Synopsis of the Thesis Entitled

STUDY ON DIVERSITY AND FISHERY OF CLASS ELASMOBRANCHII FROM MARITIME ZONE OF GUJARAT STATE

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INTRODUCTION:

The Elasmobranchii class is one of the groups of vertebrates having survived for, over 400 million years since the period. It is the second largest class of fishes after Osteichthyes (bony fish) (Boisvert et al., 2019; Compagno, 1990; Grogan et al., 2012). Elasmobranch fish can be distinguished from bony fish by their scales, which have been replaced by placoid scales in elasmobranch fish species (Meyer & Seegers, 2012). The term Elasmobranchii refers to sharks, rays, and skates which're all cartilaginous fish, they have skeletons made of calcified cartilage instead of true bones (Seidel et al., 2017). The body forms of Elasmobranch fishes share many similar characteristics, but is highly varied between orders, reflecting adaptations to lifestyle, habitat, and environment (Lisney et al., 2012).

Elasmobranchs are a diverse taxonomic group, their systematic arrangements, and phylogeny is mostly unresolved. Early taxonomic works such as that by Bigelow and Schroeder (1948) suggested that there are fundamental splits in batoids and sharks, while the recent studies (Compagno, 1977) suggested batoids are derived from sharks (such as saw sharks and angel sharks). The most discussed modern cladistic classifications of elasmobranchs are by De Carvalho (1996); Shirai (1996); Compagno, (2001) and Compagno, (2005). Recently genetic and molecular data has been widely used to make phylogenetic tree and to solve the issues related to Elasmobranch phylogeny, interrelationships, radiation, and evolution (Douady, 2003; Puckridge *et al.,* 2013). Though there are several classifications presented for chondrichthyes (eg. Mould, 1997), most widely used and recognized classification is that of Compagno (2005).

The global population of elasmobranchs consists of, around 1426 known species (Fricke, et. al, 2023). and still Every year new species is discovered. They can be found in environments ranging from freshwater to deep sea ecosystems. Some species are widespread while others are only found in particular regions. Elasmobranchs are particularly vulnerable to overfishing due to their K selected life history traits such as growth, late sexual maturity, and low reproductive rates. The limited understanding of their biology and life cycle makes it challenging to implement conservation and

management strategies. The growing demand, for fishing and incidental catch has raised concerns regarding the sustainability of elasmobranch populations.

India, ranking second globally in chondrichthyan fishing after Indonesia (FAO, 2009), Elasmobranch fisheries resources consisting of sharks, rays and skate exploited by using various gears (longlines, trawl nets, drift gillnets and hooks and lines) in the Indian Exclusive Economic Zone (EEZ). Traditionally, India has a rich fishery history, with early elasmobranch records from the southwest coast Kerala, by (Day 1863). Until 1980, elasmobranchs were occasional bycatch by different types of traditional crafts and gears operated in India. The commercial elasmobranch fishery has evolved in the last three decades due to increased effort, multiday distant water fishing, and expanded fishing areas and depths. Targeted elasmobranch fishing using gill nets, hooks and lines, and longlines began around 1990 (Bonfil 1994; Hanfee 1997, 1999). Currently, multiday distant water targeted elasmobranch fishing occurs across the Indian EEZ. In 2021, India's elasmobranch landing reached 31,277 tonnes, contributing to the estimated total marine fish landing of 3.05 million tonnes, with significant contributions from Gujarat, Tamil Nadu, Karnataka, and Kerala. (CMFRI, 2021).

The state of Gujarat, along the west coast of India, witnessed remarkable development in the marine capture fisheries sector. The State is naturally gifted with abundant marine fishery resources. Gujarat is a leading maritime state of India located in the extreme west of the country (20.1o to24.7o North and 68.4o to 74.4o East). Gujarat with about 20% of the country’s coastline (1600 km.), 33% of the continental shelf area (1,64,000 km2) and over 2, 00,000 km2 of EEZ (Exclusive economic zone) ranks second among the maritime states in marine capture fish production.

REVIEW OF LITERATURE:

Elasmobranchs in the Indian EEZ have been a significant capture fishery resource for decades, exploited by various crafts and gears (Pillai & Parakkal, 2000). The ongoing multispecies, multi-gear, year-round elasmobranch landings, coupled with India's extensive history in elasmobranch fishery, emphasize the critical need for evaluating the status of these vulnerable resources. This evaluation requires the compilation of available information. While most research on Indian elasmobrancs focuses on

diversity, taxonomy, fishery, biology, and population dynamics, there's an urgent need for comprehensive reviews of earlier research (Gupta et al, 2022).

