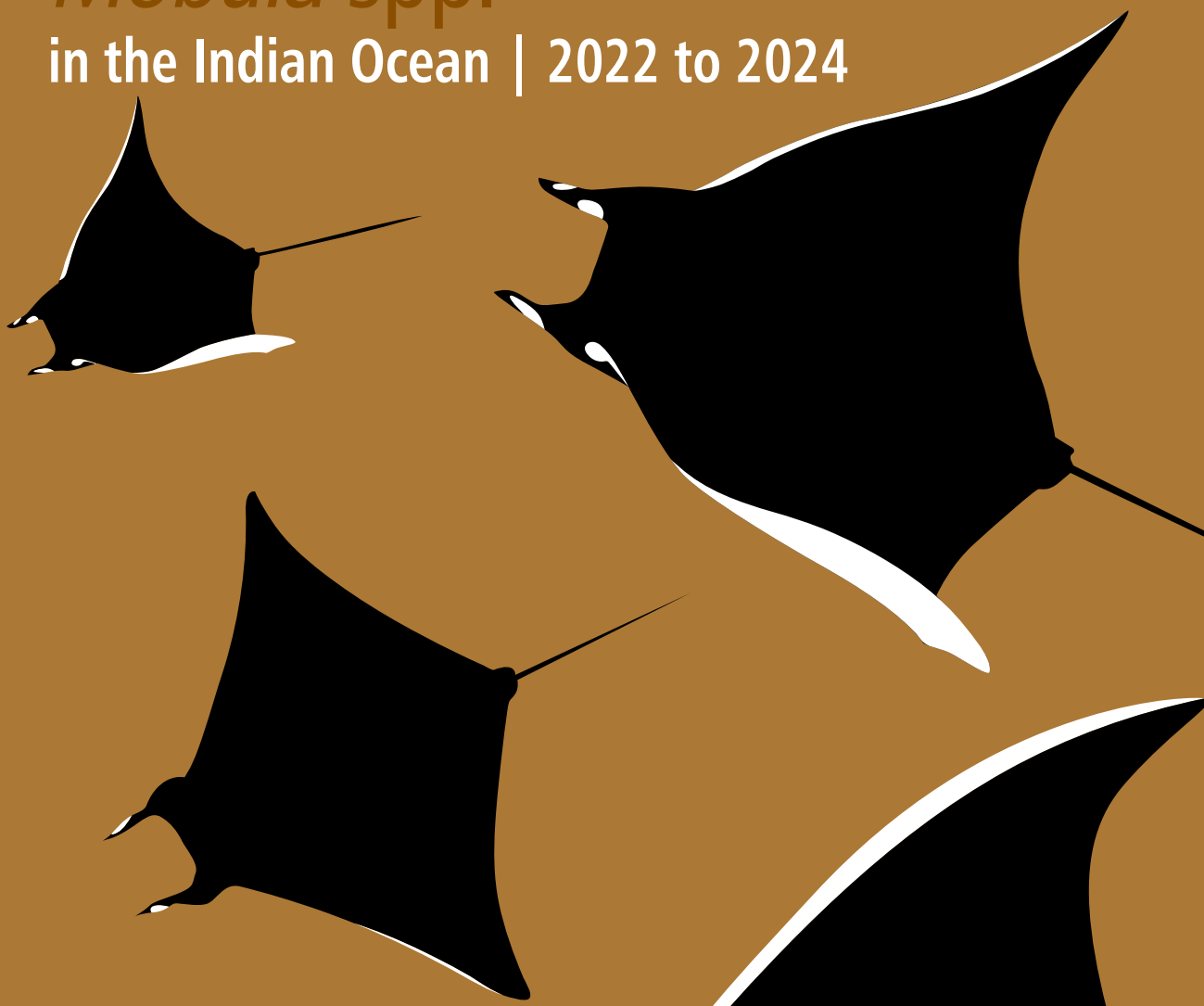
India Non-Detriment Finding for
Devil Rays
Mobula spp.
in the Indian Ocean | 2022 to 2024



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Indian Council of Agricultural Research
Central Marine Fisheries Research Institute

India Non-Detriment Finding for **Devil Rays** *Mobula* spp. in the Indian Ocean | 2022 to 2024

Contributors

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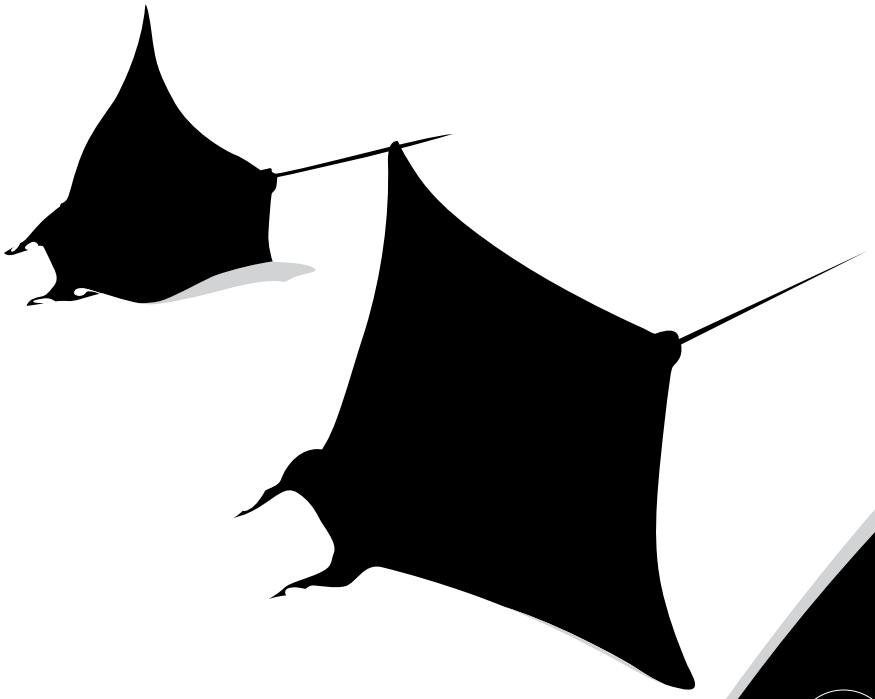

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India Non-Detriment Finding (NDF) for Devil Rays *Mobula* spp. in the Indian Ocean, 2022 to 2024

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Contents

Summary

This document was prepared by a designated Indian CITES Scientific Authority, the ICAR-Central Marine Fisheries Research Institute (CMFRI), and is the result of an online workshop of the Demersal Fisheries Division of the Institute that took place during 2-4 September 2021. The following NDF guideline was used:

Mundy-Taylor, V., Crook, V., Foster, S., Fowler, S., Sant, G., and Rice, J. 2014. *CITES Non-detriment findings guidance for shark species. 2nd Revised Version. A framework to assist Authorities in making Non-detriment Findings (NDFs) for species listed in CITES Appendix II.* Report prepared for the German Federal Agency for Nature Conservation (Bundesamt fur Naturschutz, BfN). Available at https://cites.org/eng/prog/shark/Information_resources_from_Parties_and_other_stakeholders.

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Acknowledgement

We acknowledge with gratitude the advice given by Daniel Fernando, Co-Founder, Blue Resources Trust, Sri Lanka and Rima Jabado, Chair, IUCN Shark Specialist Group and Advisory Committee Member (Asia) - CMS Sharks MoU, in the course of preparing this document.

Outcome

This Mobulid (all mobulid species except *Mobula birostris* and *Mobula alfredi*) NDF for India is "**Positive with Conditions**" to enable trade (of non-fin commodities) to continue, while improvements are made to existing fisheries and trade management and monitoring systems and while additional research activities and management measures are adopted as outlined in section 6.

This NDF will be re-evaluated after 3 years, to gauge progress against the recommendations in Section 6 and updated with newly acquired data, before agreeing to a new NDF for 2025-2029.

Section 1. Preliminary considerations

1.1(a) Is the specimen subject to CITES controls?

(How did you identify the species?)

Species name	Product form	CITES Appendix	Source of identification
MOBULIDS FAO Code: *M. eregoodoo* (Longhorned pygmy devil ray): RME *Mobula kuhlii* (Shortfin devil ray): RMK *Mobula mobular* (Giant devil ray): RMM *Mobula tarapacana* (Chilean devil ray): RMT *Mobula thurstoni* (Smoothtail mobula) : RMO *Mobula japanica* (Spinetail mobula): RMJ	Gill plates (dried gill plates exported to China and other SE Asian countries) Meat (fresh and dried salted for human consumption) - *more data is required to confirm international trade of meat.* Skin (international trade-leather) - *more data is required* Liver oil (mixed with oil from other shark species	Appendix II	Field identification guide of the Prebranchial Appendages (Gill Plates) of Mobulid Rays for Law Enforcement and Trade Monitoring Applications: https://static1.squarespace.com/static/542a662fe4b05344441016db/t/5a8418758165f5c181419bec/1518606501448/2017_MobulidGillPlateGuide.pdf https://www.cms.int/sites/default/files/publication/pew-manta-ray-gill-plate-id-guide.pdf Guide to the Manta and Devil rays of the world: https://static1.squarespace.com/static/5a196500914e6b09132e911f/t/5d491639b398e50001d5e07d/1565076193831/Manta+Trust_Guide+to+the+Manta+%26+Devil+Rays+of+the+World_Data+Collection+Protocols.pdf For whole animal identification: FAO Guides and expert identification by CMFRI Nair, 2017 Kizhakudan *et al.*, 2018 Hall and Roman, 2013; Shahid *et al.*, 2018; Stevens *et al.*, 2018 Utilisation: Pillai, 1998; Raje *et al.* 2007; Mohanraj *et al.*, 2009; Rajapackiam *et al.*, 2007; 2011; Nair *et al.*, 2013; Kizhakudan *et al.* 2015; O'Malley *et al.*, 2016; Shikha R., *pers. obs.*; ICAR-CMFRI, unpublished
In view of the above, is the specimen subject to CITES controls?	YES	GO TO Question 1.1(b)	
	NOT CERTAIN	Describe concerns in more detail below, and GO TO Question 1.1(b)	
	NO	NDF is not required	
Concerns and uncertainties:	There is a low risk that the mobulid species have been incorrectly identified; larger incidence of juveniles in landings (30-60%) along the Indian coast is a matter of concern considering low reproduction potential of the species. Species-specific traceability is lacking in mobulids product trade. Lacking sufficient information on the export of gill plates, meat, oil and skin. Following a fairly recent taxonomic revision, the family Mobulidae now comprises nine nominal species (previously 11) under a single recognised genus (previously 2); *Mobula* (White *et al.*, 2018). Under the current classification, a total of seven species are found in the Indian Ocean; *Mobula birostris* (oceanic manta ray), *Mobula alfredi* (reef manta ray), *Mobula mobular* (spinetail/giant devil ray), *Mobula tarapacana* (sicklefin devil ray), *Mobula thurstoni* (bentfin devilray), *Mobula eregoodoo* (Longhorned pigmy devil ray) and *Mobula kuhlii* (shortfin pygmy devil ray) (Lawson *et al.*, 2017). This includes *M. japanica* (Notarbartolo di Sciara *et al.* 2019) which is now considered a junior synonym of *M. mobular* (White *et al.*, 2018).		

1.1(b) From which stock will the specimen be taken/was the specimen taken? (Can origin and stock be confidently identified?)		
	Description/comments	Sources of information
Ocean basin	Indian Ocean	
Stock location/ distribution/ boundaries	There is some information on distribution of mobulid rays available and population parameters in the Indian EEZ, but stock parameters and stock structure information are not available. Mobulids are pelagic and migratory in nature with circumglobal tropical and subtropical distribution. *Mobula tarapacana*, sicklefin devil ray is distributed in Chilean Atlantic-northeast, Atlantic-southwest, Atlantic-southeast, Atlantic-western central, Atlantic- eastern central, Atlantic-northwest, Indian Ocean-western, Indian Ocean-eastern, Pacific-eastern central, Pacific-southwest, Pacific-western central, Pacific-southeast, Pacific-northwest *Mobula thurstoni*, smoothtail mobula is distributed in Atlantic-southwest, Atlantic-western central, Atlantic-eastern central, Atlantic-southeast, Indian Ocean-western, Indian Ocean-eastern, Pacific-western central, Pacific-southeast, Pacific-southwest, Pacific-northwest, Pacific-eastern central *Mobula mobular*, giant devil ray is circumglobal in tropical and warm temperate seas and distributed in Atlantic-western central, Atlantic-northeast, Atlantic-southwest, Atlantic-eastern central, Pacific-western central, Pacific-southwest, Pacific-southeast, Pacific-northwest, Atlantic-northwest, Pacific-northeast, Pacific-eastern central, Atlantic-southeast, Mediterranean and Black Sea, Indian Ocean-eastern, Indian Ocean-western *Mobula japanica*, spinetail mobula is distriuted in the Indo-Pacific, off South Africa, the Arabian Sea eastward to the Hawaiian Islands and Polynesia. Eastern Pacific: on the continental coast. Eastern Atlantic: Côte d'Ivoire but may probably be more wide-ranging. *Mobula kuhlii*, shortfin devil ray is known to occur only in Indian Ocean and portions of the Indo-Pacific region from South Africa to the Solomon Islands. It is an inshore, shelf species found in continental coastal areas to 50 m deep. The species distribution does not extend into the epipelagic zone. *Mobula eregoodoo*, longhorned pygmy devilray has a patchy distribution in the Indo-West Pacific and hence considered as endemic to this zone. It ranges from South Africa in the west to Port Moresby, Papua New Guinea in the east. It extends from Vietnam in the north to the north eastern coast of New South Wales, Australia in the south. It mostly inhabits the coastal pelagic realm close to reefs, islands and sometimes offshore reefs.	Raje *et al*., 2007; Kizhakudan *et al*., 2015; 2018 IOTC-2020-WPEB16-19 Couturier *et al*., 2012; Fernando, 2018; Flounder, 2020 Marshall *et al*., 2019a Marshall *et al*., 2019b Marshall *et al*., 2020 Marshall *et al*., 2020 Notarbartolo di Sciara, 1987; Last *et al*., 2016; Weigmann, 2016; Lawson *et al*., 2017; Chin *et al*., 2019 Bray, 2021; Marshall *et al*., 2020
Is this a shared stock (i.e., occurring in more than one EEZ and/or the high seas)?	Possibility of straddling stock ranging between India's EEZ, the high seas and likely other Indian Ocean EEZ's, as studies have shown that many species of *Mobula* undertake long distance migration (Jaine *et al*., 2014; Thorrold *et al*., 2014) However, stock studies are needed for the Indian Ocean to confirm the presence of multiple stocks, which may or may not be shared.	Jaine *et al*., 2014; Thorrold *et al*., 2014

If the stock occurs in more than one EEZ, which other Parties share this stock?	The stock of mobulid rays occurs in the EEZ of the other littoral states of the Indian Ocean.	The impact of the IOTC fisheries on mobulid rays: status and interactions, data availability, and recommendations for management (IOTC-2020-WPEB16-18)
If a high seas stock, which other Parties fish this stock?	Not much information on the high seas stock, however it is likely to be shared by other Indian Ocean EEZ's (Pakistan, Sri Lanka, Philippines, Indonesia, India, Myanmar, Bangladesh, Maldives).	The impact of the IOTC fisheries on mobulid rays: status and interactions, data availability, and recommendations for management (IOTC-2020-WPEB16-18) www.iotc.org
Which, if any, RFB(s) cover(s) the range of this stock?	With respect to the Indian Ocean region: * Indian Ocean Tuna Commission (IOTC), * Asia-Pacific Fishery Commission (APFIC), * The Bay of Bengal Programme Inter-Governmental Organisation (BOBP-IGO), * Commission for the Conservation of Southern Bluefin Tuna (CCSBT), * The Regional Organization for the Conservation of the Environment in the Red Sea and Gulf of Aden (PERSGA), * Regional Commission for Fisheries (RECOFI), * South Indian Ocean Fisheries Agreement (SIOFA), and * Southwest Indian Ocean Fisheries Commission (SWIOFC).	 http://iotc.org http://www.apfic.org http://www.bobpigo.org https://www.ccsbt.org/ http://www.persga.org/ http://www.fao.org/fishery/rfb/recofi/en http://www.fao.org/fishery/rfb/siofa/en http://www.fao.org/fishery/rfb/swiofc/en
Are all Parties listed above (which fish or share the stock concerned) Members of the relevant RFB(s)?	Yes. They are Members or Cooperating Non-Contracting Parties of IOTC. Most are CITES Parties and/or CMS, and some are also Signatories of the CMS Sharks MoU.	https://cites.org/eng/disc/parties/chronolo.php (http://www.cms.int/sharks/en/signatories-range-states)

Are there geographical management gaps?	Regional management: Mobulid rays have long been highlighted as species in need of better management. Since the mid-2000s, their catch has increased dramatically, and regional fisheries management organizations (RFMOs) have limited management to put in place to ensure a sustainable fishery. International management: Despite being listed on the Convention on the Conservation of Migratory Species of Wild Animals (CMS) a decade ago and heavily caught in RFMOs, there has been limited management progress for these species. The international scientific community strongly underlines the vulnerability of the family Mobulidae, which now comprises of a single genus; *Mobula*, consisting of 9 extant species (Hosegood *et al.*, 2018) that are commonly referred to as manta and mobula rays (collectively as mobulid rays). Mobulids are globally threatened as they have experienced high levels of bycatch and directed exploitation throughout their range, and are currently at risk of extinction. These species are captured as a bycatch by tuna fisheries operating in the Indian Ocean, and are retained and landed due to their highly valued gill plates. There is data deficiency for mobulids, however information available from various sources including Pakistan, Sri Lanka, India, Indonesia, and the Philippines, among other fisheries, provide evidence on the steep declines of mobulid populations in the Indian Ocean, which calls for immediate action for the conservation and management of all *Mobula* species. The increasing level of shark and ray catches in the Indian Ocean will have an irreversible negative impact on the stock of the above-mentioned species, justifying a precautionary approach in their management.	FAO Global capture production 2021 18th Conference of the Parties (CoP18) of the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES) IOTC-2019-S23-PropO[E] https://www.iotc.org› files › documents › 2019/05
	All *Mobula* spp. are listed in Appendix I and II of CMS. In addition, all species in the genera *Mobula* and *Manta* are now included in CITES Appendix II, thereby requiring that all international trade in their parts and products be both legal and sustainable. Cooperation through IOTC will greatly enhance the ability of IOTC member states to implement their CITES and CMS obligations. National measures in the Indian Ocean: The management measures currently in place for Indian Ocean vary across countries and not implemented uniformly. Management measures in India are restricted to coastal waters. Despite the conservation concern there are no current regional management plans in place to ensure the future of mobulid populations. At the 22nd session of the Indian Ocean Tuna Commission Proposal titled, 'On the conservation of mobula and manta rays caught in association with fisheries in the IOTC area of competence' was deferred (IOTC-2018-S21-PropL) on the basis that there was no specific research indicating an association of mobulids with surface fisheries, and requested the Scientific Committee of the IOTC to review the status of manta and mobula rays and their interactions with IOTC fisheries and report this to the Commission in 2020.	IOTC-2018-WPEB14-29_Rev1
How reliable is the information on origin?	High	
Is information on origin sufficiently detailed for Question 1.2 to be answered? (Apply this answer at end of Question 1.2)		YES

1.2 Was (will) the specimen (be) legally obtained and is export allowed?		
Is the species:	Description/comments	Sources of information
Protected under wildlife legislation, a regional biodiversity agreement, or (for a CMS Party) listed in CMS Appendix I?	Not protected under India's legislation or a regional agreement. Mobulid rays are listed on CMS Appendix II; India has been a CMS Party since 1983.	http://www.cms.int/en/page/appendix-i-ii-cms http://www.cms.int/en/parties-range-states
Sourced from illegal fishing activities (e.g., in contravention of finning regulations, or where a TAC is zero or exceeded)?	No.	
Taken from a no-take marine protected area or during a closed season?	No.	
Taken in contravention of RFB recommendations, if any?	Not in the Indian Ocean/IOTC.	https://www.iotc.org › files › documents › 2019/05
Listed as a species whose export is prohibited?	No.	
Of concern for any other reason?	No.	
In view of the above and the final section of the Worksheet for Question 1.1(b), was the specimen legally acquired and can exports be permitted?	YES.	GO TO Question 1.3
Concerns and uncertainties:	Species-specific information to be strengthened	

1.3 What does the available management information tell us?		
Part 1. Global-level information		
	Description/comments	Sources of information
Reported global catch	The production of mobulids is not reported species-wise globally except in Asia and Africa for *M. japanica*, America and Africa for *M. birostris* and Europe for *M. mobular*. The catch in Oceania was not reported exclusively for mobulids. The average global capture fisheries production of mobulids during 2000-2019 was 3756 t with a minimum of 100t in 2003 and maximum of 8488 t in 2019. The average catch of *M. japanica* during 2000-2019 was 95 t with a minimum of 50 t in 2009 and maximum of 642 t in 2018.	FAO, 2021
	The global reported catch of *Mobula* spp. (manta and devil rays) since 2000 have shown more or less increasing trend with intermittent decline in few years. The landings since 2016 have been much greater than in the previous years, which may be indicative of increasing trade associated with these species. This could possibly be due to better reporting or market-driven retention of these otherwise bycatches of drift gillnetters targeting large pelagic fishes like tuna, sword fishes etc.	Ward-Paige *et al*., 2013 Fernando and Stevens, 2011; Shahid *et al*., 2018; Moazzam, 2018.

