their cartilaginous skeletons, elasmobranchs have adapted to various marine environments. Key characteristics include the absence of a swim bladder, multiple gill clefts, ventral mouth, heterocercal tail, inflexible dorsal fins, and rows of teeth. Globally, elasmobranchs are highly diverse, with over 1,426 species inhabiting environments from freshwater lakes to deep oceans. They play critical roles in marine ecosystems, often functioning as apex predators that influence the population dynamics of their prey and maintain the balance within food webs. The decline of large predators like sharks can lead to trophic cascades, affecting the entire marine ecosystem and highlighting their importance in maintaining biodiversity and ecosystem health. They are particularly vulnerable to overexploitation due to their K-selected life history traits, including slow growth, late maturity, and low reproductive rates. This complexity, coupled with a lack of comprehensive understanding, complicates conservation efforts. Overfishing and bycatch in commercial fisheries pose significant threats, making detailed knowledge of their biology, distribution, and ecological roles essential for effective conservation and management strategies. Recent molecular studies have advanced the understanding of elasmobranch phylogeny, revealing that batoids (skates and rays) form a monophyletic group distinct from sharks. Despite these advances, taxonomic and phylogenetic debates persist, necessitating further research using both morphological and molecular data. Historically, elasmobranchs have been significant sources of food and other products. The commercial exploitation of elasmobranchs, particularly for their fins, meat, and liver oil, has grown substantially, with countries like Indonesia, India, and Spain being major contributors to the global fishery. However, overfishing and unregulated practices have led to declining stocks and raised sustainability concerns. Research on the taxonomy of elasmobranchs in Indian seas dates back to the late 18th century. British naturalist Latham (1794) and subsequent researchers described many new species, though some were later synonymized. Comprehensive studies by Day (1889) and Misra (1947, 1952, 1969) documented numerous species, with Misra confirming 114 species. Researchers like Alcock (1889, 1898) and Dutta and Roy (1977) focused on specific groups or regions. Recent studies have continued to discover new species.

India's extensive coastline and marine biodiversity play a major role in the global elasmobranch fishery. The Indian Exclusive Economic Zone (EEZ) supports diverse elasmobranch species, which are harvested using various methods. The fishery has evolved from incidental catches to targeted fishing practices, with states like Tamil Nadu, Kerala, and Gujarat contributing significantly. Challenges include bycatch and inadequate population data, hindering effective management. Post-harvest processing of elasmobranchs, particularly for liver oil, has been integral to the fishery industry since the 19th century. Shark liver oil, rich in vitamin A, was historically used as a substitute for cod-liver oil. The processing and trade of elasmobranch products, including shark fins and meat, have evolved significantly, with recent studies detailing these practices.

Advances in deep learning and machine learning, particularly using convolutional neural networks (CNNs) like YOLO (You Only Look Once), have revolutionized the monitoring and identification of elasmobranch species. Automated detection and tracking systems enhance accuracy and efficiency in species identification, aiding conservation and management efforts. These technologies provide valuable tools for biologists and policymakers to address marine biodiversity challenges. Elasmobranchs are vital to marine ecosystems, with significant ecological, economic, and conservation importance. Understanding their taxonomy, distribution, and ecological roles is essential for developing effective management and conservation strategies. Advances in molecular research and technology offer new opportunities to enhance our knowledge and protect these ancient marine vertebrates. Continued research, international collaboration, and effective policy implementation are crucial for ensuring the long-term sustainability of elasmobranch populations.

Present study was an attempt to provide updated and detailed information on various aspects of Elasmobranchs from the maritime zone of Gujarat state. The study is focused on various parameters like taxonomy, diversity, deep learning, Population dynamics and stock assessment, and poste harvest utilization of elasmobranchs. Data was collected during year 2021 to 2023 from the fishing harbours along the Gujarat coast.

Taxonomy and Diversity

The present study increased the Elasmobranchs diversity in the region and provided an updated list for the region Taxonomic account of all the confirmed species was emphasized. Description of each species are provided.

A total 48 species of elasmobranchs were recorded from the Gujarat maritime zone. 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).

In the present study no new species could be encountered of the 48 species of elasmobranchs obtained from the study area however, 06 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*.

Molecular Phylogeny of Elasmobranchs

Phylogenetic analysis to elasmobranchs with emphasis to COI gene were studied here in order to understand the genetic similarity and phylogenetic relationship within the elasmobranchs community. Phylogenetic tree was generated based on neighbour joining (NJ) trees of K2P distance were created to provide graphic representation of divergence, with 1000 bootstrap replications.