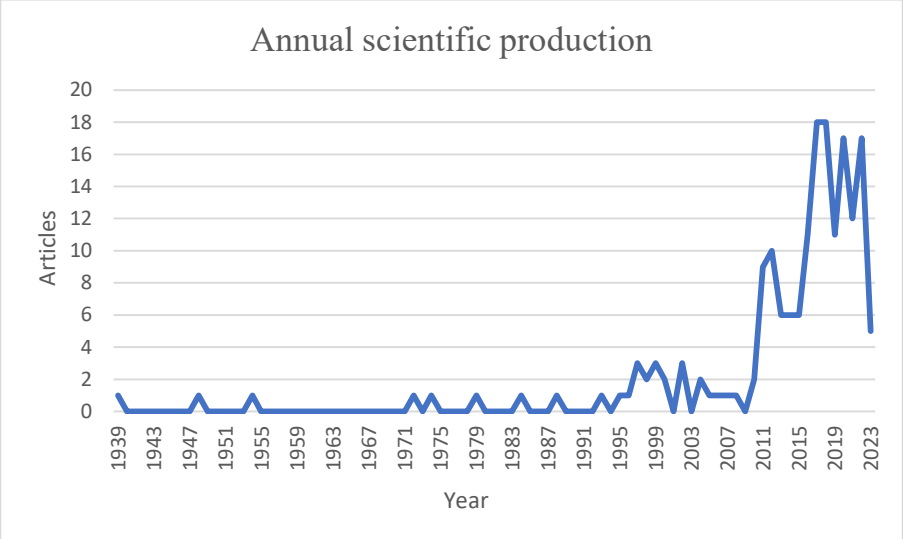
Elasmobranch taxonomy research in Indian waters spans centuries, with notable early ichthyologists. Latham (1794), a British naturalist, is credited as the first to study Indian elasmobranchs, describing Anoxypristis cuspidata from Malabar (Kerala). German naturalists Bloch and Schneider, in their 1801 publication Systema Ichthyologiae, introduced several new elasmobranchs based on materials collected from the Coromandel coast of India (southeast coast), including Aetobatus flagellum and Rhina ancylostoma.

Following Bloch and Schneider, several other researchers worked on Indian fauna during the colonial period After Bloch and Schneider, numerous researchers investigated the fauna of India in the colonial era. viz, Shaw (1803); Russell (1803); Hamilton (1822); van Hasselt (1823); Bleeker (1853); Cuvier (1853); Gronov (1854); Blyth (1860); Dumeril (1865); Day (1865); Alcock (1889); Lloyd (1908); and Annandale (1909) who all contributed significantly to understanding elasmobranch fauna of Indian waters.

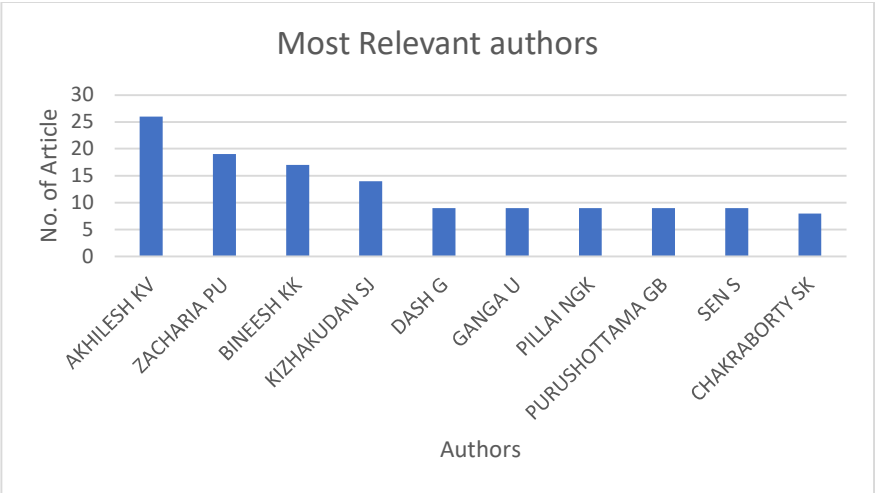
Limited studies exist on the distribution, biogeography, bathymetry, migration, and abundance of elasmobranchs in Indian waters. Misra and Menon (1955) focused on elasmobranchs and chimaeras in relation to mean annual isotherms. Mathew et al. (1996) presented distribution patterns and abundance of Indian EEZ elasmobranchs from FORV Sagar Sampada surveys. Somvanshi et al. (2009) examined the distribution of pelagic stingray Pteroplatytrygon violacea in the Indian EEZ. Sinha et al. (2010) explored spatiotemporal distribution, abundance, and diversity of oceanic sharks in Andaman waters.

Brief descriptions with diagnostic characters and regional occurrences have been published in newsletters, magazines, and popular articles by fisheries institutes such as Fishery Survey of India (FSI), Zoological Survey of India (ZSI), Central Marine Fisheries Research Institute (CMFRI), and universities etc.

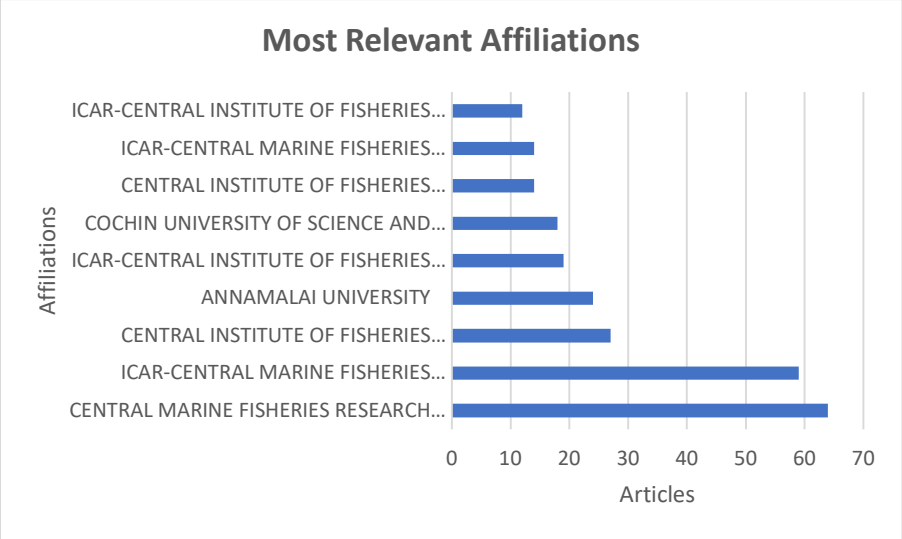
BIBLIOMETRIC ANALYSIS OF INDIAN ELASMOBRANCH RESEARCH FROM SCOPUS DATABASE:



The data spans from 1939 to 2023 and illustrates a substantial evolution in article publications. Initially, from 1939 to 1971, publication activity was minimal, often with zero or only one article per year. Notably, in 1972, 1974, and 1979, one article was published each year, with similar occurrences in 1984 and 1988. The mid-1990s marked a turning point, with a significant surge in annual articles from 1996 onwards. This trend continued into the 21st century, peaking at 18 articles in both 2017 and 2018. While recent years saw some fluctuations, the data overall signifies a remarkable increase in research output, reflecting heightened scientific activity in Elasmobranch research.



The data reveals the research contributions of various authors, notably highlighting Akhilesh K V with 26 articles and Zacharia pu with 19 articles, demonstrating significant research output. Bineesh kk follows closely with 17 articles, while Kizhakudan sj has contributed 14 articles. several authors, including Dash g, Ganga u, Pillai ngk, and Purushottama gb, have each authored nine articles, underlining consistent contributions. sen s aligns with this group, emphasizing the productivity of these authors. Chakraborty sk has contributed eight articles. in summary, this data underscores the active and productive research activities of these authors, with akhilesh kv leading in terms of the number of articles authored, collectively representing significant contributions into the Elasmobranch research.



the exported data reveals the affiliations of research articles, with "central marine fisheries research institute" leading the list with 123 articles, "central institute of fisheries education" and "annamalai university" also make substantial contributions with 27 and 24 articles, respectively. other notable affiliations include "icar-central institute of fisheries education" with 19 articles and "cochin university of science and technology" with 18 articles. these affiliations represent significant centres of research in the field of marine fisheries, emphasizing their contributions to this area of elasmobranch research.

ORIGIN OF STUDY:

Gujarat comprises India's longest coastline, constitutes a fifth of the country's total. Rich in diverse habitats like mangroves, salt marshes, coral reefs, and seagrasses, the state's continental shelf within 0–50 m depth supports commercially significant species. Despite contributing 15% to India's export economy, Gujarat lacks thorough fisheries assessments, ranking 4th globally in the need for Chondrichthyes research. The lack of scientific investigations implies a dearth of stock assessments and necessary management measures. Urgent inquiry is warranted into elasmobranch species distributions, ecology, and fishing practices in the region. especially in identifying local nursery areas. The coastal areas in Gujarat, characterized by shallow waters, mangroves, and seagrass habitats, are believed to be favourable for juvenile sharks and rays. However, specific local nursery areas in the region are yet to be identified. The presence of immature elasmobranchs from the Red Sea region indicates a higher fishing risk for juveniles in the Arabian Sea including Gujarat. Given that certain species aggregate based on age, sex, or reproductive state, their populations may be more susceptible to fishing pressure. It's crucial to promptly identify and protect potential habitats for these species in Gujarat. To address these knowledge gaps, a well-designed study is underway to enhance our understanding of elasmobranch diversity and fisheries in the maritime zone of Gujarat (Johri et. al, 2021).

OBJECTIVES:

(1) To study the species diversity and molecular characterisation of elasmobranch fishes from Maritime zone of Gujarat.

(1A) To study Morphology, Morphometry and Meristic characters of Elasmobranch.

(1B) Molecular taxonomy and Phylogeny.

(2) Fishery data analysis.

(3) Post harvesting utilization of elasmobranch.

STUDY SITE:

The Gujarat coast is renowned for its extensive network of fish landing centres and harbours, which are vital components of the state's vibrant fishing industry. These landing centres are strategically located along the coastline and have specific roles in the fishing and seafood trade. Among the notable landing centres, Veraval, Porbandar, Mangrol, Okha, Jakhau and Bhavnagar district play significant roles. Veraval stands out as one of the largest and most active fish landing centres 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. These landing centres are not only economic drivers but are also deeply ingrained in the cultural and social fabric of the coastal communities. They reflect the rich marine resources of the region, showcasing Gujarat's longstanding fishing traditions and its substantial contribution to the state's and the nation's economy.

MATERIALS AND METHOD:

Sampling site:

Four primary areas along the western coast of Gujarat, India - Veraval (20.9159_ N, 70.3629_ E), Mangrol (21.1172_ N, 70.1158_ E), Porbandar (21.6417_ N, 69.6293_ E), and Okha (22.4649_ N, 69.0702_ E) were chosen as sites for sample collection due to their high volume of elasmobranch landings.

Methodology:

Methodology mainly categorised under three parts.