	Mobulids have been reported as bycatch in 30 small- and large-scale fisheries globally. Mobulids are also reported as bycatch in 21 small-scale fisheries in 15 countries using driftnets, gillnets, traps, trawls, and longlines. Of particular concern is a small-scale driftnet fishery for skipjack tuna (*Katsuwonus pelamis*) off Indonesia with bycatch of *M. japanica, M. tarapacana, M. birostris, M. thurstoni* and *M. kuhlii.* A partial survey of landing sites led to an estimated bycatch of 1,600 individuals per year.	Croll *et al.*, 2016 White *et al.*, 2006a
Species distribution	Mobulid rays are distributed worldwide in the tropical and temperate waters of the Pacific, Atlantic and Indian Oceans.	Clark *et al.*, 2006; White *et al.*, 2006a; Couturier *et al.*, 2012; Bustamante *et al.*, 2012 Marshall *et al.*, 2019a
	Mobula tarapacana is distributed in Chilean Atlantic-northeast, Atlantic-southwest, Atlantic-southeast, Atlantic-western central, Atlantic- eastern central, Atlantic-northwest, Indian Ocean-western, Indian Ocean-eastern, Pacific-eastern central, Pacific-southwest, Pacific-western central, Pacific-southeast, Pacific-northwest	Marshall *et al.*, 2019a
	Mobula thurstoni is distributed in Atlantic-southwest, Atlantic-western central, Atlantic-eastern central, Atlantic-southeast, Indian Ocean-western, Indian Ocean-eastern, Pacific-western central, Pacific-southeast, Pacific southwest, Pacific- northwest, Pacific-eastern central	Marshall *et al.*, 2019b
	Mobula mobular is distributed in Atlantic-western central, Atlantic-northeast, Atlantic-southwest, Atlantic-eastern central, Pacific-western central, Pacific-southwest, Pacific-southeast, Pacific-northwest, Atlantic-northwest, Pacific-northeast, Pacific-eastern central, Atlantic-southeast, Mediterranean and Black Sea, Indian Ocean-eastern, Indian Ocean-western	Marshall *et al.*, 2020
	Mobula japanica is distributed in Indo-Pacific, off South Africa, the Arabian Sea eastward to the Hawaiian Islands and Polynesia; Eastern Pacific- on the continental coast, and Eastern Atlantic. Côte d'Ivoire but may probably be more wide-ranging.	Notarbartolo di Sciara, 1987; Last *et al.*, 2016; Weigmann, 2016; Lawson *et al.*, 2017; Chin *et al.*, 2019
	Mobula kuhlii is known to occur only in Indian Ocean and portions of the Indo-Pacific region from South Africa to the Solomon Islands. It is an inshore, mainly shelf species found in continental coastal areas to 50 m deep. The species distribution does not extend into the epipelagic zone.	Raje *et al.*, 2007
	Mobulid rays are reported from western Indian Ocean (eastern Arabian Sea) and eastern Indian Ocean (western Bay of Bengal) including the seas around Andaman and Nicobar Islands. The landings are recorded from east and west coasts of India.	Kizhakudan *et al.*, 2018
	In India, five species of devil rays (excluding the two manta rays) are recorded from the fishery viz. *Mobula kuhlii, Mobula mobular, Mobula tarapacana*, *Mobula eregoodoo* and *Mobula thurstoni.*	Akhilesh *et al.*, 2014; Kizhakudan *et al.*, 2015

Known stocks/ populations	Information on the population dynamics and stock structure in Indian Ocean are limited. Some information on the stock parameters of *Mobula thurstoni* and *M. japanica* is available. Life history parameters seem to vary geographically. Mobulids form 8% of the total elasmobranch landings in India. There is no targeted fishery of these species and they occasionally form a bycatch in the hook and line, gillnet and trawl fisheries.	Notarbartolo-di-Sciara, 1987; Stewart, 2002; White *et al.*, 2006a; Fernando and Stevens, 2011; Cuevas-Zimbron *et al.*, 2012; Sivadas *et al.*, 2013; Jabado and Ebert, 2015; Nair *et al.*, 2015; Pardo *et al.*, 2016; Rohner *et al.*, 2017; Shirke *et al.*, 2017; Rambahiniarison *et al.*, 2018; Marshall *et al.*, 2019a; Rigby *et al.*, 2020b; Sureandiran *et al.*, 2020 NMFDC, ICAR-CMFRI
Main catching countries	In recent years, mobulid ray fishing has expanded in many places throughout their range, primarily in response to the emerging international market for their gill plates. Mobulid catches are reported from Africa, America, Asia and Europe countries. Gill plates find a market in Chinese traditional medicine and Asian dried seafood markets and the major source of the raw materials are China, Indonesia, Vietnam, Sri Lanka and India.	FAO, 2021; White *et al.*, 2006b; Couturier *et al.*, 2009; O'Malley *et al.*, 2016
	FAO reported the mobulids exploitation to some extent based on limited landings data. Lack and Sant (2009) noted an increase in total landings of mobulids from 2000-2007, with an average of 1,593 t/yr. Global mobulids landings have since continued to increase to 8,488 t in 2019. In the Indian Ocean annual landings increased to 2,700 t in 2012, and subsequently decreased to 1,360 t in 2018.	Shahid *et al.*, 2018; Lack and Sant, 2009; FAO, 2020, 2021
	The species' preference for coastal waters places them within the range of coastal fisheries, which are known to be intensive in many parts of their range, including Pakistan, India, Sri Lanka, and elsewhere.	de Young, 200; Flewelling and Hosch, 2006
Main gear types by which the species is taken	Mobulid rays mostly occupy the surface water column of the ocean and hence encounter gears like surface set gillnets, purse seines and longlines set to catch large pelagic fishes like tunas, sword fishes etc. They are also caught in harpoons and traps. Among all the gears, gillnets were reported as the major gear catching mobulids in the tropical Indo-pacific.	White *et al.*, 2006a; Mohanraj *et al.*, 2009; Fernanado and Stevens, 2011; Moazzam *et al.*, 2018; Rambahiniarison *et al.*, 2018; Haque *et al.*, 2020
	Their tendency to aggregate makes mobulid rays particularly susceptible to bycatch in purse seine fisheries and longline fisheries, targeted capture in artisanal fisheries, and incidental entanglement	Croll *et al.*, 2016; Duffy and Griffiths, 2017
	Along Indian coast, they are landed as bycatch in the hook and line, gillnet and trawl fisheries.	NMFDC, ICAR-CMFRI (*unpublished data*).
Global conservation status	Current IUCN Status:	
	Mobula eregoodoo: Endangered (January, 2020)	Rigby *et al.*, 2020
	Mobula japanica: Endangered (November 2018)	Marshall *et al.*, 2020
	Mobula kuhlii: Endangered (January 2020)	Rigby *et al.*, 2020
	Mobula mobular: Endangered (November 2018)	Marshall *et al.*, 2020
	Mobula tarapacana: Endangered (November 2018)	Marshall *et al.*, 2019a
	Mobula thrustoni: Endangered (November 2018)	Marshall *et al.*, 2019b
Multilateral Environmental Agreements	Mobulid rays are listed in the Convention on the Migratory species (CMS) Appendix I and II, Annex 1 of the Memorandum of Understanding on the Conservation of Migratory Sharks (Sharks MOU), Inter-American Tropical Tuna Commission (IATTC) and Appendix II of the Convention on International Trade in Endangered species (CITES).	Convention on Migratory Species. UNEP/CMS/Concerted Action 12.6 https://www.cms.int/sites/default/files/document/cms_cop13_doc.28.1.6_ca-report-mobulid_e.pdf

Part 2. Stock/context-specific information		
	Description/comments	Sources of information
Stock assessments	Limited quantitative stock assessment or fishery indicators of status are currently available for Mobulids in the Indian Ocean; therefore, the stock status is highly uncertain. Most countries are not systematically reporting mobulids in fisheries data and in many cases only estimates are available based on limited catch reporting. It is highly likely that the global database reflects only a fraction of the known fishing related mortality for mobulids (Ward-Paige *et al.*, 2013). Mobulids are usually not identified to the species level in bycatch reports but aggregate data indicate that bycatch mortality maybe large (Hall and Roman, 2013). This is of particular concern given the lack of information on mobulid stocks captured in these fisheries. *Mobula japanica, M. tarapacana, M. thurstoni, M. mobular,* and probably *M. eregoodoo* and *M. kuhlii* have been reported as bycatch in purse seines the in Indian ocean	Francis and Finucci, 2019 Hall and Roman, 2013 Ward-Paige *et al.*, 2013
Main management bodies	National fisheries management agencies (in India: Ministry of Fisheries, Animal Husbandry & Dairying, Ministry of Agriculture and Farmers welfare, Ministry of Environment, Forest and Climate Change) the State Departments of Fisheries. IOTC: Working Party on Ecosystems and Bycatch; Scientific Committee; Commission. CITES, CMS, CBD, and FAO-IPOA.	
Cooperative management arrangements	In addition to arrangements and support to scientific bodies and expert groups for the implementation of the Common Fisheries Policy (ICES- International Council for Exploration of the Sea, STECF Scientific Technical and Economic Committee for Fisheries, JRC-Joint Research Centre etc.), the European Union supports through voluntary contributions scientific research for sharks and mitigation of bycatch in the RFMOs to which it is Party (e.g., IOTC, WCPFC, IATTC, ICCAT). The Areas Beyond National Jurisdiction Program (ABNJ) aims to improve cooperation between tuna RFMOs. The IOTC and WCPFC are trialling a Bycatch Data Exchange Protocol Template (BDEP) that aims to provide a framework for consistent management of bycatch data within RFMOs. A 2016 IOTC report recommends that this BDEP continue in 2017 for the Indian Ocean (IOTC-2016-WPDCS12-28 Rev_1).	http://www.commonoceans.org/home/en/ UNCLOS Annex 1 Highly Migratory species www.un.org/unlcos/annex1 http://www.commonoceans.org/tuna-biodiversity/en/ IOTC-2016-WPDCS12-28 Rev_1. http://www.iotc.org/documents/bycatch-data-exchange-protocol-indian-ocean
Non-membership of RFBs	All of the main catching countries (India, Sri Lanka, Taiwan, China, Indonesia, Iran) are members of IOTC.	MRAG, 2012; Murua *et al.*, 2012; http://www.iotc.org
Nature of harvest	Worldwide mobulid rays are encountered in gears like surface gillnets, purse seines and longlines set to catch large pelagic fishes like tunas, sword fishes etc. Due to their tendency to aggregate in the surface water column of the Ocean, they are susceptible to bycatch in purse seine fisheries and longline fisheries. They are also targeted in artisanal fisheries and caught by harpoons and traps. In India, there is no targeted fishery of these species and they occasionally form a bycatch in the hook and line, gillnet and trawl fisheries.	White *et al.*, 2006a; Mohanraj *et al.*, 2009; Fernanado and Stevens, 2011; Croll *et al.* 2016; Duffy and Griffiths, 2017; Moazzam *et al.*, 2018; Rambahiniarison *et al.*, 2018; Haque *et al.*, 2020 NMFDC, ICAR-CMFRI

Fishery types	Elsewhere in the world they are mostly bycatch of other fleets viz., tuna longline, gillnet fisheries and purse seines. In India, the majority of mobulids are caught in trawl, gillnet and hook & line fisheries as bycatch.	White *et al*., 2006a; Fernanado and Stevens, 2011; Croll *et al.* 2016, Duffy and Griffiths, 2017; Rambahiniarison *et al*., 2018 NMFDC, ICAR-CMFRI
Management units	In the Indian Ocean, the main body responsible is IOTC. India manages the mobulid ray stock through state and national authorities. Marine Fisheries Regulation Acts (MFRA) of States and National Marine Fisheries Policy. State Fisheries Departments (SFDs), Ministry of Fisheries, Animal Husbandry & Dairying (MFAH&D), Ministry of Agriculture & Farmers Welfare (MoA&FW), Ministry of Environment, Forests and Climate Change (MoEF&CC).	http://www.iotc.org https://www.ccsbt.org https://cof.gujarat.gov.in/contact-us.htm https://fisheries.maharashtra.gov.in/ http://fisheries.goa.gov.in/ http://www.karnataka.gov.in/fisheries/Pages/Home.aspx http://www.fisheries.kerala.gov.in/ http://www.fisheries.tn.gov.in/ https://www.py.gov.in/knowpuducherry/dept_fisheries.html http://apfisheries.gov.in/ http://www.odishafisheries.com/ http://www.wbfisheries.gov.in/wbfisheries/do/Forwordlink?val=32 http://agricoop.nic.in/# http://www.moef.nic.in/ http://dahd.nic.in/about-us/divisions/fisheries
Products in trade	Mobulids unlike other elasmobranchs do not attract consumers for their meat or fins but they are targeted for their prized gill plates which find market in Chinese traditional medicine and Asian dried seafood markets. China, Hong Kong and Singapore are the major markets for the dried gill plates. The dried gill plates are sold under the trade name of "Pengyusai". Dried skin is fried to make a product named "Kerupuk" similar to prawn crackers in Indonesia. The liver, other entrails, and other parts were used in extraction of liver oil and in tanneries for local utilization. Meat (fresh & dried) is utilised domestically for human consumption in India. Extent of international meat trade (if any) is currently unknown. Along Gujarat coast, oil is extracted from the meat and other entrails.	White *et al*., 2006b; Couturier *et al*., 2009; Heinrichs *et al*., 2011; O'Malley *et al*., 2016; Haque *et al*., 2020 White *et al*., 2006b; Haque *et al*., 2020 NMFDC, ICAR-CMFRI Rajapackiam *et al*., 2007; Mohanraj *et al*., 2009; Rajapackiam *et al*., 2011; Nair *et al*., 2013; Shikha R., *pers. obs.*

<table>
<tr><th colspan="3">Part 3. Data and data sharing</th></tr>
<tr><td></td><td>Description/comments</td><td>Sources of information</td></tr>
<tr><td>Reported national catch(es)</td><td>
<table>
<tr><th>Year</th><th>Catch (t)</th><th>Year</th><th>Catch (t)</th></tr>
<tr><td>2007</td><td>1,323</td><td>2014</td><td>4217</td></tr>
<tr><td>2008</td><td>2,243</td><td>2015</td><td>4066</td></tr>
<tr><td>2009</td><td>3,358</td><td>2016</td><td>5875</td></tr>
<tr><td>2010</td><td>2,428</td><td>2017</td><td>3441</td></tr>
<tr><td>2011</td><td>3,605</td><td>2018</td><td>5480</td></tr>
<tr><td>2012</td><td>2,996</td><td>2019</td><td>4821</td></tr>
<tr><td>2013</td><td>4,600</td><td>2020</td><td>1878</td></tr>
</table>
</td><td>NMFDC, ICAR-CMFRI, unpublished data</td></tr>
<tr><td>Are catch and/or trade data available from other States fishing this stock?</td><td>Trade data are reported to the FAO and IOTC by some Indian Ocean countries, including Sri Lanka, and other States fishing in the Indian Ocean.</td><td>FAO, 2021 (FAO FishStat)</td></tr>
<tr><td>Reported catches by other States</td><td>Following data, managed by IOTC Secretariat are accessible: Nominal catches, catch and effort, size frequency data from Indian Ocean from Pakistan, Sri Lanka, Philippines, Indonesia, India</td><td>http://www.iotc.org/data/datasetshttp://www.iotc.org/documents/bycatch-datasets-available-0 (2016)
IOTC-2018-WPEB14-29_Rev1</td></tr>
<tr><td>Catch trends and values</td><td>FAO reported the mobulids exploitation to some extent based on limited landings data. Lack and Sant (2009)noted an increase in total landings of mobulids from 2000-2007, with an average of 1,593 t/yr. Global mobulid landings have since continued to increase to 8,488 t in 2019. In the Indian Ocean annual landings have increased to 2,700 tonnes in 2012, and have subsequently decreased to 1,360 tonnes in 2018.</td><td>Lack and Sant, 2009</td></tr>
<tr><td>Have RFBs and/or other States fishing this stock been consulted during or contributed data during this process?</td><td>No, this NDF will be made public in order to enable other range states to make informed decisions for the management of the stock as a whole for the Indian Ocean.</td><td></td></tr>
</table>