Phylogenetic analysis revealed that *Isurus oxyrinchus* holds a distinct evolutionary position within the elasmobranch clade, indicating an ancient lineage. The close genetic association between *Galeocerdo cuvier* and *Sphyrna lewini* suggests a recent common ancestry driven by similar ecological adaptations. This analysis also revealed close genetic relationships among *Carcharhinus falciformis*, *Carcharhinus sorrah*, and *Carcharhinus limbatus*, indicating a recent common ancestry. Phylogenetic analyses reveal close evolutionary relationships between *Rhina ancylostoma* and

Glaucostegus obtusus. While genetic analyses suggest high similarity between *Mobula mobular* and *Mobula tarapacana*, Banjarsari et al. (2023) identified a closer genetic relationship between *Mobula mobular* and *Mobula thrustoni*. Studies on families Dasyatidae, Aetobatidae, and Gymnuridae highlight close genetic relationships, all belonging to the order Myliobatiformes. DNA barcoding has been crucial in delineating species boundaries and uncovering cryptic diversity within Elasmobranchii, enhancing taxonomy and aiding conservation efforts by identifying species at risk of extinction. These findings underscore the intricate evolutionary relationships and genetic structures within Elasmobranchii, providing a comprehensive framework for understanding the molecular phylogenetics of shark skates and rays and informing conservation strategies.

YOLO a deep learning approach

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.

All performance metrics such as Accuracy, Sensitivity**,** Specificity **and** F**1 Score showing a score more than 0.7 so these r**esults 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.

Quantitative measurements of elasmobranch diversity

Diversity indices were calculated from the fish abundance matrix. Monthly data collected from designated sampling sites were pooled by season and further underwent statistical analysis using the PAST software.

Shannon - Wiener diversity index, highest diversity was observed in Spring season (2.74) followed Autumn (2.15), Winter (1.91) and Summer (1.29)

The Dominance (D) values indicate varying levels of species prevalence across seasons. Spring shows the lowest dominance (0.121), Winter (0.257) and autumn (0.251) exhibit moderate dominance, Summer has the highest dominance (0.426).

The Simpson's Index of Diversity (1 - D) results show that spring has the highest diversity (0.87), indicating a very even distribution of species. Winter (0.74) and autumn (0.74) also exhibit moderate to high diversity. Summer, however, has the lowest diversity (0.57).

The Margalef richness index, the highest species richness was observed in the Spring season (5.523), followed by Autumn (4.807), Winter (3.408), and lowest richness was observed in Summer (1.961).

The Evenness index shows, the most even distribution of species was observed in the Spring season (0.36), Winter follows with an evenness value (0.29) Summer and Autumn exhibit similar and lower evenness values (0.24) and (0.24), respectively.

The SHE analysis shows that species richness (ln S) steadily increases with more samples. The Shannon-Wiener diversity index (H) rise initially, stabilize around 2500 samples, and then slightly declines or remains constant. Evenness (ln E) remains consistently low.

The individual rarefaction analysis indicates that spring has the highest species richness, Autumn follows with slightly lower species richness, while winter shows moderate richness. Summer has the lowest species richness.

Taxonomic distinctness indicates Spring has the highest diversity (1.565) and taxonomic distinctness (1.782). Autumn also shows comparatively high values for diversity (1.325) and taxonomic distinctness (1.77) then winter and summer, Winter presents moderate diversity (1.154) and taxonomic distinctness (1.552), and Summer has the lowest diversity (0.718) and taxonomic distinctness (1.25).

The K - Dominance plot shows that summer indicating high dominance by a few species. Winter indicating moderate dominance. The autumn reflecting higher evenness and lower dominance than summer and winter. The spring indicating the highest evenness and lowest dominance among the seasons.

Cluster analysis adopting Bray-Curtis similarity was performed for comparing the species diversity of different seasons. Some similarity around 0.69 was observed between Summer and winter among the seasons. Spring and Autumn joined at a similarity level of around 0.71. Overall, the two groups (Summer-Winter and Spring-Autumn) cluster together at a lower similarity level of around 0.57, indicating a moderate overall similarity between these two seasonal groups.

The NMDS (Non-metric Multi-Dimensional Scaling): Spring and Autumn indicating a high similarity in their species compositions. Summer is somewhat distant from Spring and Autumn but closer to them than to Winter, suggesting moderate similarity. Winter is positioned further away from the other seasons, indicating that its species composition is the most distinct compared to the other seasons.