1) To study the species diversity and molecular characterisation of elasmobranch Maritime zone of Gujarat:

Species identification of collected elasmobranch specimens were based on Alcock (1899); Misra (1952); Compagno (1984 ab); Smith and Heemstra (1986); Shirai and Tachikawa (1993); Didier and Stehman (1996); Compagno (2001); Compagno *et al.* (2005 a); White *et al.* (2006 b); Last *et al.* (2008 ab); Ebert (2013) etc. and other available references of particular genus and species. Morphological features of specimens will be examined with fine precisions. The linear measurements will be taken by using normal scale/measuring tape, fine pointed divider and forceps to the nearest cm, following methodologies prescribed by Compagno (1984, 2001) for sharks; Last *et al.* (2008) for skates. Morphometric measurements as expressed in percent of total length (% TL) unless otherwise stated. The molecular identification has been carried out by barcoding the COI gene of the specimens to be matched with the records of the database of BOLD and NCBI. The secondary data derived from these sources and the primary data from the present study would assist in creating phylogenetic maps at species level and phylogeography studies on the distribution pattern of selected elasmobranch fish. The YOLO object bases image classification was carried out using MATLAB Software from the collected images. In preparing the fish detection model using YOLO, annotate the dataset with bounding boxes using the specific YOLO labelling format, split the data into training and validation sets, train the model with the configured YOLO architecture, evaluate its performance on the validation set, and implement post-processing techniques.

2) Fishery data analysis:

The monthly, seasonal, and annual data of elasmobranch fish for present study was collected from selected fish landing centre of Gujarat coast. Based on the length frequency data, various parameters of population dynamics were calculated. The

elasmobranch fish catch trends of the state was analysed by conducting socio economic survey.

3) Post harvesting utilization of elasmobranch:

A detailed study of all the post-harvesting techniques/process was carried out.

Data was validated through local communication with fishermen and by visits to processing units. Based on survey data of post-harvest utilization, market channels, and trade were analysed.

RESULT:

Objective 1

The surveys conducted at fish landing site and fish markets within Gujarat state. Elasmobranchs were sampled opportunistically, including species from the Selachii (sharks) and Batoidea (rays). Within the Selachii, recorded twenty-two species comprising three orders, six families, and twelve genera. while within the Batoidea recorded twenty-five species, comprising three orders, nine families, and sixteen genera. Additional specimen photographs and research grade identifications for each specimen can be found at iNaturalist: https://www.inaturalist.org. Note that 2 specimens for which taxonomic identities remained unknown are not included. Taxonomic identity of specimens from five species were confirmed by sequencing and phylogenetic analyses in the current study. Phylogenetic analyses of one species are presented in Fig.1 To provide a graphical depiction of the patterning of divergences, Neighbour Joining (NJ) trees of Kimura two-parameter (K2P) distances were built (Fig.1). The results of a phylogenetic study and a comparison of the DNA barcodes of the present Gujarat specimen (OR252866) with those of U. granulatus from GenBank (KF899471, MF039700, MZ363898) demonstrate a match of more than 99.5%.

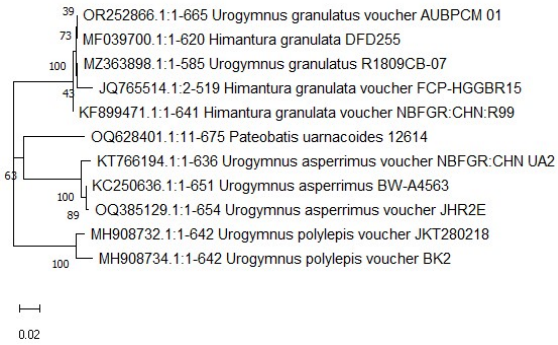


Figure-1 Molecular phylogenetic tree of *Urogymnus granulatus.*

The elasmobranchs are represented in 6 orders, of which Carcharhiniformes and Myliobatiformes contributed the same 36.4% with 17 no. of species each followed by Rhinopristiformes 12.76 % having 6 species, Lamniformes 6.38%, with 3 species, orectoolobiformes and Torpediniformes contribute same 4.25 % with 2 species each. Among the 13 families recorded, Carcharhinidae is the dominant family with 13 species. Earlier studies by Johri et. al, (2021) reported 31 species of elasmobranchs at Gujarat coast, indicated the dominance of Carcharhiniformes and Myliobatiformes with 38.70 % and 29.03% respectively.

Biodiversity indices of elasmobranchs:

Spatio-temporal variability in biodiversity indices such as Simpson_1-D, Shannon – Wiener species diversity (H), Margalef's species richness (d), Menhinick, and Margalef were calculated using PAST 4.03 version. Values are given in the belove.

Diversity indices	Winter	Summer	monsoon
Simpson_1-D	0.6745	0.8909	0.7863
Shannon_H	1.914	2.731	2.251
Evenness_e^H/S	0.1993	0.4147	0.2435
Menhinick	1.013	0.8901	1.02
Margalef	4.697	4.829	5.214

To understand the diversity, different diversity indices have been calculated to quantify the diversity of species within an elasmobranch fishes community. Different indices were calculated the different aspects of diversity, including species richness, evenness, and dominance. Results in above table shows that summer season consistently shows

the highest diversity across all indices, indicating a more diverse and evenly distributed community of elasmobranch. As Margalef index emphasizes the importance of rare species in a community, the result of this index suggests that Monsoon has the highest diversity, emphasizing the importance of rare species. On the other hand, The Menhinick's index suggests relatively low species richness across all seasons. Evenness is highest in Summer, indicating a more balanced distribution of species whereas winter generally has lower diversity and evenness compared to Summer and Monsoon.