Section 2. Intrinsic biological and conservation concerns

2.1 What is the level of intrinsic biological vulnerability of the species?

Intrinsic biological factors	Level of vulnerability	Indicator/metric
Median age at maturity	Low	
	Medium	The reported age at maturity for *M. tarapacana,* and *M. mobular* is in the range of 5-6 years (Cuevas-Zimbron *et al*., 2013; Pardo *et al*., 2016; Stevens *et al*., 2018; Marshall *et al*., 2019a; Marshall *et al*., 2020). The estimated age at maturity for *M. thurstoni* is between 4.5 and 12.7 years and for *M. japanica,* between 7.9 and 9.1 years (Rambahiniarison *et al*., 2018).
	High	
	Unknown	
Median size at maturity	Low	
	Medium	*M thurstoni* females attain maturity in the size range of 150-163 cm DW and the males attain the same at 150-158 cm DW (Marshall *et al*., 2019b). *M. kuhlii* female is reported to mature at the size of 116 cm DW (Rigby *et al*., 2020b); a size at maturity of 115-119 cm DW was reported by White *et al*. 2006a. For *M. eregoodoo,* size at maturity is reported to be 92.5 for female and 99 cm for male (Broadhurst *et al*., 2018).
	High	The females of *M. tarapacana* are known to mature in the size range of 270-280 cm DW as reported from Arabian Sea, whereas males are known to attain maturity in the size range of 240-250 cm (Jabado and Ebert, 2015). Marginally lower size at maturity of 264.8 cm for female and 252.1cm for male has been reported from Philippines (Rambahiniarison *et al*., 2018). The females of *M. mobular* attain maturity at the size of 207 cm DW (Stevens *et al*., 2018), 215-240 cm DW (Marshall *et al*., 2020) whereas the male attains sexual maturity at the size of 210 cm (Stevens *et al*., 2018), 200-220 cm DW (Marshall *et al*., 2020). From Sri Lankan waters the male of *M. mobular* is known to attain maturity at 200 cm DW. *M. japanica* females are known to mature in the size range of 200-220 cm DW (Swatipriyanka, S.,*pers. obs*., West Bengal; Sujitha T. and Purushottama G. B., *pers obs*., Karnataka; Rambahiniarison *et al*., 2018). Males attain maturity at size of 199 to 215 cm DW (Purushottama G. B. and Sujitha T., *pers obs*., Karnataka); Notarbartolo-di-Sciara, 1987; Rambahiniarison *et al*., 2018).
	Unknown	
Maximum age/ longevity in an unfished population	Low	
	Medium	The maximum age for *M. tarapacana*, *M. thurstoni,* and *M. mobular* is between 15-20 years (Stevens *et al*., 2018, Cuevas-Zimbron *et al*., 2013; Pardo *et al*., 2016; Marshall *et al*., 2019a; Marshall *et al*., 2020). The longevity of *M. japanica* is estimated between 14 to 20 years (Cuevas-Zimbron *et al*., 2013; Rambahiniarison *et al*., 2018).
	High	
	Unknown	

Maximum size	Low	
	Medium	The maximum reported size for *M. thurstoni* is 220 cm for an unsexed specimen from Arabian sea (Jabado and Ebert, 2015). The females and male of maximum known size is 197 cm and 182 cm DW, respectively were from Philippines (Rambahiniarison *et al.*, 2018). From Indian waters a female of 176 cm and male of 168 cm DW was recorded at Mandapam, Tamil Nadu (Remya, L., *pers. obs.*). The maximum reported size for female and male *M. kuhlii* were 135 cm DW (Rigby *et al.*, 2020b) and 119.7 cm DW (White *et al.*, 2006a). Maximum size reported for *M. eregoodoo* is 130 cm for female (Broadhurst *et al.*, 2018) and 95.6 for males (Notarbartolo di Sciara *et al.*, 2017).
	High	The maximum reported sized for an unsexed specimen of *M. tarapacana* is as high as 370 cm DW (Compagno and Last, 1999; Marshall *et al.*, 2019a). The largest known female and male were of size 322 cm DW from India (Nair *et al.*, 2015) and 317 cm DW from Philippines (Rambahiniarison *et al.*, 2018), respectively. A single male individual of 314 cm DW has also been reported from Sri Lankan waters (Fernando and Stevens, 2011). The largest known *M. mobular* is of 350 cm DW (unsexed, Notarbartolo di Sciara *et al.*, 2020a). The largest known female and male were of size 340 cm DW (Notarbartolo di Sciara and Serena, 1988) and 306 cm DW (Abudaya *et al.*, 2018). The maximum reported size for female and male *M. kuhlii* were 471 cm DW (Swatipriyanka S., *pers. obs.* West Bengal) and 310 cm DW (Nair *et al.*, 2015) from India.
	Unknown	
Natural mortality rate (M)	Low	
	Medium	
	High	0.087 yr^{-1} estimated for *M. japanica* (Pardo *et al.*, 2016), the same value (0.087 yr^{-1}) is adopted for *M. thurstoni* for Philippines waters (Rambahiniarison *et al.*, 2018).
	Unknown	
Maximum annual pup production (per mature female)	Low	
	Medium	
	High	The litter size for *M. tarapacana, M. japanica* and *M. Kuhlii* is one (Notarbartolo di Sciara, 1987; Nair *et al.*, 2015; Rigby *et al.*, 2020b; Swatipriyanka S., *pers. obs.*, Sujitha T. and Purushottama G. B., *pers. obs.*). In the case of *M. thurstoni*, the number of pups per female is mostly one (Notarbartolo di Sciara, 1987; Remya L., *pers. obs.*) and occasionally two (Doumbouya, 2011; Rambahiniarison *et al.*, 2018). In the case of *M. mobular* also it is most often one (Notarbartolo di Sciara and Serena, 1988; Serrano-Lopez *et al.*, 2021) and rarely two (Marshall *et al.*, 2020). In *M. eregoodoo,* the number of pups per female is one (Broadhurst *et al.*, 2018).
	Unknown	
Intrinsic rate of population increase (r)	Low	
	Medium	
	High	rmax = 0.077 yr^{-1} (*M. japanica*, Pardo *et al.*, 2016) rmat (= rmax) = 0.016-0.023 yr^{-1} (*M. japanica*, Rambahiniarison *et al.*, 2018)
	Unknown	

Geographic distribution of stock	Low	*M. tarapacana*: Patchy circumglobal distribution in tropical, subtropical, and temperate waters (Couturier *et al.*, 2012, Marshall *et al.*, 2019a) *M. thurstoni*: Circumglobal distribution and is found in tropical, subtropical, and temperate waters (Couturier *et al.* 2012, Lawson *et al.* 2017). *M. mobular/ M. japanica*: Patchy circumglobal in temperate and tropical waters throughout all oceans (Lawson *et al.*, 2017; Marshall *et al.*, 2020). *M. kuhlii*: Patchy distribution in Indo-West Pacific distribution from South Africa to the Solomon Islands (Lawson *et al.*, 2017, Rigby *et al.*, 2020b) *M. eregoodoo*: Patchy distribution in the Indo-west Pacific from South Africa to Australia and most likely more wide-ranging then current confirmed records (Notarbartolo di Sciara *et al.*, 2020).
	Medium	
	High	
	Unknown	
Current stock size relative to historic abundance	Low	
	Medium	
	High	Mobulid population in general is suspected to have 50-79% decline globally in last three generation length (GL) (Marshall *et al.*, 2019). *M. tarapacana*: From Indonesian waters the recorded catch registered decline of 77-99% at major landing sites during 2001-05 to 2014 (Lewis *et al.*, 2015). In Arabian Sea region population decline of 75% in last three GL (Jabado *et al.*, 2017). *M. japanica/ M. mobular*: From Indonesian waters the recorded catch registered decline of 50-96% at major landing sites during 2001-05 to 2014 (Lewis *et al.*, 2015). In Arabian Sea region population decline of 30-50% in last three GL (Jabado *et al.*, 2017). *M. thurstoni*: From Indonesian waters the recorded catch registered decline of 75-100% at major landing sites during 2001-05 to 2014 (Lewis *et al.*, 2015). In the Arabian Sea region population decline of 30-50% in last three GL (Jabado *et al.*, 2017). *M. kuhlii:* From Indonesian waters the recorded catch registered decline of 93-100% at major landing sites during 2001-05 to 2014 (Lewis *et al.*, 2015). In the Arabian Sea region population decline of 200-30% in last three GL (Jabado *et al.*, 2017). *M. eregoodoo*: At locations where the species is reported a declining trend in catch is observed (Khan. 2018, Notobartolo di Sciara *et al.*, 2020, Lewis *et al.*, 2015).
	Unknown	
Behavioural factors	Low	
	Medium	
	High	Easy target owing to their slow swimming speed and aggregative behaviour. They also have predictable habitat use and lack behavioural avoidance to human proximity (Jabado *et al.*, 2017).
	Unknown	

Trophic level	Low		
	Medium	*M. eregoodoo*: 3.4 (Froese and Pauly, 2021) *M. japanica*: 3.43 (Sampson *et al.*, 2010) *M. kuhlii*: 3.40 (Froese and Pauly, 2021) *M. mobular*: 3.7 (Froese and Pauly, 2021) *M. tarapacana:* 3.8 (Froese and Pauly, 2021) *M. thurstoni*: 3.48 (Sampson *et al.*, 2010)	
	High		
	Unknown		

SUMMARY for Question 2.1 Intrinsic biological vulnerability of species			
High	Medium	Low	Unknown

Please refer to Appendix-I for further detail on the life history by region for devil rays

These highly specialized group of fishes are pelagic and migratory in nature with circumglobal tropical and subtropical distribution (Couturier *et al.*, 2012; Fernando, 2018; Flounder, 2020).

Though, estimates of age at maturity for individual species are not certain, it is believed to be in the range of 4.5 to 12.7 years (Stevens *et al.*, 2018; Rambahiniarison *et al.*, 2018; Marshall *et al.*, 2019a, Marshall *et al.*, 2019b, Marshall *et al.*, 2020). The late maturity coupled with pup size of 1 (occasionally 2 in some species) lead to very low reproductive potential for the devil rays (Notarbartolo di Sciara, 1987; Doumbouya, 2011; Nair *et al.*, 2015; Rambahiniarison *et al.*, 2018; Serrano-Lopez *et al.*, 2021).

Devil rays are long-lived species (15-20 years) with large and broad body size with maximum recorded size of 370 cm DW for *M. tarapacana* (Compagno and Last, 1999; Stevens *et al.*, 2018; Marshall *et al.*, 2019a).

Devil rays have been a major bycatch species the trawl, large mesh gillnets and long lines mostly targeting large pelagic species. The large and broad body size make them highly vulnerable to these gears (Mohanraj *et al.*, 2009; Fernanado and Stevens, 2011; Moazzam *et al.*, 2018; Haque *et al.*, 2020; ICAR-CMFRI unpublished)

Most of the mobulid species have high value gill plates used mainly in Asian medicine (Croll *et al.*, 2015, Lawson *et al.*, 2017). This demand for dried gill plates have led to increased harvest of these large bodied fishes as indicative in global catches since 2006 (Ward-Paige *et al.*, 2013).

2.2 What is the severity and geographic extent of the conservation concern?

Conservation concern factors	Level of severity / scope of concern	Indicator/metric
Conservation or stock assessment status	Low	
	Medium	
	High	Regional Conservation status (Arabian Sea Region) (Jabado *et al.*, 2017) Endangered: *M. tarapacana, M. thurstoni, M. mobular* Near Threatened: *M. kuhlii*
	Unknown	

Comments: The global IUCN redlist assessment put all the five species *M. tarapacana, M. thurstoni, M. mobular*, *M. japanica* (assessed as *M. mobular*) and *M. kuhlii* as Endangered (Marshall *et al.*, 2019a; Marshall *et al.*, 2019b; Marshall *et al.*, 2020; Rigby *et al.*, 2020). The regional status done for Arabian Seas Region assessed *M. tarapacana, M. thurstoni,* and *M. mobular* as Endangered whereas *M. kuhlii* was assessed as Near Threatened (Jabado *et al.*, 2017).

Population trend	Low	
	Medium	
	High	Declining trends in population
	Unknown	

Comments:

The global population of Mobulids is known to decline by 50-79% over the last three generation length (Marshall *et al.*, 2019a). Even from Indonesian waters severe reduction in landings (75-100%) were observed for *M. tarapacana*, *M. thurstoni* and *M. japanica* at major landings sites (Lewis *et al.*, 2015). In Indian context, mobulids accounted for 0.55 to 13.01% of total elasmobranch landings but since 2016, there is a general declining trend in catch of mobulids. The population of mobulids is known to decline by atleast 20-30% in last three GL in case of *M. kuhlii* and up to 75% in last three GL for *M. tarapacana* in Arabian Seas Region (Jabado *et al.*, 2017).

Geographic extent/ scope of conservation concern	None	
	Low	
	Medium	
	High	Identified threats affect the Indian Ocean population as well as global population of the species
	Unknown	

Comments:

Devil rays are specialized species having very low biological productivity (1 or 2 pups) and late age at maturity. They are either targeted or caught as bycatch throughout their cirumglobal distribution for their high value gill plates, which is reflected in increased global landings since 2006 (FAO Global capture production: online query). All the five species included here are assessed Endangered, globally (Marshall *et al.*, 2019a; Marshall *et al.*, 2019b; Marshall *et al.*, 2020; Rigby *et al.*, 2020) and four were also found endangered in Arabian Seas Region (Jabado *et al.*, 2017). The vulnerability of the species to different fishing gears and higher incidence of juveniles (30-60%) along Indian coast (ICAR-CMFRI, *unpub. data* and personal observations by Subal R., Remya L., and Swatipriyanka S.) could pose threats to these migratory species in the Indian Ocean.

SUMMARY for Question 2.2

Severity and geographic extent of conservation concern

Assess the overall severity and geographic extent of the conservation concern for this species or stock (tick appropriate box below). Explain how conclusions were reached and the main sources of information used.

High	Medium	Low	Unknown

Explanation of conclusion and sources of information used:

This is a low productive genus landed by trawl nets, gillnets, purse seine and long lines in Indian Ocean (Mohanraj *et al*., 2009; Fernanado and Stevens, 2011; Coelho *et al*., 2011; Lezama-Ochoa *et al*., 2015; Moazzam *et al*., 2018; Haque *et al*., 2020; CMFRI unpublished; Swatipriyanka S., Subal R., Mahesh V., Remya L., *pers. obs*.). Global population decline in devil rays (Marshall *et al*., 2019a), and 20-75% decline in population of different mobulid species in last three GL from Arabian Seas Region (Jabado *et al*., 2017), indicate that the status of the Indian Ocean stock is also of concern. The conservation needs and threats to this species are therefore high in the Indian Ocean.

Given the importance of this species in various fisheries and the lack of robust data to evaluate the fishery and population trend in the Indian Ocean, devil ray populations should be constantly monitored and managed to ensure their sustainability.

Section 3. Pressures on species

3.1 What is the severity of trade pressure on the stock of the species concerned?

Factor	Level of severity of trade pressure	Indicator/metric
(a) Magnitude of legal trade	Low	
	Medium	
	High	Reported mobulid landings are fairly good (0.55 to 13.01% of elasmobranch landings). Species-specific trade information limited.
	Unknown	

Level of confidence:			
	Low	Medium	High

Reasoning

Mobulids attract traders for their prized gill plates which find a market in Chinese traditional medicine and Asian dried seafood industries (White *et al*., 2006; Couturier *et al*., 2009). Sun-dried gill pates from Kerala and Tamil Nadu are known to enter international trade mostly through Chennai (Kizhakudan *et al*., 2015; Nair *et al*., 2015). The meat is mostly consumed locally in fresh or dried form. Along Gujarat coast, the meat and entrails are used along with other elasmobranch for oil extraction which is consumed locally (Shikha R., *pers. obs*.). The species are landed as bycatch by different gears operated in EEZ and are retained by its high value gill plates. The average annual landing during the last five years (2016-2020) is around 4300 t along Indian coast (Source: NMFDC, CMFRI). Species-specific trade information not available.

(b) Magnitude of illegal trade	Low	
	Medium	
	High	
	Unknown	The capture and trade of the species in Indian context is not prohibited by law.

Level of confidence:			
	Low	Medium	High

Reasoning:

As mobulids in Indian waters do not enjoy any legal protection, the capture and subsequent trade in the species and their parts are currently legal.

3.2 What is the severity of fishing pressure on the stock of the species concerned?			
Factor	Level of severity of fishing pressure	Indicator/metric	
Fishing mortality (retained catch)	Low		
	Medium		
	High	The regional assessment in Arabian Sea Region (Jabado *et al.*, 2017)	
	Unknown		
Level of confidence:			
	Low	Medium	High
Reasoning: The population in the Arabian Sea Region is known to have declined from 20-30% in *M. kuhlii* to 75% in the case of *M. tarapacana* during the last three generation length (Jabado *et al.*, 2017). As the known natural mortality for mobulids is very low (Pardo *et al.*, 2016; Rambahiniarison *et al.*, 2018), population declines must be fishery mediated.			
Discard mortality	Low	There are virtually no discards of mobulids from Indian fisheries.	
	Medium		
	High		
	Unknown		
Level of confidence:			
	Low	Medium	High
Reasoning: In India, discard mortality is very low because all mobulids caught are retained owing to their high-value gill plates.			
Factor	Level of severity of fishing pressure	Indicator/metric	
Size/age/ sex selectivity	Low		
	Medium	High numbers of juveniles and skewed sex ratio observed in the landings along the Indian coast	
	High		
	Unknown		
Level of confidence:			
	Low	Medium	High
Reasoning: As the mobulids landed along Indian coast are bycatch of gears like gillnets and trawl, a wider size range are observed in landings. The large size, late maturity and longevity indicates that a major share of catch (30-60%) are juveniles (Swatiprinyanka S., Subal R., Shoba J. K., Remya L. and Mahesh V., *pers.obs.*). There are reports of marginally skewed sex ratio in females (Fernando and Stevens, 2011; Fernando, 2018; Haque *et al.*, 2020) from Indian Ocean for *M. tarapacana* and *M. thurstoni* and *M. kuhlii.* For *M. mobular* both the dominance of male and female are reported from different parts of India and adjoining nations (Zacharia and Kanthan, 2010; Fernando, 2018; Haque *et al.*, 2020).			

Magnitude of illegal, unreported and unregulated (IUU) fishing	Low	
	Medium	
	High	
	Unknown	Capture and trade of species from Indian waters is not prohibited under any legal ruling

Level of confidence:			
	Low	Medium	High

Reasoning:

Capture and domestic trade of mobulids is not prohibited in India. The international trade is regulated as a part of CITES appendix II (https://cites.org/eng/app/appendices.php). In Indian Ocean region, the species is legally protected in countries like Bangladesh and Maldives (Haque *et al.*, 2020; https://saveourseas.com/update/all-ray-species-now-protected-in-the-maldives). Low compliance to international trade norms and national protection law for mobulids have been highlighted by Haque *et al.* (2020) from Bangladesh.