Population dynamics and Stock Assessment of Carcharhinus falciformis (Bibron, 1839) Silky shark

The present study utilized length-based stock assessment methodologies. Analysed using the FiSATII Computer Program, the monthly length frequency of Carcharhinus falciformis was examined the various parameters.

ELEFAN technique employing FiSATII programme gave an estimate of L_∞ as 326.55 cm TL and K of 0.13/year (Fig. 2.12). Powell and Wetherall plot gives the preliminary estimates of growth parameters L_∞ of 325 cm and Z/K of 3.17 (Fig. 2.13). Shepherd‟s method yielded as L_∞ as 326.55 cm TL and K of 0.13/year.

The low K value for *C. Falciformis* (0.13/yr) indicates that this species grows at a slower rate to attain the asymptotic length (326.55 cm TL).

The phi prime (Φ) value estimated in this work, which is 4.142, provides stronger support for the estimation of L∞ and K.

Average Total mortality rate (Z), natural mortality rate (M), and fishing mortality rate (F) were estimated to be 0.45, 0.22, 0.23, respectively.

This study revealed that the recruitment pattern of *C. falciformis* shows continuous recruitment throughout the year, with a two peak around June and July month. The percent recruitment varied from 0.8% to 23.97%. The highest (23.97%) and lowest (0.8%) percent recruitment was observed in the months of July and May respectively.

VPA shows that F for the species has an increasing for the large size groups and suddenly increases at 291-300 cm TL. The reason for this sudden increase in F possibly due to larger sharks is coming as bycatch.

The exploitation ratio (E) calculated as 0.51. When E is more than 0.5 for the stocks, are supposed to be over exploited. The results of the present study ascertain the need for monitoring the fishing effort for *C. falciformis* along the maritime zone of Gujarat State, India.

Post harvesting utilisation of elasmobranch fishes

A survey was conducted from 2021 to 2023 at various fishing harbours and landing sites along the Gujarat coast. Interviews with fishermen and traders provided insights into their demographics, fishing practices, and perceptions of elasmobranch fisheries. The semi-structured interviews covered demographics, fishing practices, utilization and trade of products, and awareness of regulations.

Trade and Product Utilization

Profitability: Most fishermen found it difficult to rely on shark and ray fishing due to low catch and market value. Some traders profited from exporting ray fish.

Meat Utilization: Fishermen generally did not consume elasmobranch meat due to taste and texture preferences, but some local markets existed. Products were often salted, dried, and sold to other Indian states. Fins and Liver Oil: Shark fin trade is illegal and not practiced locally. Shark liver oil is processed and used for boat varnishing, with some traders producing significant quantities. Other Products: Low-quality elasmobranch fish are sold to the fish meal industry.

Demographics survey

Interviews conducted: 64 (48 fishermen, 16 traders) in regions like Veraval, Mangrol, Porbandar, Okha, and Jakhau.

Age range: Fishermen (21-65 years, mean 41), Traders (32-65 years, mean 32).

Experience: Fishermen (1-50 years, mean 21.5), Traders (10-40 years, mean 22.25).

Most fishermen learned fishing from family and operated mechanized boats, with many serving as captains.

Fishing Gear and Techniques: Fishermen target multiple species year-round using various gears. Sharks are primarily caught using gillnets and hook & line, while rays are caught using trawl nets.

Knowledge of Elasmobranchs: Fishermen and traders could identify species based on unique morphological features but had difficulty distinguishing similar species.

Fishing Periods and Seasons: Fishing occurs about nine months a year, with peak seasons in September-October and February-March. Fishing activity reduces or halts in July and August due to low catch and a seasonal ban.

Population Trends and Perceived Causes of Declines: All respondents noted a decline in elasmobranch abundance over the last decade due to overfishing and an increasing number of fishing boats. Common small sharks like *Scoliodon laticaudus* were still abundant.

Awareness and Perceptions Regarding Regulations: Fishermen and traders were aware of fishing regulations, seasonal bans, and protected species. Misconceptions about certain regulations were noted.

The undertaken aspects of the present study revealed that there is a dearth of information of Elasmobranchs from the region. Considering the information gap from the region the present survey attempts to form a baseline emphasizing an urgent need to further explore their biodiversity for better management as well as sustainable utilization and better conservation actions of its faunal diversity.