Objective 2:

Estimation of growth parameters:

The monthly length frequency of *carcharhinus falciformis* was analyzed using the FiSAT Software. The parameters of von Bertalanffy's growth functions (VBGF), asymptotic length (L∞) and growth co-efficient (K) were estimated using ELEFAN-1 routing incorporated into the FiSAT Software. K Scan routine was conducted to assess a reliable estimate of the K value. ELEFAN technique employing FiSAT programme gave an estimate of L∞ as 316 cm TL and K of 0.14/year.

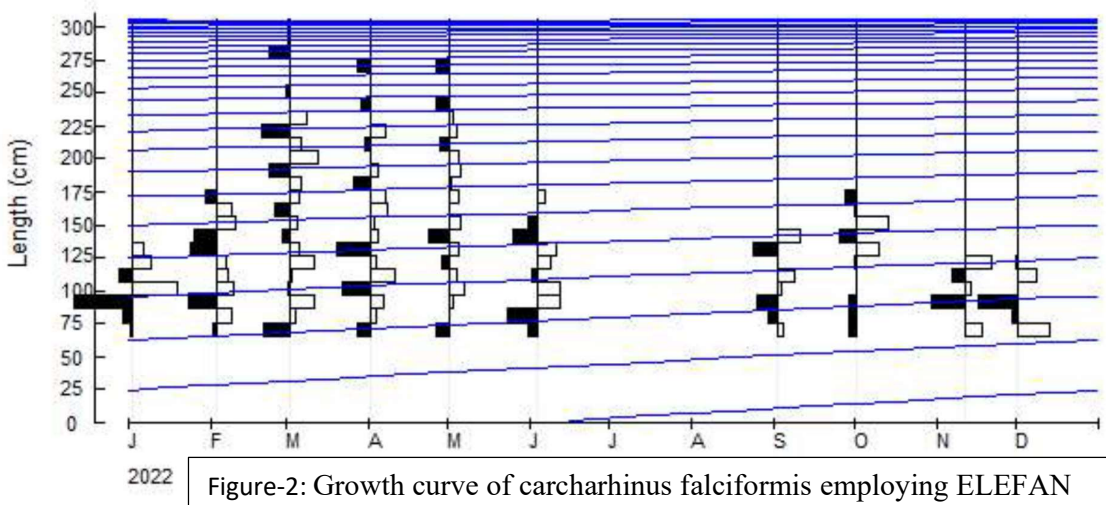


Figure-2: Growth curve of carcharhinus falciformis employing ELEFAN

Mortality Parameters:

The key parameters used to describe the rate of death are called the "mortality parameters". The total mortality rate of the cohort (batch of fish having approximately the same age and belonging to the same stock) Z is the sum of the instantaneous rate of fishing mortality F, which is caused by the fishing operation and the instantaneous rate of natural mortality M which includes deaths caused by all other factors other than fishing like lack of food, competition, predation, and old age. The Z obtained by length converted catch curve was 0.25.(Fig.3).

Other age- and growth-related parameters such as Gulland and Holt plot (1959), Powell and Wetherall Plot, Munro's method (1982), and Ford-Walford plot are also calculating.

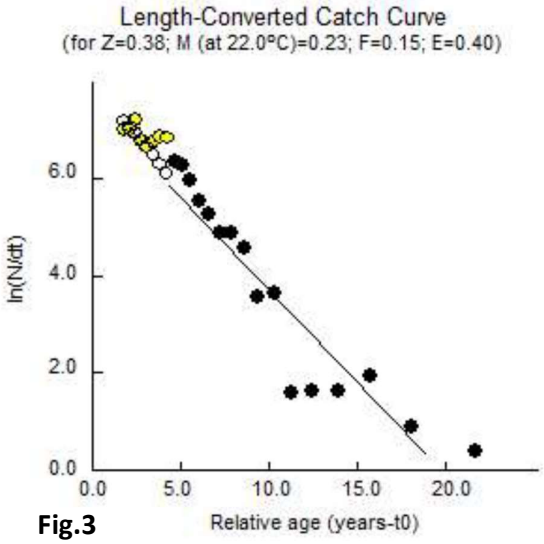


Fig.3

Objective 3

Trade characteristics of Elasmobranch fishery:

Category	Questions	Respondents
Elasmobranch landings	Commonly caught elasmobranch	*S. laticaudus, R. acutus, R. Oligolinx, C, falciformis, I. omnanensis, Brevitrygon sp. R. annandalei, R punctifer*
Fishing patterns	Season of highest catch	March, April, September, October

	Season of lowest catch	June, July, December, January
	Time of catch	Day and Night
	Gear that caught elasmobranch	Gillnet, Hook and line, Trawl.
Trade patterns	Sale of meat	Yes (Fresh/dry fish)
	Sale of liver oil	Yes
	Sale of Fins	Yes (but did not know details)
Conservation	Quantity of elasmobranch catch	Decrease
	Price	Increase (regular mode)
	Conservation status	Only know about whale shark.

Objective: 3

Post harvesting utilization:

Elasmobranchs, encompassing sharks and batoids, are encountered incidentally or captured as bycatch, rather than being the primary target of fishing activities. with prominent families such as Carcharhinidae, Dasyatidae and Rhinobatidae dominating the catch. Following bycatch, traders buy fishes from the boat owners and a post-harvesting processing is carried out. smaller or damaged individuals sold for local consumption, while medium size fresh shark such as silky shark packed in ice box and transported to Bangalore (Karnataka) and Kerala, while Fresh Ray fishes are transported to Howrah (West Bengal). This was based on the species, quantity, and quality of catch. Remaining fish catch undergoes at a designated processing unit. In processing Washing, cutting, salting, and drying of fish is done there.