Section 4. Existing management measures

Preliminary compilation of information on existing management measures

Existing management measures	Is the measure generic or species-specific?	Description/comments/sources of information
(Sub-) National		
Seasonal ban on mechanized fishing	Generic	Closure of mechanized fishing activities for 61 days from 15th April to 14th June along east coast and 1st June to 31st July along west coast (both days inclusive), implemented through State MFRAs. Fishing ban order dated 10.03.2017: No. 30035/15/97-Fy(T-I) Vol. IV. Govt. of India, Ministry of Agriculture & Farmers Welfare (Department of Animal Husbandry, Dairying & Fisheries)
No take zones	Generic	There are 129 Marine Protected Areas where fishing activities are regulated (Sivakumar, 2013; ENVIS, 2021: Marine Protected Areas (wiienvis.nic.in)).
Gear-specific regulations	Generic	Regulation of mesh size, restrictions on operation of certain gears like ring seines, purse seines and pair trawling, implemented through State MFRAs. http://indianfisheries.icsf.net/en/page/827-Indian%20Legal%20Instruments.html http://old.icsf.net/icsf2006/uploads/resources/legalIndia/pdf/english/state/1112187832409***Gujarat_Marine_Fisheries_Rules_2003. PDF http://old.icsf.net/icsf2006/uploads/resources/legalIndia/pdf/english/state/1112240177836***Maharashtra_Marine_Fishing_Regulation_Rules,_1982.PDF http://164.100.150.120/mpeda/pdf/state_mfras/mfra_goa.pdf http://164.100.150.120/mpeda/pdf/state_mfras/mfra_karnataka_1987.pdf http://164.100.150.120/mpeda/pdf/state_mfras/mfra_kerala.pdf http://164.100.150.120/mpeda/pdf/state_mfras/mfra_tamil_nadu.pdf http://old.icsf.net/icsf2006/uploads/resources/legalIndia/pdf/english/state/1165227972133***Andra_Pradesh_Marine_Fishing_Regulation_Rules_1995_Amendment_dated_26th_October_2004.PDF http://164.100.150.120/mpeda/pdf/state_mfras/mfra_orrissa.pdf http://old.icsf.net/icsf2006/uploads/resources/legalIndia/pdf/english/state/1112241236819***West_bengal_Marine_Fishing_Regulation_(Amendment)_Rules,_1998.PDF
Regional/International		
Resolution 19/03 on the conservation of mobulid rays caught in association with fisheries in the IOTC area of competence	Species - specific	It was introduced in 2019, banning the retention of mobulids by any fishery, other than those for subsistence, throughout the IOTC Area of Competence.

CMS	Species - specific	Listing of all nine devil ray species (*Mobula* spp.) in Appendices I and II of the Convention on Migratory Species (CMS, 2017; 2021), which requires member countries to enact legislation protecting the species within their territorial waters. CMS (2021) Report on the implementation of the concerted action for the mobulid rays (Mobulidae). Gandhinagar, India. CMS (2017) Concerted action for the Mobulid rays (Mobulidae). Manila
CITES	Species - specific	Listing of all nine devil ray species (*Mobula* spp.) in Appendix II of CITES in 2017. Species included in Appendix II are not necessarily threatened with extinction, but trade in them is controlled to avoid utilization incompatible with their survival. Which requires that exports from CITES Parties be accompanied by permits based on findings that parts are sourced from legal and sustainable fisheries. https://cites.org/eng/prog/shark/more.php https://www.cms.int/sites/default/files/document/cms_cop13_doc.28.1.6_ca-report-mobulid_e.pdf
Manta Trust	Species - specific	Since 2011, the Manta Trust has been coordinating global efforts to conserve mobulid rays and their habitat. In 2014, the Manta Trust and its collaborators assembled and launched the Global Mobulid Conservation Programme (GMCP) - a strategic and long-term plan to ensure the conservation of the world's mobulid rays. This programme ensures collaboration of Manta Trust with policy makers, national governments, trade officials, local communities and NGOs in key mobulid fishing nations for extending current research efforts studying mobulid rays, with a specific focus on furthering the knowledge of key biological aspects of these species' life history - information that is crucial to monitoring and regulating fisheries and making informed management decisions. https://www.mantatrust.org/global-mobulid-conservation-programme
Wildlife Conservation Society	Species - specific	The Wildlife Conservation Society is an international conservation organization working to save wildlife and wild places worldwide through science, conservation action, education, and inspiring people to value nature. WCS is a Cooperating Partner to CMS Sharks MoU as well as a founding partner of the Global Sharks and Rays Initiative (GSRI), a global ten-year strategy, aims to save shark and ray species from extinction, sustainable fishery of shark and ray, control international trade in shark and ray parts and products and reduce consumption of shark and ray products from illegal or unsustainable sources. https://www.cms.int/sites/default/files/document/cms_cop13_doc.28.1.6_ca-report-mobulid_e.pdf
IUCN	Species - specific	*Mobula mobular, M. kuhlii* and *M. thurstoni* are listed as IUCN Species Specialist Group SSG and partners review progress and revise actions under the Global Devil and Manta Ray Conservation Strategy every three years https://www.iucnredlist.org/species/110847130/176550858 https://www.iucnredlist.org/species/161439/124485584 https://www.iucnredlist.org/species/60200/124451622

4.1 Are existing management measures appropriately designed and implemented to mitigate pressures affecting the stock?			
Factor	Existing management measure(s)	Relevant monitoring, control and surveillance (MCS) measure(s)	Overall assessment of compliance regime *(tick as appropriate)*
Trade Pressure			
(a) Magnitude of legal trade	The primary driver for mobulid fisheries is the gill plate trade. No documentation of gill plate trade in India. Market surveys at Guangzhou, Hong Kong, and Macau in China, as well as Singapore estimated the annual volume of gill plate sales as about 21,000 kilograms (46,300 pounds) of dried manta ray gill plates expected to be exported from India, Sri Lanka and Indonesia	No management exists for the international trade in manta products. Inspections by SFD officials, Wildlife Department and SFDs, MPEDA and Customs & Excise Department, Indian Coast Guard	Unknown (no information on compliance) Poor (limited relevant compliance measures in place) Moderate (some relevant compliance measures in place) Good (comprehensive relevant compliance measures in place)
	Reasoning/comments: At present no management measures are in place in India for *Mobula* spp. https://www.pewtrusts.org/en/research-and-analysis/fact-sheets/2013/01/18/cites-2013-manta-rays		
(b) Magnitude of illegal trade			Unknown (no information on compliance) Poor (limited relevant compliance measures in place) Moderate (some relevant compliance measures in place) Good (comprehensive relevant compliance measures in place)
	Reasoning/comments No information available on illegal trade of mobulids		

Fishing Pressure			
(a) Fishing mortality (retained catch)	Average reported catch increased from 2936 t (2007-13) to 4254 t (2014-20) shows nearly 45% increase, indicating high fishing mortality in recent years (ICAR-CMFRI, *unpub. data*) Closed seasons for all mechanised fisheries. Marine Protected Areas	No on-board observer programmes. Port monitoring takes place. Inadequate log book sharing with officials Inspection by state fisheries department officials	Unknown (no information on compliance) Poor (limited relevant compliance measures in place) Moderate (some relevant compliance measures in place) Good (comprehensive relevant compliance measures in place)
	Reasoning/comments: At present there are no management measures in place in Indian laws preventing capture of these iconic species; whatever information available is from landed data (CMFRI published data)		
(b) Discard mortality	No known discards from fisheries in India	Not applicable.	Unknown (no information on compliance) Poor (limited relevant compliance measures in place) Moderate (some relevant compliance measures in place) Good (comprehensive relevant compliance measures in place)
	Reasoning/comments: It is assumed that all dead rays caught, except prohibited species, are retained on-board.		
(c) Size/age/ sex selectivity			Unknown (no information on compliance) Poor (limited relevant compliance measures in place) Moderate (some relevant compliance measures in place) Good (comprehensive relevant compliance measures in place)
	Reasoning/comments: Limited information available from the landed data of these species which were either accidently landed or captured as bycatch of tuna long liners.		

(d) Magnitude of IUU fishing	IUU fishing POA in preparation for Indian waters.		Unknown (no information on compliance)
			Poor (limited relevant compliance measures in place)
			Moderate (some relevant compliance measures in place)
			Good (comprehensive relevant compliance measures in place)
	Reasoning/comments: Issues of IUU fishing by IOTC's IUU provisions (IOTC-2016-CoC13-CR27 Rev1). The BOBP-IGO organized the 'National Workshop for Preparation of Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing' during 23 - 24 April 2018 in Chennai and the Report of the Workshop was sent to the Ministry of Fisheries, Animal Husbandry and Dairying for further action at their end. Subsequently, the BOBP-IGO in collaboration with the member-countries (Bangladesh, India, Maldives, Sri Lanka) also organized a couple of activities to prepare the draft Regional Plan of Action on IUU Fishing (RPOA-IUU). The RPOA-IUU is now with the Bangkok Office of FAO and will be further taken up once the BOBLME Phase 2 starts (BOBP-IGO, 2021, *pers. comm.*).		

4.2 Are existing management measures effective/likely to be effective in mitigating pressures affecting the stock/population?

Factor	Existing management measure(s)	Are relevant data collected and analysed to inform management decisions? (e.g. landings, effort, fisheries independent data)		Is management consistent with expert advice?
Trade Pressure				
(a) Magnitude of legal trade	Regulations in place and complied with. (Notification No. 110 (RE-2013)/2009-2014)	No data OR data are of poor quality OR data are not analysed (adequately) to inform management		No expert advice on management identified
		Limited relevant data are collected AND analysed to inform management		Not consistent
		Some relevant data are collected AND analysed to inform management		Expert advice partially implemented
		Comprehensive data collected AND analysed to inform management		Consistent
	Management measure(s) effective/likely to be effective?			
	Yes	Partially	No	Insufficient information
	Reasoning/comments: Only generic declaration of export is done in India. All management measures are complied with.			

<table>
<tr><td rowspan="8">(b) Magnitude of illegal trade</td><td rowspan="4">In general trade is monitored in different levels and actions taken according to national laws by Central Board of Excise and Customs and Wildlife Crime Control Bureau</td><td colspan="2">No data OR data are of poor quality OR data are not analysed (adequately) to inform management</td><td>No expert advice on management identified</td></tr>
<tr><td colspan="2">Limited relevant data are collected AND analysed to inform management</td><td>Not consistent</td></tr>
<tr><td colspan="2">Some relevant data are collected AND analysed to inform management</td><td>Expert advice partially implemented</td></tr>
<tr><td colspan="2">Comprehensive data collected AND analysed to inform management</td><td>Consistent</td></tr>
<tr><td colspan="4">Management measure(s) effective/likely to be effective?</td></tr>
<tr><td>Yes</td><td>Partially</td><td>No</td><td>Insufficient information</td></tr>
<tr><td colspan="4">Reasoning/comments:
No information on illegal trade of mobula rays from India.</td></tr>
<tr><td colspan="5">Fishing Pressure</td></tr>
<tr><td rowspan="6">(a) Fishing mortality (retained catch)</td><td rowspan="4">No mobulid discard in fishery</td><td colspan="2">No data OR data are of poor quality OR data are not analysed (adequately) to inform management</td><td>No expert advice on management identified</td></tr>
<tr><td colspan="2">Limited relevant data are collected AND analysed to inform management</td><td>Not consistent</td></tr>
<tr><td colspan="2">Some relevant data are collected AND analysed to inform management</td><td>Expert advice partially implemented</td></tr>
<tr><td colspan="2">Comprehensive data collected AND analysed to inform management</td><td>Consistent</td></tr>
<tr><td colspan="4">Management measure(s) effective/likely to be effective?</td></tr>
<tr><td>Yes</td><td>Partially</td><td>No</td><td>Insufficient information</td></tr>
<tr><td colspan="4">Reasoning/comments:
Monitoring activities are described in the previous section. There is limited management expert advice provided by IOTC</td></tr>
<tr><td rowspan="6">(b) Discard mortality</td><td rowspan="4">No mobulid discards from Indian fisheries - no management measures</td><td colspan="2">No data OR data are of poor quality OR data are not analysed (adequately) to inform management</td><td>No expert advice on management identified</td></tr>
<tr><td colspan="2">Limited relevant data are collected AND analysed to inform management</td><td>Not consistent</td></tr>
<tr><td colspan="2">Some relevant data are collected AND analysed to inform management</td><td>Expert advice partially implemented</td></tr>
<tr><td colspan="2">Comprehensive data collected AND analysed in some cases to inform management</td><td>Consistent</td></tr>
<tr><td colspan="4">Management measure(s) effective/likely to be effective?</td></tr>
<tr><td>Yes</td><td>Partially</td><td>No</td><td>Insufficient information</td><td>N/A</td></tr>
<tr><td colspan="4">Reasoning/comments:
The trawl discard composition study from India doesn't report this species in discard along the coast (Dineshbabu et al., 2013, Lobo et al., 2010). All ray bycatch in other fisheries is fully utilised. There are no management measures for discards of mobulids</td></tr>
</table>

(c) Size/age/ sex selectivity	No measures adopted in India (no size specific targeted ray fisheries). Procedures proposed in FADs management plan, IOTC resolution 17/08.	No data OR data are of poor quality OR data are not analysed (adequately) to inform management		No expert advice on management identified
		Limited relevant data are collected AND analysed to inform management		Not consistent
		Some relevant data are collected AND analysed to inform management		Expert advice partially implemented
		Comprehensive data collected AND analysed to inform management		Consistent
	Management measure(s) effective/likely to be effective?			
	Yes	Partially	No	Insufficient information
(d) Magnitude of IUU fishing	NA. No target shark fishing; no specific regulation of bycatch shark fisheries; limited monitoring of IUU fishing.	No data OR data are of poor quality OR data are not analysed (adequately) to inform management		No expert advice on management identified
		Limited relevant data are collected AND analysed to inform management		Not consistent
		Some relevant data are collected AND analysed to inform management		Expert advice partially implemented
		Comprehensive data collected AND analysed to inform management		Consistent
	Management measure(s) effective/likely to be effective?			
	Yes	Partially	No	Insufficient information
	Reasoning/comments Issues of IUU fishing by IOTC's IUU provisions (IOTC-2016-CoC13-CR27 Rev1). The BOBP-IGO organized the 'National Workshop for Preparation of Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing' during 23 - 24 April 2018 in Chennai and the report of the workshop was sent to the Ministry of Fisheries, Animal Husbandry and Dairying for further action at their end. Subsequently, the BOBP-IGO in collaboration with the member-countries (Bangladesh, India, Maldives, Sri Lanka) also organized a couple of activities to prepare the draft Regional Plan of Action on IUU Fishing (RPOA-IUU). The RPOA-IUU is now with the Bangkok Office of FAO and will be further taken up once the BOBLME Phase 2 starts (BOBP-IGO, 2021, personal communication).			

Section 5. Non-Detriment Finding and related advice

Based on the outcomes of the previous steps, is it possible to make a positive NDF (with or without associated conditions) or is a negative NDF required?

Step 2: Intrinsic biological vulnerability and conservation concern					
Intrinsic biological vulnerability (Question 2.1)		High	Medium	Low	Unknown
Conservation concern (Question 2.2)		High	Medium	Low	Unknown

Step 3: Pressures on species		Step 4: Existing management measures	
Pressure	Level of severity (Questions 3.1 and 3.2)	Level of confidence (Questions 3.1 and 3.2)	Are the management measures effective* at addressing the concerns/pressures/impacts identified? (Question 4.2) **taking into account the evaluation of management appropriateness and implementation under Question 4.1*
Trade pressures			
(a) Magnitude of legal trade	High Medium Low Unknown	High Medium Low	Yes Partially No Insufficient information Not applicable**
(b) Magnitude of illegal trade	High Medium Low Unknown	High Medium Low	Yes Partially No Insufficient information Not applicable**
** Only to be used where the trade pressure severity was assessed as "Low" for any of the Factors in Step 3 and a judgement is made that the impacts on the shark stock/population concerned are so low that mitigation is not required.			
Fishing pressures			
(a) Fishing mortality (retained catch)	High Medium Low Unknown	High Medium Low	Yes Partially No Insufficient information Not applicable**
(b) Discard mortality	High Medium Low Unknown	High Medium Low	Yes Partially No Insufficient information Not applicable**

(c) Size/age/sex selectivity of fishing	High	High	Yes
	Medium	Medium	Partially
	Low	Low	No
	Unknown		Insufficient information
			Not applicable**
(d) Magnitude of IUU fishing	High	High	Yes
	Medium	Medium	Partially
	Low	Low	No
	Unknown		Insufficient information
			Not applicable**
**Only to be used where the fishing pressure severity was assessed as "Low" for any of the Factors in Step 3 and a judgement is made that the impacts on the shark stock/population concerned are so low that mitigation is not required.			
Can a positive NDF be made?	Yes- *go to B*	*go to Step 6 and list recommendations for measures to improve monitoring/management under Reasoning/comments below*	
Are there any mandatory conditions to the positive NDF?	Yes-list under Reasoning/comment below and go to C		
Are there any other further recommendations?	YES - *go to Step 6*		
Reasoning/comments: This mobulid (all mobulid species except *M. birostris* and *M. alfredi*) NDF for India is "**Positive with Conditions**" to enable trade (of non-fin commodities) to continue, while improvements are made to existing fisheries and trade management and monitoring systems and while additional research activities and management measures are adopted as outlined in section 6. This NDF will be re-evaluated after 3 years, to gauge progress against the recommendations in Section 6 and updated with newly acquired data, before agreeing to a new NDF for 2025-2029			

Section 6. Further measures

6.1 Improvement in monitoring or information is required

Monitoring and data recommendations for Mobulids in the Indian Ocean	
Generic measures	
Recommendation	Potential leads
Fishery-dependent monitoring and research:	
Fishery monitoring:	
Improve the existing species-specific landing observation programme, through training and capacity-building of field staff.	ICAR- CMFRI, NGOs
Look into establishing an informal communication group (e.g.Instagram/WhatsApp/Google) of shark identification experts (both local and international), to help field staff to identify sharks and/or shark products with a camera photo at short notice.	ICAR- CMFRI
Build upon the developing programme for introducing vessel monitoring systems.	State Fisheries Depts, FSI
Investigate options for introducing mandatory logbook reporting on species-wise landings by fishers.	State Fisheries Departments and ICAR-CMFRI
Use interviews with fishers to obtain enquiry-based information on shark (by)catch, particularly where access to logbooks is difficult; develop databases for records of species, catch, date and area of capture (geolocation), and gear types.	ICAR-CMFRI
Ensure that species-specific data provided to the Ministry of Fisheries, Animal Husbandry & Dairying are passed on to the FAO.	DoF, GoI
Identifying area & season breeding and nursery aggregations of the species, using a participatory approach with fishers.	ICAR-CMFRI
Research:	
Undertake biological and stock assessment studies, utilizing data on sex ratios, size/age structure, annual reproductive output, BRPs, and fishing effort collected at landing sites by CMFRI fisheries officers and population genetic studies on stocks of mobulids	ICAR-CMFRI, Universities
Monitoring of domestic and international trade:	MPEDA in collaboration with State Fisheries Departments and ICAR-CMFRI in collaboration with and stakeholders (fishers and traders)
Improve the level of trade data reporting - data declaration by traders (species, source of obtaining the product, size of fish (length & weight), quantity, product form).	
Provide international trade data, as relevant, to CITES, FAO, IOTC.	MPEDA, DoF
Undertake market survey, interviews with fishermen & traders, collate information from Customs & other databases, and from trade channels	ICAR-CMFRI, Universities, NGOs
Recommend to the Marine Products Export Development Authority (Ministry of Commerce and Industry) that species-specific codes be added to the current generic product-specific codes for trade records; offer to collaborate with them to develop codes.	DoF and MPEDA
Promoting the use of genetic analysis by CMFRI for ambiguous products in trade and raise awareness with relevant government departments that this service exists.	ICAR- CMFRI
Resource-specific measures	
Recommendation	Potential leads
Taxonomic studies on mobulid species (classic and molecular taxonomy)	ICAR-CMFRI

Fishery-independent population monitoring and research Tag and release: Research to assess distribution, movement and post release mortality of mobulids using electronic tags.	Fishery Survey of India, possibly in collaboration with other national research institutes and regional bodies IOTC, BOBP-IGO.
Research to assess habitat ecology, critical habitats and post-release mortality of mobulids using electronic tags and assess stock structure using genetic tags.	ICAR-CMFRI, possibly in collaboration with other national research institutes and regional bodies IOTC, BOBP-IGO.
Distribution and Abundance: Undertake resource-specific exploratory surveys Identify spatial and seasonal mobulids breeding and nursery aggregations	Fishery Survey of India in collaboration with ICAR- CMFRI and Centre for Marine Living Resources & Ecology (CMLRE)
Fishery-dependent monitoring and research: Fishery monitoring: Use interviews with fishers to obtain enquiry-based information on mobulid catch, particularly where access to logbooks is difficult; develop database for records of mobulid catch, date and area of capture (geolocation) and gear types.	ICAR-CMFRI
Identifying area, breeding season and nursery aggregations of mobulids, using a participatory approach with fishers.	ICAR-CMFRI, Universities
Research: Undertake biological and stock assessment studies on mobulids in Indian waters, utilizing data on sex ratios, size/age structure, annual reproductive output, BRPs, and fishing effort collected at landing sites by CMFRI. Carry out population genetic studies on stock(s) of mobulids in the Indian EEZ.	ICAR-CMFRI, Universities

6.2 Improvement in management is required

Management recommendations for Mobulids in the Indian Ocean

Generic measures

Recommendation	Potential leads
Strict implementation of each state's Marine Fishery Regulation Act (MFRA) regarding gear, mesh size, operation in no-take zones and closed seasons	State Fishery Departments, Coast guard, Marine Enforcement Police
Strengthen Monitoring, Control and Surveillance (MCS)	State Fisheries Departments Coast guard and Marine Enforcement Police, Dept of Forestry, Wildlife Crime Control Bureau, MoEF & CC
Improve participatory management and inter-departmental coordination through fishery management councils, as developed under the FAO CCRF	National and State Fishery Management Councils
Create awareness through visual, print and electronic media and mass campaigns	CMFRI, NETFISH-MPEDA, NGOs
Seasonal closure of fishing in identified breeding/nursery grounds	States, through MFRAs
Improved surveillance to check for IUU fishing by foreign vessels, and develop protocol for identifying species on board	Indian Navy and Coast guard
Continue to monitor and where necessary improve compliance with existing fisheries management regulations (national, regional and international)	Department of Fisheries (DoF)
Adopt and implement the NPOA-Sharks for India with a special focus on plans for shark species listed in CITES and CMS, encourage and take part in regional initiatives to develop a regional shark plan.	DoF
Urge Ministry of Commerce and Industry to introduce HS codes for all shark products to collect improved data on imports and exports.	MPEDA
Increase awareness for shark processors, traders, and exporters regarding the fin export ban, and CITES requirements for the export of other products derived from CITES listed shark species (this includes export permits accompanied by the Legal Acquisition Finding and Non-Detriment Findings).	ICAR-CMFRI, MPEDA & NGOs

Resource-specific measures

Recommendation	Potential leads
Develop a fisher awareness program aimed to: • improve identification of juvenile and pregnant mobulids, their seasonal abundance in specifc areas and techniques to maximize live release • improve logbook data recording. • provide an overview and increase awareness of mobulid biology, global status, and management measures in place both locally and internationally.	ICAR-CMFRI, SFDs, Universities, NGOs
Suggest Minimum Legal Size (MLS) for sustainable harvest of mobulid species in India	ICAR-CMFRI

Timeline of Activities for Implementation of NDF Recommendations

Sl. No	Activity	I YEAR	II YEAR	III YEAR
1	Linkages and coordination with various organizations for implementation of NDF recommendations			
2.	Awareness programs and stakeholder meetings			
3	Fishery independent studies: Tag and release / stock assessment studies/ abundance and distribution studies			
4	Fishery dependent: catch and effort, participatory fishery monitoring			
5.	Trade monitoring and regulations			
6	Capacity building for stakeholders and managers			

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APPENDIX - I
Supplementary information on devil rays *Mobula* spp.

Introduction

Manta and devil rays (collectively known as *mobulids*) are medium to large migratory batoid fishes. Currently, mobulids comprises single genus *Mobula*, having 9 extant species with two mantas and seven devil ray species (Haque *et al*., 2020). This highly specialized group of fishes are pelagic and migratory in nature with circumglobal tropical and subtropical distribution (Couturier *et al*., 2012; Fernando, 2018; Flounder, 2020). These large elasmobranchs are interestingly planktivore filter feeders using an array of swimming pattern to increase feeding efficiency coupled by use of cephalic fins to guide prey to gill plates to filter out planktons and small fishes (Couturier *et al*., 2012; Stevens *et al*., 2018). These species warrant conservation management as they are highly vulnerable to increased fishing pressure including higher incidence of bycatch. The intrinsic biological features like late maturity, low fecundity giving birth to single pup after every 2-7 years, and longer gestation period (~1 year) renders them highly vulnerable to fishing activity (Couturier *et al*., 2012; Stevens *et al*., 2018; Flounder, 2020). The highly similar gross morphology coupled with overlapping distributional ranges has led to several taxonomic and identification ambiguities especially by field enumerators (Couturier *et al*., 2012). Several studies in recent past has addressed the issue resulting in taxonomic revision of the group (Notarbartolo di Sciara., 1987; Notarbartolo di Sciara *et al*., 2017; White *et al*., 2018; Notarbartolo di Sciara *et al*., 2020a, b; Hosegood *et al*., 2020). Family Mobulidae now became monotypic, represented by a valid genus *Mobula* Rafinesque, 1810 and 11 valid species namely *Mobula mobular* (Bonnaterre, 1788), *Mobula birostris* (Walbaum, 1792), *Mobula hypostoma* (Bancroft, 1831), *Mobula japanica* (Muller & Henle, 1841), *Mobula eregoodoontenkee* (Bleeker, 1859), *Mobula alfredi* (Krefft, 1868), *Mobula rochebrunei* (vaillant, 1879), *Mobula tarapacana* (Philippi, 1892), *Mobula thurstoni* (Lloyd, 1908), and *Mobula munkiana* Notarbartolo-di-Sciara, 1987 (White, *et al*., 2017; Froese and Pauly, 2021). But several recent publications proposed the merging of *Mobula japanica* into *Mobula mobular* as the former is claimed to be the junior synonym of the latter (White *et al*., 2018; Stevens *et al*., 2018; Stewart *et al*., 2018 Notarbartolo di Sciara *et al*., 2020a). Previously, *M. eregoodootenkee* has been synonymized with *M. kuhlii* (White *et al*., 2017), now resurrected and redescribed as a valid species *M. eregoodoo* on the basis of morphological and ecological evidence (Notarbartolo di Sciara *et al.* 2020b). In the Indian context, seven species of devil rays are recorded from the fishery (Akhilesh *et al*., 2014; Kizhakudan *et al*., 2015). There are several landing reports in the name of *Mobula diabolus* from different parts of India (Rajapackiam *et al*., 1994; Pillai, 1998; Rajapackiam *et al*., 2007; Raje and Zacharia, 2009). The species at present is not a valid species and considered as a junior synonym of *Mobula mobular* as the original description of *M. diabolus* by Shaw (1804) was preceded by the original description of *M. mobular* by Bonnaterre (1788), both of which referred the same specimen for their description (White *et al*., 2018). Also, the reports of the species *M. diabolus* in Indian context are believed to be mostly representing *M. mobular* (Couturier *et al*., 2012).

Thus, following a fairly recent taxonomic revision, the family Mobulidae now comprises nine nominal species (previously 11) under a single recognized genus (previously 2); *Mobula* (White *et al*., 2017). Under the current classification, a total of seven species are found in the Indian Ocean; *Mobula birostris* (oceanic manta ray),

Mobula alfredi (reef manta ray), *Mobula mobular* (spinetail/giant devil ray), *Mobula tarapacana* (sicklefin devil ray), *Mobula thurstoni* (bentfin devil ray), *Mobula kuhlii* (shortfin pygmy devil ray) and *M. eregoodoo* (longhorned pygmy devil ray) (Hall and Roman, 2013; Shahid *et al.*, 2018; Stevens *et al.*, 2018)

General description of the species

(Adopted from Compagno *et al.*, 1989; Adnet *et al.*, 2012; Tomita *et al.*, 2013; Ebert, 2014; Jabado and Ebert, 2015; Notarbartolo di Sciara *et al.*, 2017; Kizhakudan *et al.*, 2018; Stevens *et al.*, 2018; Notarbartolo di Sciara *et al.*, 2020a, b; The national checklist of Taiwan, 2021)

Sicklefin/ Chilean devil ray *Mobula tarapacana* (Philippi, 1892)

A medium-sized devil ray devoid of caudal spine. The species is characterized by a longer neck, short cephalic fins, lunate rostrum, and broad and sub-terminal (ventral) mouth. The species possesses large teeth, tessellated, in apical view crown appear sub-hexagonal; its surface pitted, its buccal edge comb-like. Spiracles are elongated longitudinal slit in appearance placed dorsal to the plane of pectoral fins. Dorsal surface uniform greenish green to brown; dorsal fin plain without white tip; upper part of ventral surface shaded white and lower part shaded grey, often a dark patch extending from cephalic fins posteriorly along the gill areas. The trailing edge of the pectoral fins strongly falcate. The tail is shorter than disc width. The dorsal midline has a distinct ridge. The species have medium to large size gill plates with fused and rounded terminal lobe. The gill plates are distinctly bi-coloured with black outer lobes and white inner lobes.

Bentfin devil ray *Mobula thurstoni* (Lloyd, 1908)

A small-sized devil ray without the presence of caudal spine. The species has a characteristic short-necked appearance coupled with short cephalic fins less than 16% of total disc width. The mouth is broad with sub-terminal mouth. Teeth sub-hexagonal, wider than long. Teeth tessellated in the juvenile, turning imbricate in the adult. The crown rugose, file like and the teeth in adult is with two wide based long cusps on buccal margin. The spiracles are small, sub-circular placed ventral to the plane of pectoral fins. Dorsal surface dark blue with a purple tinge, ventral surface white, black margin along anterior disc. A distinctive curve in mid of anterior margin of pectoral fin present. The dorsal fin height is 78% of base and with white tip. The tail equal or longer than disc width, the base of the tail dorso-ventrally compressed. The gill plates are of small to medium size with terminal lobe twice as long as wide in leaf-like in appearance. The gill plates are uniformly dark up to mid region with grey terminal lobes.

Spinetail devil ray, *Mobula mobular* (Bonnaterre, 1788)

A large-sized devil ray with the presence of serrated caudal spine. The species has a short neck and cephalic fins. The mouth is broad and sub-terminal. The teeth are very small in widely spaced parallel rows the crown appear cardiform in apical view, with a cusp pointing buccally. The spiracles are short transverse slit placed above margin of pectoral fins. Dorsal surface deep blue and ventral surface whitish, ventral white extends above eye on dorsal side. A thick black band on top of head extending from one eye to the other, clearly darker than the surrounding colour. The head band though visible only in live individuals. A very long whip-like tail

equal to or longer than disc width, with rows of tubercles present on either side of tail. The elongated dorsal fin white tipped. The gill plates are of medium size with separate and pointed lobe. The terminal lobes are of leaf-like shape. The lobes are dark coloured with pinkish-white terminal lobe.

Spinetail mobula *Mobular japanica* (Muller & Henle, 1841) (junior synonym of *M. mobular)*

The spinetail devil ray *Mobula japanica* is a relatively large zooplanktivorous species with a broad rhomboid disc, nearly twice as wide as long. Pectoral fins with straight to slightly curved margins, which may be convex in the anterior and concave in posterior, wing tip is sharply pointed. Head and cephalic fins are broad flat and short. Spiracles are small and slit like (almost circular in embryos/juveniles) located above margin of pectoral fins and under a distinct ridge. Mouth is wide and sub-terminal. Cephalic fins are moderate, distinct from the pectorals. Small numerous teeth present on both jaws and extending the angles of the mouth. It has a single dorsal fin with conspicuous white tip and fin height is 96% of base. The tail is long and whip-like tail, twice as long as body, flattened ventrally with prominent white lateral denticles and a short, serrated stinging spine behind dorsal fin. Disc is bluish black with lighter shoulder patches that fade in adults and bright white underside devoid of any obvious markings. Ventral white colouration extends up to behind eyes.

Shortfin pygmy devil ray *Mobula kuhlii* (Muller & Henle, 1841)

The shortfin pygmy devil ray *Mobula kuhlii* is a small-sized ray having appearance of 'neckless' body with broad rhomboid disc, short cephalic fins, relatively short and triangular pectoral fins having slightly curved tips. Mouth is broad and sub-terminal, small and sub-circular spiracles located below margin of pectoral fins. Disc is 1.9 times as wide as long and tail is shorter than disc, devoid of spine in adults. However, tail length is longer than disc width in embryos and juveniles. Base of tail behind dorsal fin dorsally flattened with longitudinal grooves along the flat region, and moderately compressed laterally; tail tapering shortly behind into a whip-like shape. Anterior and posterior margin of pectoral fins are nearly straight except near the apex, where the fin is slightly curved backward. Dorsal fin height is 68% of base. Teeth are comb-like, sub-hexagonal, wider than long. The upper and lower tooth bands constitute 72 and 79% of mouth width respectively. Tip of cephalic fin to spiracle 13.8% of disc width. Preoral distance less than 3.3% of disc width. Branchial filter plates unattached from neighbouring plates, with compact ascending lobes and spade-shaped terminal lobes with a rounded cusp. Dorsal fin often possessing a white tip. Pale grey stripe runs along the anterior dorsal margin of pectoral fins.

Longhorned pygmy devil ray *Mobula eregoodoo* (Cantor, 1849)

The longhorned pygmy devil ray *Mobula eregoodoo* (Cantor, 1849), is a small-sized ray having distinctive appearance of 'long-necked' body with cephalic fin length $>$16% of disc width. Disc narrow and rhomboid with width being 1.7 times as long. Pectoral fins relatively short with moderately curved tips. Mouth is broad, sub-terminal and distance between the tip of the cephalic fins and corner of the mouth is 1.36 times the mouth width, which is 2.1 times the preoral length. Spiracle very small and sub-circular located under a ridge caudal to postorbital process, Disc is 1.73 times as wide as long and tail is shorter than disc width, devoid of spine. Dorsal fin height is 64% of base, often with white tip. Base of tail behind dorsal fin dorsally flattened with longitudinal grooves along the flat region, and moderately compressed laterally; tail tapering shortly behind into a whip-like

shape. Filter plates with four (rarely five) ascending lobes, the smallest number in the genus, unattached from those of contiguous plates. Terminal lobes are leaf shaped and distinctively elongated, more so than in any other *Mobula*, with a pointed cusp. A highly distinctive dark blotch, variable in size and shape, is present on the ventral side at the midpoint of the leading edge of pectoral fin.

Global Distribution and Habitat

Mobula tarapacana

Distribution: Atlantic-northeast, Atlantic-southwest, Atlantic-southeast, Atlantic-western central, Atlantic-eastern central, Atlantic-northwest, Indian Ocean-western, Indian Ocean-eastern, Pacific - eastern central, Pacific-southwest, Pacific-western central, Pacific-southeast, Pacific - northwest (Marshall *et al.*, 2019a). The sicklefin devil ray is primarily oceanic, but also found in coastal waters, and appears to be a seasonal visitor along productive coastlines with regular upwelling in oceanic island groups, and near offshore pinnacles and seamounts (Marshall *et al.*, 2019a) (Fig 1.).

Fig. 1. Global distribution of *Mobula tarapacana* (Marshall *et al.*, 2019a;IUCN)

Mobula thurstoni

Distribution: Atlantic-southwest, Atlantic-western central, Atlantic-eastern central, Atlantic-southeast, Indian Ocean-western, Indian Ocean-eastern, Pacific-western central, Pacific-southeast, Pacific southwest, Pacific-northwest, Pacific- eastern central (Marshall *et al.*, 2019b). The Bentfin devil ray occurs in neritic and oceanic waters from the surface to depths of 100 m (Weigmann 2016). The Bentfin devil ray is a seasonal visitor along productive coastlines with regular upwelling, off oceanic island groups, and near offshore pinnacles and seamounts (Gadig *et al.* 2003, White *et al.*, 2006, Mendonca 2011, Poortvliet *et al.* 2015, Lawson *et al.* 2017) (Fig 2.).

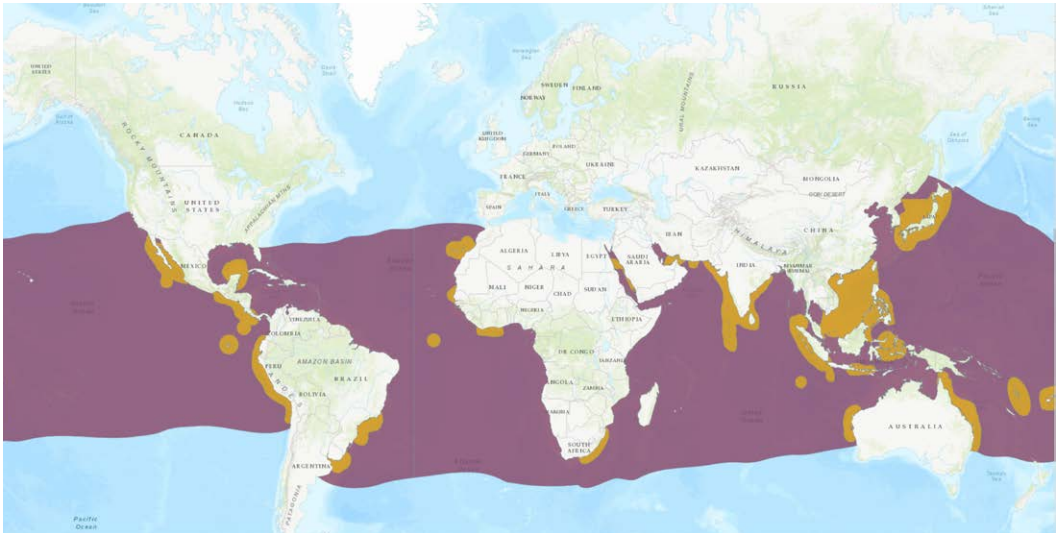

Fig. 2. Global distribution of *Mobula thurstoni* (Marshall *et al*., 2019b; IUCN)

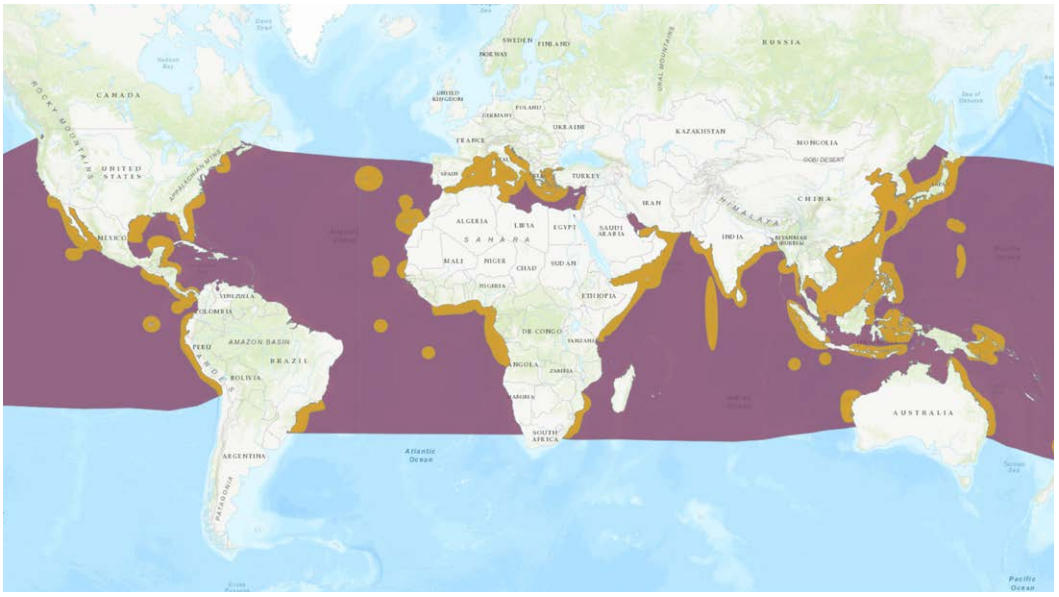

Fig. 3. Global distribution of *Mobula mobular* (Marshall *et al*., 2020; IUCN)

Mobula mobular

Atlantic-western central, Atlantic - northeast, Atlantic - southwest, Atlantic-eastern central, Pacific-western central, Pacific - southwest, Pacific - southeast, Pacific - northwest, Atlantic - northwest, Pacific - northeast, Pacific-eastern central, Atlantic - southeast, Mediterranean and Black Sea, Indian Ocean - eastern, Indian Ocean - western. The spinetail devil ray is a pelagic species that resides in coastal and continental shelf waters up to 50 m depth and occasionally dive into more deeper waters (Marshall *et al*., 2020) (Fig 3.).