After cutting, in the process of salting, the pieces of meat are kept with salt for 12-15 days and then left in the sun to dry. Liver which is separated during cutting and liver oil is made from it, the separation of liver oil is a crucial step, and it is utilized for boat exteriors.

while the other excess material is sent to the fishmeal industry, from which fishmeal is made. The dried fish is packed and transported to the state of Karnataka, Kerala, and Tamil Nadu, as per the demand of the market. Fin cutting and export activities are not significantly observed.

REFERENCES:

- Alcock, A. (1889). On the bathybial fishes of the Bay of Bengal and neighbouring waters, obtained during the seasons 1885-1889. *Annals and Magazine of Natural History*, (Series 6), 4: 376-399.
- Alcock, A. (1889). On the bathybial fishes of the Bay of Bengal and neighbouring waters, obtained during the seasons 1885-1889. *Annals and Magazine of Natural History*, (Series 6), 4: 376-399.
- Annandale, N. (1909). Report on the fishes taken by the Bengal fisheries steamer "Golden Crown." Part I, Batoidei. *Memoirs of the Indian Museum*, 2: 1-60.
- Bigelow, H. B., & Schroeder, W. C. (1948). Fishes of the Western North Atlantic: Lancelets, cyclostomes, sharks. Sears Foundation for Marine Research, Yale University. https://books.google.co.in/books?id=mYzImgEACAAJ.
- Bleeker, P. (1853). Nalezingen op de ichthyologische fauna van Bengalen en Hindostan. Verhandelingen van het Bataviaasch Genootschap van Kunsten en Wetenschappen. 25 (8): 1-166.
- Bloch, M.E. and Schneider, J.G.(1801) M. E. Blochii, Systema Ichthyologiae Iconibus cx Ilustratum. Post obitum auctoris opus inchoatum absolvit, correxit, interpolavit Jo. Gottlob Schneider, Saxo. Berolini. Sumtibus Auctoris Impressum

et Bibliopolio Sanderiano Commissum. M. E. Blochii, Systema Ichthyologiae. 1-584.

- Blyth, E. (1860). The cartilaginous fishes of lower Bengal. *Journal of Asiatic Society of Bengal,* 29 (1): 35-45.
- Boisvert, C. A., Johnston, P., Trinajstic, K., & Johanson, Z. (2019). Chondrichthyan evolution, diversity, and senses. Heads, jaws, and muscles: anatomical, functional, and developmental diversity in chordate evolution, 65-91.
- Bonfil, R. (1994). Overview of world elasmobranch fisheries. FAO Fisheries Technical Paper No. 341. Rome. 119.
- Bonfil, R. (1994). Overview of world elasmobranch fisheries. FAO Fisheries Technical Paper No. 341. Rome. 119.
- Compagno, L. J. (1977). Phyletic relationships of living sharks and rays. American Zoologist, 17(2), 303-322.
- Compagno, L. J. (1990). Alternative life-history styles of cartilaginous fishes in time and space. Environmental Biology of Fishes, 28, 33-7.
- Compagno, L.J.V. (2005). Checklist of living Chondrichthyes. In Hamlett, W.C., ed. Reproductive Biology and phylogeny of chondrichthyes: sharks, batoids, and chimaeras. Science Publishers, Inc., Enfield, New Hampshire, pp. 501–548.
- Compagno, L.J.V.(1984 a). FAO Species Catalogue. Vol. 4. Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Part 2 - Carcharhiniformes. *FAO Fisheries Synopsis* 125: 251–655. Compagno, L.J.V.(1984 b). FAO species catalogue. Vol. 4. Sharks of the world. An annotated and illustrated catalogue of shark species of world known to date. Part 1 - Hexanchiformes to Lamniformes. *FAO Fisheries Synopsis,* 125: 249 pp.
- Compagno, L.J.V.(1984 a). FAO Species Catalogue. Vol. 4. Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Part 2 - Carcharhiniformes. *FAO Fisheries Synopsis* 125: 251–655.
- Compagno, L.J.V.(1984 b). FAO species catalogue. Vol. 4. Sharks of the world. An annotated and illustrated catalogue of shark species of world known to date. Part 1 - Hexanchiformes to Lamniformes. *FAO Fisheries Synopsis,* 125: 249 pp.
- Compagno, L.J.V.(2001). Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Bullhead, mackerel and carpet sharks (Heterodontiformes, Lamniformes and Orectolobiformes). FAO
- Compagno, L.J.V.(2001). Sharks of the world. An annotated and illustrated catalogue of shark species known to date. Bullhead, mackerel and carpet sharks

(Heterodontiformes, Lamniformes and Orectolobiformes). FAO Species Catalogue for Fishery Purposes. No. 1, Vol. 2., Rome, FAO. 269 pp.