Earlier the spinetail devil ray *Mobula japanica* was recorded as a pelagic species with a worldwide distribution in tropical and subtropical waters. Indo-Pacific: off South Africa, the Arabian Sea eastward to the Hawaiian Islands and Polynesia. Eastern Pacific: on the continental coast. Eastern Atlantic: may probably be more wide-ranging (Fig 4.).

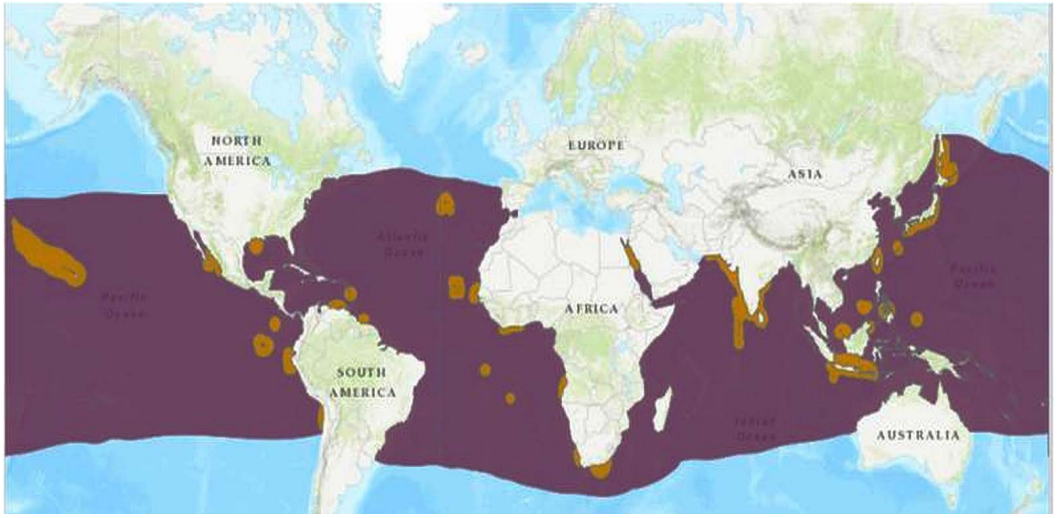

Fig. 4. Global Distribution of *Mobula japanica* (Marshall *et al.*, 2020; IUCN)

Fig. 5. Global distribution of *Mobula kuhlii* (Rigby *et al.*, 2020a; IUCN)

Mobula kuhlii

The shortfin pygmy devil ray is known to be occurring only in Indian Ocean and portions of the Indo-Pacific region from South Africa to the Solomon Islands (Notarbartolo di Sciara, 1987; Lawson *et al.* 2017; Chin *et al.* 2019). It is an inshore, mainly shelf species found in continental coastal areas to 50 m deep (Last *et al.* 2016; Weigmann, 2016). The species distribution does not extend into the epipelagic zone (Fig 5.).

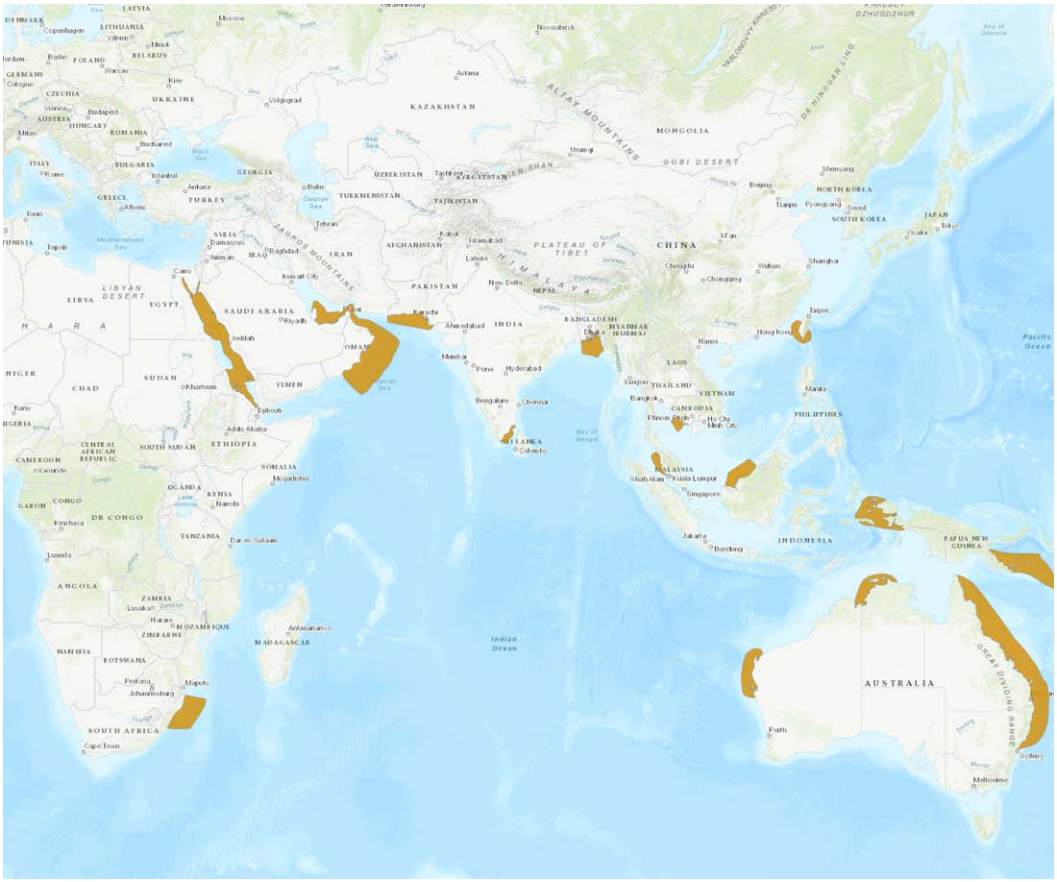

Fig. 6. Global distribution of *Mobula eregoodoo* (Rigby *et al.*, 2020b; IUCN)

Mobula eregoodoo

The longhorned pygmy devilray has a patchy distribution in the Indo-West Pacific and hence considered as endemic to this zone. It ranges from South Africa in the west to Port Moresby, Papua New Guinea in the east. It extends from Vietnam in the north to the north eastern coast of New South Wales, Australia in the south (Rigby *et al.*, 2020b). It mostly inhabits the coastal pelagic realm close to reefs, islands and some time offshore reefs (Bray, 2021) (Fig 6.).

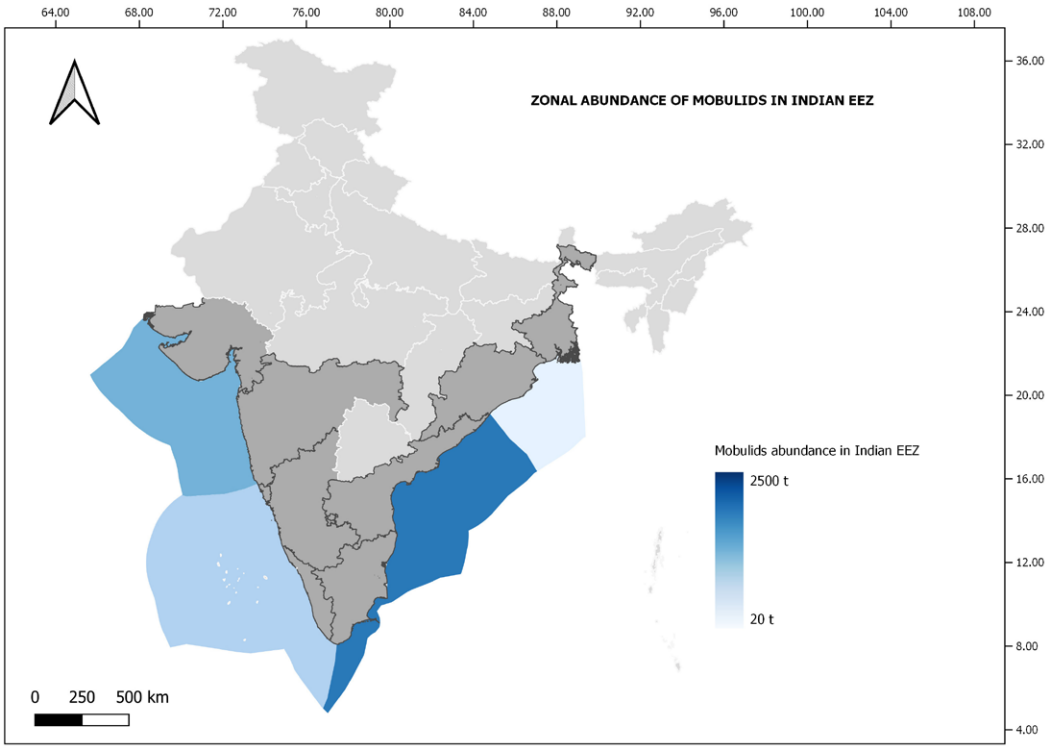

Fig 7. Zonal abundance of *Mobula* spp in Indian EEZ

Distribution in India

Mobula spp. is reported from all along the Indian Coast and is observed in the Indian EEZ. Zonal abundance of *Mobula* spp is shown in Fig 7.

Biology

(i) Size and growth

Mobula tarapacana

Sicklefin devil rays are known to grow to a size of 370 cm in disc width (DW) and weigh up to 400-450 kg in weight (Compagno and Last, 1999; White *et al.*, 2017; Marshall *et al.*, 2019a; Nair *et al.*, 2013; Stevens *et al.*, 2018). But the average or common size encountered are in the range of 200-270 cm DW (Stevens *et al.*, 2018). Several reports on landings of *M. tarapacana* from Indian Ocean are there, with maximum recorded size of 322.0 cm DW from the south-west coast of India for the females. The maximum recorded size for males from India (248 cm DW) was much smaller than females (Nair *et al.*, 2015) from India, but a larger male of 314 cm DW has been reported from adjoining Sri Lanka waters (Fernando and Stevens, 2011). The males are also known to grow to bigger sizes (> 300 cm DW) as reflected in several reports from other parts of tropical Indo-Pacific (White *et al.*, 2006a; Rambahiniarison *et al.*,

2018). An unsexed specimen as big as 330 cm DW has been reported from Arabian Sea (Jabado and Ebert, 2015). Though species-specific information on the longevity of the species is yet to be ascertained, it is likely to be around 15-20 years as inferred based on information on other con-genres (Cuevas-Zimbron *et al.*, 2013; Pardo *et al.*, 2016; Marshall *et al.*, 2019a; Stevens *et al.*, 2018). Length weight relationship for the species, though based on very limited number of individuals depicted isometric growth (b = 2.92) from Gulf of California and hyper-allometric (b = 3.486) from tropical indo-pacific (Notarbartolo di Sciara, 1988; Rambahiniarison *et al.*, 2018). Table 1 presents a comparison of estimates of maximum size and age and size and age at maturity from different localities.

Table1. Measures of size and growth of *M. tarapacana* from different locations

Parameters	Value	Region/Area	Reference
Longevity (in years)	Min. 15		Stevens *et al.*, 2018
	20		Cuevas-Zimbron *et al.*, 2013; Pardo *et al.*, 2016; Marshall *et al.*, 2019a
Maximum size (F) (DW in cm)	305.2	Gulf of California	Notarbartolo di Sciara, 1988
	310.0	Sri Lanka	White *et al.*, 2006a
	328.0	Indonesia	White *et al.*, 2006a
	295.0	Philippines	Rambahiniarison *et al.*, 2018
	190.0	Calicut, India	Mahesh V., *pers. obs.*
	322.0	Kochi, India	Nair *et al.*, 2015
Maximum size (M) (DW in cm)	249.4	Gulf of California	Notarbartolo di Sciara, 1988
	304.0	Indonesia	White *et al.*, 2006a
	317.0	Philippines	Rambahiniarison *et al.*, 2018
	314.0	Sri Lanka	Fernando and Stevens, 2011
	208.0	Calicut, India	Mahesh V., *pers. obs.*
	248.0	Kochi, India	Nair *et al.*, 2015
Maximum size (unsexed) (DW in cm)	370.0	———-	Compagno and Last, 1999; White *et al.*, 2017; Marshall *et al.*, 2019a
	340.0	———-	Stevens *et al.*, 2018
	330.0	Arabian sea	Jabado and Ebert, 2015
Size range (F) (DW in cm)	163.9-328.0	Indonesia	White *et al.*, 2006a
	160.0-295.0	Philippines	Rambahiniarison *et al.*, 2018
	195.0-242.0	Bohol Sea, the Philippines	Rohner *et al.*, 2017
	134.0-260.0	Calicut, India	Mahesh V., *pers. obs.*
	112.0-322.0	Kerala coast, India	Nair *et al.*, 2015
	270.0 (240 kg)	Cuddalore, India	Sureandiran *et al.*, 2020

Parameters	Value	Region/Area	Reference
Size range (M) (DW in cm)	139.5-304.0	Indonesia	White *et al.*, 2006a
	164.0-317.0	Philippines	Rambahiniarison *et al.*, 2018
	200.0-279.0	Bohol Sea, the Philippines	Rohner *et al.*, 2017
	137.0-288.0	Calicut, India	Mahesh V., *pers. obs.*
	226.0-248.0	Kerala, India	Nair *et al.*, 2015
Size range (Unsexed) (DW in cm)	138-314* (*largest size was male)	Sri Lanka	Fernando and Stevens, 2011
	206.0-297.0 (150-450 kg)	Kerala, India	Nair *et al.*, 2013
Length-weigh relationship (LWR)	WT (kg) = $2.376x10^{-8}$DW $(mm)^{2.92}$(r^2= 0.998)	Gulf of California	Notarbartolo di Sciara, 1988
	WT (kg) = $7.344x10^{-7}$ $DW(cm)^{3.486}$(r^2 = 0.98)	Philippines	Rambahiniarison *et al.*, 2018

Mobula thurstoni

Bentfin devil ray is a relatively smaller-size devil ray known to grow to a maximum size of 220 cm DW (unsexed) (Jabado and Ebert, 2015) and weigh up to 200 kg (Stevens *et al.*, 2018). The largest known female has grown to the size of 197 cm whereas male of DW 182 cm were recorded from Indo-pacific region (Rambahiniarison *et al.*, 2018). The species has been reported from several other countries surrounding Indo-pacific region (White *et al.*, 2006a; Fernando and Stevens, 2011; Jabado and Ebert 2015; Rohner *et al.*, 2017; Shirke *et al.*, 2017). From Indian waters, it has been reported from Andaman Sea, a female specimen of 62.4 cm (DW) (Shirke *et al.*, 2017) and off Pamban, Tamil Nadu. The maximum reported size for males and females from Indian waters were 168 and 176 cm DW, respectively. The species is likely to have longevity of at least 10 years and up to 20 years based on inference drawn from other congeners (Cuevas-Zimbron *et al.*, 2013; Pardo *et al.* 2016; Stevens *et al.*, 2018). The regression slope for the LWRs were found in the range of 2.78-3.139 (Notarbartolo di Sciara, 1988; Rambahiniarison *et al.*, 2018) from different regions. Pardo *et al.* (2016) has estimated the population parameters for *M. japanica* which was used as the strong priors for population parameters DW∞ (198.9 cm) and K (0.12-0.28 yr^{1}) used in the Philippines water (Rambahiniarison *et al.*, 2018) considering comparable life span of *M. japanica* and *M. thurstoni*. Mobulids are known to have very low natural (predation) mortality, mostly caused by shark attacks, several of which are non-fatal (Couturier *et al.*, 2012). The probable natural mortality coefficient for the species should be comparable to *M. japanica* (M= 0.087 yr^{1}) (Rambahiniarison *et al.*, 2018). Table 2 presents a comparison of estimates of maximum sizes, age, length weight relationship and growth from different localities.

Table 2. Measures of size and growth of *M. thurstoni* from different locations

Parameters	Value	Region/Area	Reference
Longevity (in years)	At least 10 years		Stevens *et al*., 2018
	20 years		Cuevas-Zimbron *et al*., 2013; Pardo *et al*., 2016
Maximum size (F) (DW in cm)	180.1	Gulf of California	Notarbartolo di Sciara, 1988
	179.0	Indonesia	White *et al*., 2006a
	197.0	Philippines	Rambahiniarison *et al*., 2018
	182.0	Gulf of California	Serrano Lopez *et al*., 2021
	62.4 (2.47 kg)	Andaman, India	Shirke *et al*., 2017
	176.0	Pamban, Gulf of Mannar, India	Remya L., *pers. obs.* (Tamil Nadu)
Maximum size (M) (DW in cm)	177.0	Gulf of California	Notarbartolo di Sciara, 1988
	168.1	Indonesia	White *et al*., 2006a
	173.0	Gulf of California	Serrano Lopez *et al*., 2021
	182.0	Philippines	Rambahiniarison *et al*., 2018
	168.0	Pamban, Gulf of Mannar, India	Remya L., *pers. obs.* (Tamil Nadu)
Maximum size (unsexed) (DW in cm)	197.0	———-	Marshall *et al*., 2019b
	189.0	Sau Paulo, Brazil	Gadig *et al*., 2003
	220.0	Arabian sea	Jabado and Ebert, 2015
	168.0	Sri Lanka	Fernando and Stevens, 2011
	210.0	SW Gulf of California	Sampson *et al*., 2010
Size range (F) (DW in cm)	21.0-180.1	Gulf of California	Notarbartolo di Sciara, 1988
	82.6-179.0	Indonesia	White *et al*., 2006a
	92.0-197.0	Philippines	Rambahiniarison *et al*., 2018
	108.0-187.0	Bohol Sea, Philippines	Rohner *et al*., 2017
	94.0-182.0	Gulf of California	Serrano Lopez *et al*., 2021
	62.4 (2.4 kg)	Andaman, India	Shirke *et al*., 2017
	73.5-176.0	Pamban, Gulf of Mannar, India	Remya L., *pers. obs.* (Tamil Nadu)
Size range (M) (DW in cm)	93.0-168.1	Indonesia	White *et al*., 2006a
	63.0-177.0	Gulf of California	Notarbartolo di Sciara, 1988
	92.0-197.0	Philippines	Rambahiniarison *et al*., 2018
	126.0-182.0	Bohol Sea, the Philippines	Rohner *et al*., 2017
	90.0-173.0	Gulf of California	Serrano Lopez *et al*., 2021
	64.0-168.0	Sri Lanka	Fernando and Stevens, 2011
	164.0-168.0	Pamban, Gulf of Mannar, India	Remya L., *pers. obs.* (Tamil Nadu)
Size range (Unsexed) (DW in cm)	86.0-210.0	SW Gulf of California	Sampson *et al*., 2010
Length-weight relationship (LWR)	WT (kg)= 4.817x10-8DW (mm)2.78(r^2= 0.99)	Gulf of California	Notarbartolo di Sciara, 1988
	WT (kg) = 5.414x10-6 DW $(cm)^{3.139}$(r^2= 0.97)	Philippines	Rambahiniarison *et al*., 2018
*Population Parameter			
DW∞ (cm)	198.9	Philippines	Rambahiniarison *et al*., 2018
K ($year^{-1}$)	0.12-0.28	Philippines	Rambahiniarison *et al*., 2018
t_0 (year)	-1.68	Philippines	Rambahiniarison *et al*., 2018
M ($year^{-1}$)	0.087	Philippines	Rambahiniarison *et al*., 2018

*Adopted as priors from Cuevas-Zimbron *et al*., 2013, Pardo *et al*., 2016 by Rambahiniarison *et al*., 2018 for *M. thurstoni*

Mobula mobular

The species is known to have a life span of 15-20 years (Cuevas-Zimbron *et al.* 2013; Pardo *et al.* 2016; Stevens *et al.*, 2018; Marshall *et al.*, 2020). The maximum recorded size for the documented females of the species was 340 cm DW from Northern Tyrrhenian Sea (Notarbartolo di Sciara and Serena, 1988) and 306 cm DW for males from Gaza (Abudaya *et al.*, 2018). The maximum reported size from Indian waters were 204 and 150 cm DW for female and male, respectively (Remya, L., *pers. obs.*; Mahesh, V. *pers. obs.*). An unsexed specimen as large as 220 cm DW has been reported from Tuticorin, Tamil Nadu (Zacharia and Kanthan, 2010). An unsexed specimen of the species of size 520 cm DW were reported from off Algeria waters (Pellegrin, 1901; Notarbartolo di Sciara *et al.* 1987; Fernando, 2018), which is mostly a specimen of *M. birostris* misidentified as *M. mobular* (Notarbartolo di sciara *et al.*, 2020a). The hyper-allometric growth has been reported waters of Gaza (Abudaya *et al.*, 2018). Table 3 presents a comparison of estimates of maximum size and age and size and age at maturity from different localities.

Table 3. Measures of size and growth of *M. mobular* from different locations

Parameters	value	Region/Area	Reference
Longevity (in years)	Min. 15		Stevens *et al.*, 2018
	20		Pardo *et al.* 2016,Cuevas-Zimbron *et al.* 2013,Marshall *et al.*, 2020
Maximum size (F) (DW in cm)	320.0	Gaza	Abudaya *et al.*, 2018
	340.0	Northern Tyrrhenian Sea	Notarbartolo di Sciara and Serena, 1988
	270.0	Gulf of Antalya	Basusta and Ozbek, 2017
	217.0	Gulf of California	Gaskins, 2019
	270.0	Gulf of California	Serrano Lopez *et al.*, 2021
	204.0	Pamban, Gulf of Mannar, India	Remya L., *pers. obs.* (Tamil Nadu)
	153.0	Orissa, India	Subal R., *pers. obs.* (Orissa)
	148.0	Calicut,India	Mahesh V., *pers. obs.* (Kerala)
Maximum size (M) (DW in cm)	306.0	Gaza	Abudaya *et al.*, 2018
	300.0	Adriatic Sea	Scacco *et al.*, 2009
	272.0	Gulf of Antalya	Basusta and Ozbek, 2017
	270.0	Gulf of California	Serrano Lopez *et al.*, 2021
	149.0	Orissa, India	Subal R., *pers. obs.* (Orissa)
	150.0	Calicut, India	Mahesh V., *pers. obs.* (Kerala)
Maximum size (unsexed) (DW in cm)	350 .0	Gulf of California	Notarbartolo di Sciara *et al.*, 2020a
	455.0*	Gulf of Cadiz (Spain)	Lozano, 1928
	470.0*	Paris Museum	Bigelow and Schroeder, 1953
	483.0**	France	Notarbartolo di Sciara *et al.*, 2020a
	520.0**	Off Algeria	Pellegrin, 1901; Notarbartolo di Sciara *et al.*, 1987
	320.0		Stevens *et al.*, 2018
	320.0	Gaza	Abudaya *et al.*, 2018
Size range (F) (DW in cm)	240.0-320.0	Gaza	Abudaya *et al.*, 2018
	197.0-217.0	Gulf of California	Gaskins, 2019
	101.0-270.0	Gulf of California	Serrano Lopez *et al.*, 2021
	145.0-153.0	Orissa, India	Subal R., *pers. obs.* (Orissa)
	55.0-125.0	Calicut, India	Mahesh V., *pers. obs.* (Kerala)

Parameters	value	Region/Area	Reference
Size range (M) (DW in cm)	180.0-300.0	Gaza	Abudaya *et al.*, 2018
	90.0-230.0	Sri Lanka	Fernando, 2018
	76.0-280.0	Gulf of California	Serrano Lopez *et al.*, 2021
	132.0-149.0	Orissa, India	Subal R., *pers. obs.* (Orissa)
	67.0-128.0	Calicut, India	Mahesh V., *pers. obs.* (Kerala)
Size range (Unsexed) (DW in cm)	173.0-320.0	Gaza	Abudaya *et al.*, 2018
	180.0-300.0	Adriatic Sea	Bello *et al.*, 2012
	162.0-220.0	Tuticorin Fishing Harbour, India	Zacharia and Kanthan, 2010
Length-weight relationship (LWR)	WT (kg) = $2.68x10^{-6}$DW $(cm)^{4.39}$(r^2 = 0.97)	Gaza	Abudaya *et al.*, 2018

** The specimens are currently confirmed as Manta birostris*

*** the specimen is currently presumed to be of M. birostris (Notarbartolo di Sciara et al., 2020a)*

Several reports in the name *Mobula diabolus* are available from Indian waters with maximum reported size for female and male as 450 and 265 cm DW (Rajapackiam *et al.*, 1994; Pillai, 1998). The landings from Indian waters were in the size range of 114.3 to 450 cm DW for females (Setna and Sarangdhar, 1949; Pillai, 1998) and 175 to 265 cm DW for male (Rajapackiam *et al.*, 1994). Table 4 presents a comparison of estimates of maximum size and age and size and age at maturity from different localities.

Table 4. Measures of size and growth of *M. diabolus* from different locations

Parameters	Value	Region/Area	Reference
Maximum size (F) (DW in cm)	127.0	Mumbai, India	Setna and Sarangdhar, 1949
	450.0*	Vizhinjam, India	Pillai, 1998
	265.0	Gulf of Mannar, India	Rajapackiam *et al.*, 1994
	140.0	Mumbai, India	Raje and Zacharia, 2009
	240.0	Chennai, India	ICAR-CMFRI, *unpub. data*
Maximum size (M) (DW in cm)	265.0	Gulf of Mannar, India	Rajapackiam *et al.*, 1994
	130.0	Mumbai, India	Raje and Zacharia, 2009
	245.0	Chennai, India	ICAR-CMFRI, unpub. data
Maximum size (unsexed) (DW in cm)	112.0	Calicut, India	Devadoss, 1984
	167.4	Gulf of Mannar, India	Talwar and Kackar, 1984
	79.0	Veraval, India	Borrell *et al.*, 2011
Size range (F) (DW in cm)	396.0-450.0* (500-850 kg)	Vizhinjam, India	Pillai, 1998
	165.0-265.0	Gulf of Mannar, India	Rajapackiam *et al.*, 1994
	114.3-127.0	Mumbai, India	Setna and Sarangdhar, 1949
	108.0-240.0	Chennai, India	ICAR-CMFRI, *unpub. data*
Size range (M) (DW in cm)	175.0-265.0	Gulf of Mannar, India	Rajapackiam *et al.*, 1994
	85.0-245.0	Chennai, India	ICAR-CMFRI, *unpub. data*
Size range (Unsexed) (DW in cm)	62.0-112 .0	Calicut, India	Devadoss, 1984
	57.2-167.4 (14-44 kg)	Gulf of Mannar	Talwar and Kackar, 1984
	75.0-79.0	Veraval, India	Borrell *et al.*, 2011

*Note: *The size is much larger than reported from any other part of the world and could probably be a case of misidentification of M. birostris as M. diabolus.*

Mobula japanica (junior synonym of *M. mobular)*

The spinetail devil ray (*Mobula japanica*) is a relatively large-sized ray growing to >300 cm DW. The maximum size reported for the species globally was 3.1m (Paulin *et al.*, 1982). The age at maturity and maximum age of spine tail devil ray are 2 and 14 respectively. It is a late maturing species males and females mature at 210 and 207 cm DW respectively (Notarbartalo di Sciara, 1988). It has a long lifespan of about 15-20 years and is a late maturing species (Rambahiniarison *et al.*, 2018). Studies from Indian waters are sparse. The size common in the fishery is reported to be 67 to 301 cm. The maximum size reported from India is 304 cm (Nair *et al.*, 2013). The asymptotic disc width estimated at 299 cm (Bohol Sea, Philippines). Table 5 presents a comparison of estimates of maximum size and age and size and age at maturity from different localities.

Table 5. Measures of size and growth of *M. mobular* reported as *M. japanica* from different locations

	Measure (DW, cm)	Location	References
Maximum size (F) (DW in cm)	248.0	Gulf of Mexico	Notarbartolo di Sciara, 1987
	310.0	New Zealand	Paulin *et al.*, 1982
	284.0	Indonesia	White *et al.*, 2006a
	235.0	Philippines	Rambahiniarison *et al.*, 2018
	471.0	Off West Bengal, India	Swatipriyanka S., *pers. obs.*
	280.0	Off Karnataka, India	Sujitha T. and Purushottama, G. B. *pers. obs.*
	183.0	Off Gujarat, India	Shikha R., *pers. obs.*
	390.0	Off Kochi, India	Rekha J. N., *pers. obs.*
	176.0	Off Chennai, India	Shoba J. K., *pers. obs.*
	215.0	Off Vizag, India	Muktha M., *pers. obs.*
Maximum size (M) (DW in cm)	240.0	Indonesia	White *et al.*, 2006a
	246.0	Off Karnataka, India	Sujitha T. and Purushottama, G. B. *pers. obs.*
	218.0	Off Chennai, India	Shoba J. K., *pers. obs.* (Tamil Nadu)
	213.0	Off Vizag, India	Muktha M., *pers. obs.* (Andhra Pradesh)
Unknown	310.0	Kerala, India	Nair *et al.*, 2015
Size at maturity (F) (DW in cm)	>236.0	Gulf of Mexico	Notarbartolo di Sciara, 1987b
	213.8	Philippines	Rambahiniarison *et al.*, 2018
	205.0	Off Karnataka, India	Purushottama, G. B. and Sujitha T. *pers. obs.*
	200.0-220.0	Off West Bengal, India	Swatipriyanka S., *pers. obs.* (West Bengal)
Size at maturity (M) (DW in cm)	205.0-215.0	Gulf of Mexico	Notarbartolo di Sciara, 1987b
	201.6	Indonesia	White *et al.*, 2006a
	205.8	Philippines	Rambahiniarison *et al.*, 2018
	199.0	Off Karnataka, India	Purushottama, G. B. and Sujitha T. *pers. obs.*
Age at maturity (F) (years)	5-6		Pardo *et al.*, 2016
	9.1	Philippines	Rambahiniarison *et al.*, 2018
Age at maturity (M)			
Max age (years)	14	Mexico	Cuevas-Zimbron *et al.*, 2012
	20	Philippines	Rambahiniarison *et al.*, 2018

	Measure (DW, cm)	Location	References
Length-weight relationship (LWR)		California waters	Croll *et al.*, 2012
		Northern Peru	Alfaro-Cordova *et al.*, 2017
		Off Karnataka, India	Purushottama, G. B. and Sujitha T. *pers. obs.*
Population parameters			
DW∞ (cm)	299	Philippines	Rambahiniarison *et al.*, 2018
K (year^{1})	0.28	Mexico	Cuevas-Zimbron *et al.*, 2012
	0.12	Philippines	Rambahiniarison *et al.*, 2018
t0 (year)	-1.68	Philippines	Rambahiniarison *et al.*, 2018

Mobula kuhlii

The shortfin devil ray (*Mobula kuhlii*) is a small to medium-sized ray growing to >100 cm disc width (DW). The maximum size reported for the species globally was 1.35 m (Rigby *et al.*, 2020a). The age at maturity and maximum age of shortfin devil ray are unknown. It is a late maturing species and males and females mature at 115 and 116 cm DW respectively (Last *et al.* 2016, Stevens *et al.*, 2018). Studies from Indian waters are sparse. Asymptotic size of *M. kuhlii* is unknown. Table 6 presents a comparison of estimates of maximum sizes from different localities.

Table 6. Measures of maximum sizes of *M. kuhlii* from different locations

Parameters	Value	Region/Area	Reference
Maximum size (F) (DW in cm)	120.0	Muttrah, Gulf of Oman	Randall, 1995
	70.0-125.0	Muttrah, Gulf of Oman	Reeve and Henderson, 2012
	23.9-45.0	Fujeirah, UAE, Gulf of Oman	Notarbartolo di Sciara *et al.*, 2017
	32.4-122.0	Sharjah and Ras Al Khaimah, UAE, Gulf of Oman	Notarbartolo di Sciara *et al.*, 2017
Maximum size (M) (DW in cm)	119.7	Indonesia	White *et al.*, 2006a
	109.0-116.0	Muttrah, Gulf of Oman	Reeve and Henderson, 2012
	90.4-103.4	Arabian Sea	Notarbartolo di Sciara *et al.*, 2017
	90.4-103.4	Salalah, Oman, Arabian Sea	Notarbartolo di Sciara *et al.*, 2017
	83.9-110.0	Fujeirah, UAE, Gulf of Oman	Notarbartolo di Sciara *et al.*, 2017
	62.0	Muttrah, Gulf of Oman	Reeve and Henderson, 2012
	65.6	Off Iran	Ali Rastgoo, in litt
	122.0	Pamban, Gulf of Mannar, India	Remya L., *pers. obs.* (Tamil Nadu)
Maximum size (unsexed) (DW in cm)	135.0		Couturier *et al.*, 2012

Mobula eregoodoo

The longhorned pygmy devil ray (*Mobula eregoodoo*) is a small to medium-sized ray growing to >120 cm DW. The maximum size reported for the species globally was 1.30 m. The age at maturity and maximum age of longhorned pygmy devil ray are unknown. It is a late maturing species and males female mature at 92.5 and 99 cm DW respectively (Broadhurst *et al.*, 2018). Studies from Indian waters are sparse. The maximum size reported from India is 125 cm (Remya, *pers. obs.*). Asymptotic size of *M. eregoodoo* is also unknown. Table 7 presents a comparison of estimates of maximum size of *M. eregoodoo* from different localities.

Table 7. Measures of maximum sizes of *M. eregoodoo* from different locations

Parameters	Value	Region/Area	Reference
Maximum size (F) (DW in cm)	105.0	Qatar, Gulf	Moore, 2012
	62.0	Jeddah, Saudi Arabia, Red Sea	Spaet and Berumen, 2015 Spaet, *pers. comm.*
	88.9	Various location, Gulf	Notarbartolo di Sciara *et al.*, 2017
	58.4	Fujeirah, UAE Gulf of Oman	Notarbartolo di Sciara *et al.*, 2017
	130.0	Northern New South Wales, Australia	Broadhurst *et al.*, 2018
	125.0	Pamban, Gulf of Mannar, India	Remya L., *pers. obs.* (Tamil Nadu)
Maximum size (M) (DW in cm)	77.8	Penang, Malaysia	**Cantor, 1849
	93.0	Muttrah, Gulf of Oman	Henderson and Reeve, 2011
	95.6	Various location, Gulf	Notarbartolo di Sciara *et al.*, 2017

***Dicerobatis regodoo* Cantor, 1849 was one of previous synonyms of *M. eregoodoo*

(ii) Reproduction

Mobula tarapacana

Like all mobulids, sicklefin devil rays exhibit aplacental viviparity giving birth to live young ones. These mobulids are one among the slow growing species attaining maturity at relatively older age compared to several other elasmobranchs. The age at maturity for the species is yet unknown but it could possibly be in the range of 5-6 years as inferred from information on other related species (Cuevas-Zimbron *et al.*, 2013; Pardo *et al.*, 2016; Stevens *et al.*, 2018; Marshall *et al.*, 2019a). The size at maturity were observed in the DW range of 270-280 cm for females and 198-250 cm for males (Stevens *et al.*, 2018). A recent study from the tropical Indo-Pacific (Philippines) estimated size at maturity for the species as 264.8 cm DW and 252.1 cm DW for the females and males of *M. tarapacana,* respectively (Rambahiniarison *et al.*, 2018). A report from Indonesian waters found the size at maturity for males in the range of 234-252.2 cm DW (White *et al.*, 2006a). The species gives birth to one pup after a gestation period of one year. The estimated age at birth was in the range of 117-132 cm (Stevens *et al.*, 2018). The pups of *M. tarapacana* as small as 103 cm DW has been recorded from Indian waters (Nair *et al.*, 2015). Nair *et al.* (2013) indicated the predominance of females in the fishery along the south west coast of India whereas the sex ratio of unity (1:1) or close to unity has been reported from other parts of tropical Indo-pacific (White *et al.*, 2006a; Haque *et al.*, 2020). The available information has been compiled and presented in Table 8.