- Compagno, L.J.V., Dando, M. and Fowler, S. (2005 a). A field guide to sharks of the world. Harper Collins Publishing Ltd., London., 368 pp.
- 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. Le Règne Animal (Edition 2) v. 2: 1-406.
- Day, F. (1863). The Land of the Permauls, Or, Cochin, Its Past and Its Present: Gantz Bros., at the Adelphi Press, 578 p.
- Day, F. (1865) The fishes of Malabar. London. 1-293.
- De Carvalho, M. R. (1996). Higher-level elasmobranch phylogeny, basal squaleans, and paraphyly. Interrelationships of fishes, 3, 35-62.
- Didier, D. A. and Stehmann M. F. W. (1996) *Neoharriotta pumila*, a new species of longnose Chimaera from the northwestern Indian Ocean (Pisces, Holocephali, Rhinochimaeridae). *Archiv für Fischereiwissenschaft*, (4): 955-965.
- Douady, C.J., Dosay, M., Shivji, M.S. and Stanhope, M.J. (2003). Molecular Phylogenetic evidence refuting the hypothesis of Batoidea (rays and skates) as derived sharks. Molecular Phylogenetic Evolution, 26: 215-221.
- Dumeril, A.H.A. (1852). Monographie de la famille des torpédiniens, ou poisons plagiostomes électriques, comprenant la description d'un genre nouveau, de 3 espèces nouvelles, et de 2 espèces nommées dans le Musée de Paris, mais non encore décrites. Revue et Magasin de Zoologie (Sér. 2) v. 4: 176-189, 227-244, 270-285.
- Ebert, D.A. (2013) Deep-sea Cartilaginous Fishes of the Indian Ocean. Volume 1. Sharks FAO Species Catalogue for Fishery Purposes. No. 8, Vol. 1. Rome, FAO. 256 pp.
- FAO (2009). Food and Agriculture Organization, FISHSTAT Plus (v. 2.30), Capture Production Database, 1950–2007, and Commodities Trade and Production. Database 1976–2007. FAO, Rome, Italy.
- Fricke, R., Eschmeyer, W. N. & Van der Laan, R. (2023). http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp.
- Grogan, E. D., Lund, R., & Greenfest-Allen, E. (2012). The origin and relationships of early chondrichthyans. Biology of sharks and their relatives, 2, 3-29.
- Gronov (1854) In Gray, J.E. (1854). Catalogue of fish collected and described by Laurence Theodore Gronow, now in the British Museum. London. Catalogue of fish collected and described by Laurence Theodore Gronow: i-vii + 1-196.
- Gupta, T., Karnad, D., Kottillil, S., Kottillil, S., & Gulland, E. M. (2022). Shark and ray research in India has low relevance to their conservation. Ocean & Coastal Management, 217, 106004.
- Hamilton, F. (1822). An account of the fishes found in the river Ganges and its branches. Edinburgh and London. i-vii + 1-405, Pls. 1-39.

- Hanfee, F. (1997). Trade in Sharks and Shark Products in India: A preliminary survey TRAFFIC India, New Delhi. 50pp.

- Hanfee, F. (1997). Trade in Sharks and Shark Products in India: A preliminary survey TRAFFIC India, New Delhi. 50pp.

- Hanfee, F. (1999). Management of shark fisheries in two Indian coastal states: Tamil Nadu and Kerala. In: Shotton, R. (Ed.), Case Studies of the Management of Elasmobranch Fisheries. Part 1. FAO Fisheries Technical Papers–T378/1. FAO, Rome. 316-338.

- Hanfee, F. (1999). Management of shark fisheries in two Indian coastal states: Tamil Nadu and Kerala. In: Shotton, R. (Ed.), Case Studies of the Management of Elasmobranch Fisheries. Part 1. FAO Fisheries Technical Papers–T378/1. FAO, Rome. 316-338.

- Johri, S., Livingston, I., Tiwari, A., Solanki, J., Busch, A., Moreno, I., ... & Dinsdale, E. A. (2021). Reducing Data Deficiencies: Preliminary Elasmobranch Fisheries Surveys in India, Identify Range Extensions and Large Proportions of Female and Juvenile Landings. Frontiers in Marine Science, 8, 619695.
- Last, P.R., White, W.T. and Pogonoski, J.J. (2008 a). (Eds.) Descriptions of New Australian Chondrichthyans. CSIRO Marine and Atmospheric Research 022, 1-368.

- Last, P.R., White, W.T. and Pogonoski, J.J. (2008 a). (Eds.) Descriptions of New Australian Chondrichthyans. CSIRO Marine and Atmospheric Research 022, 1-368.

- Last, P.R., White, W.T., Pogonoski, J. J. and Gledhill, D.C. (2008 b). Descriptions of new Australian skates (Batoidea: Rajoidei). CSIRO Marine and Atmospheric Research Paper No. 021.181 pp.

- Last, P.R., White, W.T., Pogonoski, J. J. and Gledhill, D.C. (2008 b). Descriptions of new Australian skates (Batoidea: Rajoidei). CSIRO Marine and Atmospheric Research Paper No. 021.181 pp.

- Latham, J.F. (1794). An essay on the various species of sawfish. *The Transactions of the Linnean Society of London*, 2 (art. 25): 273-282, Pls. 26-27.
- Lisney, T., Theiss, S., Collin, S., & Hart, N. (2012). Vision in elasmobranchs and their relatives: 21st century advances. Journal of Fish Biology, 80(5), 2024-2054.
- Lloyd, R.E. (1908). On two new species of eagle-rays (Myliobatidae), with notes on the skull of the genus *Ceratoptera*. *Records of the Indian Museum,* 2: 175-180.
- Mathew, G., Devadoss, P., Vivekanandan, E., Ferozkhan, M. and Zacharia, P.U. (1996). Distribution and abundance of elasmobranchs of the Indian EEZ as revealed by FORV Sagar Sampada surveys. In: Proceedings of the Second Workshop on Scientific Results of FORV Sagar Sampada. Pillai, V.K., Abidi, S.A.H., Ravindran, V., Balachandran, K.K., Agadi, V.V. (Eds). pp.285-293. Department of Ocean Development, New Delhi.
- Meyer, W., & Seegers, U. (2012). Basics of skin structure and function in elasmobranchs: a review. Journal of Fish Biology, 80(5), 1940-1967.
- Misra, K.S. (1952). An aid to the identification of the fishes of India, Burma and Ceylon. 1. Elasmabranchii and Holocephali. *Records of the Indian Museum,* 49 (1): 89-137.

- Misra, K.S. and Menon, M.A.S. (1955). On the distribution of the Elasmobranchs and Chimaeras of the Indian region in relation to the mean annual isotherms. *Records of the Indian Museum,* 53: 73-86.
- Mould, B. (1997). Classification of the recent elasmobranchii. A Classification of the Living Sharks and Rays of the World. 178 pp.
- Pillai, P. P., & Parakkal, B. (2000). Pelagic sharks in the Indian seas their exploitation, trade, management and conservation. CMFRI Special Publication, 70, 1-95.
- Puckridge, M., Last, P.R., White, W.T. and Andreakis, N. (2013). Phylogeography of the Indo-West Pacific maskrays (Dasyatidae, *Neotrygon*): a complex example of chondrichthyan radiation in the Cenozoic. *Ecology and Evolution,* 3(2): 217–232.
- Russell, P. (1803). Descriptions and figures of two hundred fishes; collected at Vizagapatam on the coast of Coromandel. W. Bulmer, Shakspeare Press, London, vol. 1, pp. i-vii, 1-78.
- Seidel, R., Blumer, M., Pechriggl, E.-J., Lyons, K., Hall, B. K., Fratzl, P., Weaver, J. C., & Dean, M. N. (2017). Calcified cartilage or bone? Collagens in the tessellated endoskeletons of cartilaginous fish (sharks and rays). Journal of structural biology, 200(1), 54-71.
- Shaw, G. (1803). General zoology or systematic natural history ... Pisces. G. Kearsley, London, 1800-1826. Pisces in vol. 4 (1803) and vol. 5 (1804). General zoology or systematic natural history v. 4: (pt. 1) i-v + 1-186, Pls. 1-25; (pt 2), i-xi + 187-632.
- Shirai, S. and Tachikawa, H. (1993). Taxonomic resolution of the *Etmopterus pusillus* species group (Elasmobranchii, Etmopteridae), with description of *Etmopterus bigelowi,* new species. *Copeia,* 2: 483 - 494.
- Sinha, M.K., Pandian, P.P., Pattanayak, S.K. and Kar, AB. (2010). Spatio-temporal distribution, abundance and biodiversity of oceanic sharks occurring in Andaman and Nicobar waters. In Raghunathan, R.C. and Sivaperuman, C. (eds). Recent Trends in Biodiversity of Andaman and Nicobar Islands. ZSI., 373-385.
- Smith, M.M. and Heemstra, P.C. (Eds.). 1986. Smiths' Sea Fishes. Macmillan South Africa, Johannesburg. xx + 1047 pp.
- Somvanshi, V.S., Varghese, S.P. and Varghese, S. (2009). Distribution, abundance and biology of Pelagic stingray *Pteroplatytrygon violacea* (Bonaparte, 1832) (Myliobatiformes, Dasyatidae) in the Indian EEZ. *Journal of the Bombay Natural History Society,* 106 (1): 57-62.
- Species Catalogue for Fishery Purposes. No. 1, Vol. 2., Rome, FAO. 269 pp.
- 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 I Deel (no. 20): 315-317.
- White, W.T., P.R. Last, J.D. Stevens, G.K. Yearsley, Fahmi and Dharmadi. (2006 b). Economically important sharks and rays of Indonesia. ACIAR. Monograph series; no. 124. 338.

CONFERENCE AND PRESENTATION:

- Participated and delivered an oral presentation THE DIVERSITY OF SKATES AND RAYS FROM SAURASHTRA COAST-THE PENINSULAR REGION OF GUJARAT, INDIA at the National Conference organized by the Department of Biochemistry-Biotechnology, St. Xavier's College (Autonomous), Ahmedabad on 10-11- December - 2021.
- Participated and delivered an oral presentation on Catch composition of Ray fishes (Elasmobranchii, Batoids) from Gujarat Coast, India at the National Conference organized by the Department of Bioscience, Veer Narmad South Gujarat University Surat on 30-31-July-2022.
- Participated in Workshop on Hands-on training program "Capillary sequencing & fragment analysis jointly organized by Gujarat Biotechnology Research Centre and Saurashtra University at Gandhinagar on 21-25, March 2022.

Publications

- Manuscript Accepted on "First record of Mangrove whipray, Urogymnus granulatus (Macleay, 1883) (Elasmobranchii: Dasyatidae) from Gujarat, North-West Coast of India" in the Journal of Experimental Zoology, India.
- Conference proceeding on The Diversity of Skates and Rays from Saurashtra Coast-the Peninsular Region Of Gujarat, India in Proceedings of the 4th National Conference Present Day Biology: Recent Advancements in Biological Sciences ISBN- 978-93-90996-06-3.

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