Table 8. Reproductive traits of *M. tarapacana*

Parameters	Value	Region/Area	Reference
Age at maturity (in years)	5-6		Cuevas-Zimbron *et al.*, 2013; Pardo *et al.*, 2016; Stevens *et al.*, 2018; Marshall *et al.*, 2019a
Size at maturity (F) (DW in cm)	270.0-280.0		Stevens *et al.*, 2018
	264.8	Philippines	Rambahiniarison *et al.*, 2018
	270.0-280.0	Arabian Sea	Jabado and Ebert, 2015
Size at maturity (M) (DW in cm)	198.0-250.0		Stevens *et al.*, 2018 Marshall *et al.*, 2019a
	248.6 (234-252.2)	Indonesia	White *et al.*, 2006a
	252.1	Philippines	Rambahiniarison *et al.*, 2018
	240.0-250.0	Arabian Sea	Jabado and Ebert, 2015
Sex ratio (M:F)	1.09:1	Indonesia	White *et al.*, 2006a
	1:1	Bangladesh	Haque *et al.*, 2020
	0.81:1	Sri Lanka	Fernando and Stevens, 2011
	0.75:1	Sri Lanka	Fernando, 2018
	1:1.2	Kochi, India	Rekha J. N., *pers. obs.* (Kerala)
Size at birth in cm DW & number of pups (litter size)	117.0-132.0 (1)		Stevens *et al.*, 2018
	>105.2 (1)	Taiwan	Notarbartolo di Sciara, 1987
	100.0-140.0	Arabian Sea	Jabado and Ebert 2015
	103.0 (1)	Kerala coast, India	Nair *et al.*, 2015

Mobula thurstoni

The species exhibits aplacental viviparity giving birth to either one or two pups in the size range of 40.5-90 cm DW (Doumbouya, 2011; Rambahiniarison *et al.*, 2018; Remya, L. *pers. obs.*). The estimated age at maturity is not clearly known but believed to be in the range of 4.5-12.7 years (Rambahiniarison *et al.*, 2018). The females are known to attain maturity in the size range of 150-163.6 cm whereas the males attain maturity in the size range of 150-158.4 cm DW (Notarbartolo di Sciara, 1987; White *et al.*, 2006a; Stevens *et al.*, 2018; Rambahiniarison *et al.*, 2018; Jabado and Ebert 2015; Marshall *et al.*, 2019b). Most of the reports documented the dominance of females (White *et al.*, 2006a; Fernando and Stevens, 2011; Haque *et al.*, 2020) barring the report from Gulf of California (Notarbartolo di Sciara, 1987), where the males slightly outnumbered females. The available information has been compiled and presented in Table 9.

Table 9. Reproductive traits of *M. thurstoni*

Parameters	Value	Region/Area	Reference
Age at maturity (in years)	4.5-12.7	Philippines	Rambahiniarison *et al.*, 2018
Size at maturity (F) (DW in cm)	150.0		Notarbartolo di Sciara, 1987, Stevens *et al.*, 2018, Jabado and Ebert 2015
	150.0-163.0		Marshall *et al.*, 2019b
	150.0-160.0	Gulf of California	Serrano Lopez *et al.*, 2021
	163.6	Philippines	Rambahiniarison *et al.*, 2018

Size at maturity (M) (DW in cm)	150.0		Notarbartolo di Sciara, 1987, Stevens *et al.*, 2018, Jabado and Ebert, 2015
	150.0-158.0		Marshall *et al.*, 2019b
	151.38	Gulf of California	Serrano Lopez *et al.*, 2021
	153.8	Indonesia	White *et al.*, 2006a
	158.4	Philippines	Rambahiniarison *et al.*, 2018
Sex ratio (M:F)	1.18: 1	Gulf of California	Notarbartolo di Sciara, 1988
	1.01:1	Gulf of California	Serrano Lopez *et al.*, 2021
	0.89:1	Indonesia	White *et al.*, 2006a
	0.6:1	Bangladesh	Haque *et al.* 2020
	0.81:1	Sri Lanka	Fernando and Stevens, 2011
	1:1	Sri Lanka	Fernando, 2018
Size at birth in cm DW & number of pups (litter size)	65-85(1)		Stevens *et al.*, 2018
	70-90(1)		Marshall *et al.*, 2019b
	1 pup	Gulf of California	Serrano Lopez *et al.*, 2021
	1or 2* pup (25% of female examined had 2 pups)	Republic of Guinea	Doumbouya, 2011
	65-85(1)	Taiwan	Notarbartolo di Sciara, 1987
	90 (1 or 2*) [*observed only 2 times i.e. 1.4% of pregnancy]	Philippines	Rambahiniarison *et al.*, 2018
	65-85	Arabian sea	Jabado and Ebert, 2015
	40.5-60.5 (1)	Pamban, Gulf of Mannar, India	Remya L., *pers. obs.* (Tamil Nadu)

Mobula mobular

The species attain maturity at the age of 5-6 years (Stevens *et al.*, 2018; Marshall *et al.*, 2020). At the disc width of 200 cm DW, both males (Sri Lanka, Fernando, 2018) and females are known to mature (Gaza, Abudaya *et al.*, 2018). Wide variation in sex ratio have been reported from different parts of the world. The pre-dominance of male as high as 11.36 times of female were reported from Gaza (Abudaya *et al.*, 2018) whereas from Bangladesh the females were known to be dominant in the catch (Haque *et al.*, 2020). From Indian waters also, the females were found dominant in commercial landings (Zacharia and Kanthan, 2010). The new born pups are mostly one in number (rarely two) and in the size range of 90-160 cm (Marshall *et al.*, 2020). The available information has been compiled and presented in Table 10.

Table 10. Reproductive traits of *M. mobular*

Parameters	value	Region/Area	Reference
Age at maturity (in years)	5-6 years	Philippines	Stevens *et al.*, 2018, Marshall *et al.*, 2020
Size at maturity (F) (DW in cm)	207.0		Stevens *et al.*, 2018,
	200.0	Gaza	Abudaya *et al.*, 2018
	215.0-240.0		Marshall *et al.*, 2020
	205.0-215.0	Gulf of California	Serrano Lopez *et al.*, 2021

Size at maturity (M) (DW in cm)	210 .0		Stevens *et al.*, 2018
	200.0-220.0		Marshall *et al.*, 2020
	200 .0	Sri Lanka	Fernando, 2018
	196.36	Gulf of California	Serrano Lopez *et al.*, 2021
Sex ratio (M:F)	11.36:1	Gaza	Abudaya *et al.*, 2018
	0.41:1	Bangladesh	Haque *et al.* 2020
	0.86:1	Sri Lanka	Fernando, 2018
	0.62:1	Gulf of California	Serrano Lopez *et al.*, 2021
	4.26:1	Tuticorin Fishing Harbour, India	Zacharia and Kanthan, 2010
Size at birth in cm DW & number of pups (litter size)	>160 (1)		Stevens *et al.*, 2018
	90-160 (1 or occasionally 2)		Marshall *et al.*, 2020
	165.9 (1)	Northen Tyrrhenian Sea	Notarbartolo di Sciara and Serena, 1988
	91(1)	Gulf of California	Gaskins, 2019
	1	Gulf of California	Serrano Lopez *et al.*, 2021

Mobula diabolus (junior synonym of *M. mobular*)

The smallest known female of the species is 114 cm (Setna and Sarangdhar, 1949) while the smallest free-swimming male observed in the fishery off Chennai, India measured 85 cm DW (Shoba J. K., *pers. obs.*) and male attain maturity at the smallest known size of 115 cm (Raje and Zacharia, 2009). The sex ratio (M: F) was found in the range of 0.5:1 (Mumbai, Raje and Zacharia, 2009) to 1.2: 1 (Gulf of Mannar, Rajapackiam *et al.*, 1994). The species is a viviparous matrotroph, giving birth to single pup of size 37.5-40 cm DW (Setna and Sarangdhar, 1949; ICAR-CMFRI, *unpubl.*). The available information has been compiled and presented in Table 11.

Table 11. Reproductive traits of *M. diabolus*

Parameters	value	Region/Area	Reference
Size at maturity (F)	130	Mumbai, India	Raje and Zacharia, 2009
(DW in cm)	114	Mumbai, India	Setna and Sarangdhar, 1949
Size at maturity (M) (DW in cm)	115	Mumbai, India	Raje and Zacharia, 2009
Sex ratio (M:F)	0.5:1	Mumbai, India	Raje and Zacharia, 2009
	1.2: 1	Gulf of Mannar, India	Rajapackiam *et al.*, 1994
	0.63:1	Chennai, India	ICAR-CMFRI, *unpub. data*
Size at birth in DW cm (litter size)	37.5-40 (1)	Mumbai, India	Setna and Sarangdhar, 1949
Smallest free-swimming individual	<85 (1)	Chennai, India	Shoba J.K., *per.obs*

Mobula japanica (junior synonym of *M. mobular*)

The spinetail devil ray exhibits aplacental vivipary or ovoviviparity, i.e., the pup wrapped in a membranous eggcase hatches inside mother's uterus and feeds on mother's uterine milk until full development (Stevens *et al.*, 2018). Size at pregnancy is estimated at 261.1 cm at the end of 9.8 years (Rambahiniarison *et al.*, 2018). Gestation period is one year with a pregnancy interval of 2-5 years, litter size is one and size at birth ranges between 58 and 100 cm (Notarbartolo di Sciara, 1988; Homma *et al.*, 1997; Marshall and Bennet 2010; Croll *et al.*, 2015). Reports are scanty regarding the reproduction of spinetail devil ray in the Indian waters. More pregnant females encountered in April, June-July. The maximum density of juveniles was recorded from nearshore waters during October to

December and February (Shoba J. K., *pers. obs.,* Purushothama G. B., *pers. obs.,* Swatipriyanka S., *pers. obs.*). The pupping season of *M. japanica* off Karnataka was observed during August to December (Purushothama G. B., *pers. obs.).* The available information has been compiled and presented in Table 12.

Table 12. Reproductive traits of *M. japanica*

Parameters	value	Region/Area	Reference
Age at maturity (F)	5-6		Pardo *et al.*, 2016
(in years)	9.1	Philippines	Rambahiniarison *et al.*, 2018
Size at maturity (F)	>236.0	Gulf of Mexico	Notarbartolo di Sciara, 1987
(DW in cm)	213.8	Philippines	Rambahiniarison *et al.*, 2018
	205.0	Off Karnataka, India	Purushottama G. B. and Sujitha T. *pers. obs.*
	200.0-220.0	Off West Bengal, India	Swatipriyanka S., *pers. obs.*
Size at maturity (M)	205.0-215.0	Gulf of Mexico	Notarbartolo di Sciara, 1987
(DW in cm)	201.6	Indonesia	White *et al.*, 2006a
	205.8	Philippines	Rambahiniarison *et al.*, 2018
	199.0	Off Karnataka, India	Purushottama G. B. and Sujitha T. *pers. obs.*
Sex ratio (M:F)	1:1.31	Indonesia	White *et al.*, 2006a
Size at birth in cm DW	58.0-85.0	New Zealand	Paulin *et al.*, 1982
(litter size)	56.0	New Zealand	Stewart, 2002
	90.0	Indonesia	White *et al.*, 2006a
	100.0-104.0	Philippines	Rambahiniarison *et al.*, 2018
	110.0	Tuticorin, India	Sivadas *et al.*, 2013
	<93 (1)	Chennai, India	Shoba J. K., *pers. obs.*
	80-103 (1)	Off Karnataka, India	Purushottama G. B. and Sujitha T. *pers. obs.*
	70-90 (1)	Off West Bengal, India	Swatipriyanka S., *pers. obs.*
	>105.2 (1)	Gulf of California	Notarbartolo di Sciara, 1988
	(1)		Marshall and Bennet 2010
	103.0 (1)	Off Kochi	Rekha J. N., *pers. obs.* (Kerala)
Pupping season	August to December	Off Karnataka, India	Purushottama G. B. and Sujitha T. *pers. obs.*

Mobula kuhlii

The shortfin devil ray exhibits aplacental vivipary, i.e., the pup wrapped in a membranous eggcase hatches inside mother's uterus and feeds on mother's uterine milk until full development (Stevens *et al.*, 2018). Gestation period is unknown, pup size is one and size at birth ranges between 31 and 34 cm (Rigby *et al.*, 2020a). Reports are scanty regarding the reproduction of shortfin devil ray in the Indian waters. The pupping season also unknown for *M. kuhlii* and the expected resting period for all mobulids is 1 to 3 years between pregnancies (Rambahiniarison *et al.* 2018). There is not much published information on reproductive behaviour of shortfin devil ray. The available information has been compiled and presented in Table 13.

Table 13. Reproductive traits of *M. kuhlii*

Parameters	value	Region/Area	Reference
Size at maturity (M) (DW in cm)	1.15-1.19	Indonesia	White *et al.*, 2006a,
Size at birth in cm DW ((litter size))	31.0-34.0 (1) 49.8-64.5 (1)	Indonesia	Rigby *et al.*, 2020a White *et al.*, 2006a

Mobula eregoodoo

The longhorned pygmy devil ray exhibits aplacental vivipary or ovoviviparity. Size at maturity is estimated at 99 and 92.5 cm for male and female respectively (Broadhurst *et al.*, 2018). Gestation period estimated at 10 months, probably one year with a pregnancy interval of 1-3 years. The pup size is one and size at birth ranges between 7 and 43 cm (Broadhurst *et al.*, 2018; Rigby *et al.*, 2020b). Reports are scanty regarding the reproduction of longhorned pygmy devil ray in the Indian waters except at Pamban, Gulf of Mannar, where one gravid female of 125 cm disc width was landed during November 2016 (Remya L., *pers. obs.).* The pupping season unknown for *M. eregoodoo,* while more gravid females observed during April and December off northern New South Wales, Australia (Broadhurst *et al.*, 2019). The available information has been compiled and presented in Table 14.

Table 14. Reproductive traits of *M. eregoodoo*

Parameters	value	Region/Area	Reference
Size at maturity (F) (DW in cm)	92.5	Northern New South Wales, Australia	Broadhurst *et al.*, 2018
Size at maturity (M) (DW in cm)	99.0	Northern New South Wales, Australia	Broadhurst *et al.*, 2018
Sex ratio (M:F)	1:1.81	Northern New South Wales, Australia	Broadhurst *et al.*, 2018
Size at birth in cm DW (litter size)	43.0 (1) 7.0-21.2 (1)	Northern New South Wales, Australia	Rigby *et al.*, 2020b Broadhurst *et al.*, 2018

(iii) Feeding ecology

Mobula tarapacana

Like most other mobulids the species is believed to be the filter feeder. Their diet composed of crustacean zooplanktons and smaller fishes like carangids, anchovies & tetradontids. It was noted that mesh size of gill plates was bigger than other mobulids species which could have accounted for higher percentage of fish in the diet of the species (Notarbartolo di Sciara, 1988). The dominance of crustacean zooplankton was also recorded from Indo-pacific region (Rohner *et al.*, 2017).

Mobula thurstoni

The species exhibits filter feeding behavior (Stevens *et al.*, 2018) with affinity towards crustacean zooplanktons. It is reported to have preference towards euphausiids as their major prey. The seasonal variation in prey preference were also noticed with mysids being dominant component during winter (Notarbartolo di Sciara, 1988; Sampson *et al.*, 2010; Rohner *et al.* 2017; Coasaca-Cespedes *et al.*, 2019). From Indian waters, it is known to feed upon *Lucifer sp* and *Nanocalanus sp.*as the major prey item (Shirke *et al.*, 2017) and also have fishes and cephalopods (Remya L., *pers. obs.*) as diet components.

Mobula mobular

Like most of the other devil ray species, the species is reported to have preference towards crustacean zooplanktons. The euphausiids were found to be the most dominant component of the prey items followed by other copepods (Coasaca-Cespedes, *et al.*, 2019). Basusta and Ozbek (2017) reported sea grass and parts of bony fish in the guts of *M. mobular.*

Mobula diabolus

The species is known to prey upon crustaceans, zooplanktons and other small pelagic fishes as recorded from NW and SW coast of India (Devadoss, 1984; Borrell *et al.* 2011).

Mobula japanica

Mobula japanica occupies a medium trophic level, 3.43 in the ecosystem. It is a stenophagous predator, feeding almost exclusively upon the subtropical euphausiid *Nyctiphanes simplex*, and to a lesser extent to cephalopods, myctophid fishes and other pelagic crustaceans (Notarbartolo di Sciara, 1988, Sampson *et al.*, 2010, Rohner *et al.*, 2017). Diet of the species from Indian waters includes *Acetes* spp., *Charybdis smithii*, *Solenocera* spp., *Parapenaeopsis sculptilis, Stolephorus* spp. (Purushottama G. B., *pers. obs.*; Rekha J. N., *pers. obs.*); shrimps, small sciaenids, nemipterids and clupeids (Swatipriyanka S., *pers. obs.*)

Mobula kuhlii

The species exhibits filter feeding behavior (Sommer *et al.*, 1996) with affinity towards crustacean zooplanktons. The detailed study on diet of *M. kuhlii* is limited in the literatures.

Mobula eregoodoo

Longhorned pygmy devil ray is primarily a filter feeder, feeding mostly upon zooplankton and zooplanktivorous teleosts (Burgess *et al.*, 2020). Remnants of undigested sandy sprat, *Hyperlophus vittatus* (Barbato *et al.*, 2019) are also reported.

(iv) Contribution to catches/landings

Mobula tarapacana

The species, though having patchy distribution contributes significantly to the total mobulid landings of several countries. Significant contributions of more than 20% to the total mobulid catch were recorded from Sri Lanka and Indonesia (White *et al*., 2006a; Fernando and Stevens, 2011). Guangzhou market of China which caters most of the mobulid gill plate trade reported 13% of mobulids as *M. taracapana* in 2013 (O'Malley *et al*., 2016) (Table 15).

Table 15. Catch of *M. tarapacana* across various localities over the years

Catch/% of mobulids	Area/country	Period	Reference
2% of devil rays	Philippines	2002	Marshall *et al*., 2019a
23.5% of mobulid catch	Indonesia	2001-05	White *et al*., 2006a
11.83% of the mobulid catch	Sri Lanka	2011	Fernando and Stevens, 2011
21.9% of mobulid catch	Sri Lanka	2017-18	Fernando, 2018
130 t	West African coast	2003-2007	Amande *et al*., 2010
13% of mobulids	Guangzhou market, china	2013	O'Malley *et al*., 2016
3% of total mobulids	Pakistan	2013-18	Moazzam, 2018
11.2% of mobulid catch	Bangladesh	2018-19	Haque *et al.* 2020
20% of mobulid catch	Tamil Nadu, India	2015-20	Remya L., *pers. obs.*

Mobula thurstoni

The species is less abundant than some of the other congeners but contributes significantly to the mobulids landings of countries like Indonesia, Pakistan and Bangladesh (White *et al*., 2006a; Moazzam, 2018; Haque *et al*., 2020). Along southeast coast of India, 15% of the landed species were identified as *M. thurstoni* and 20% of them were juveniles (Remya L., *pers. obs.*) (Table 16.)

Table 16. Catch of *M. thurstoni* across various localities over the years

Catch/% of mobulids	Area/country	Period	Reference
1% of devil rays	Peru (Tumbes)	2014	Marshall *et al*., 2019b
8.8% of mobulid catch	Indonesia	2001-05	White *et al*., 2006a
1.58% of mobulid catch	Sri Lanka	2017-18	Fernando, 2018
7% of total mobulids	Pakistan	2013-18	Moazzam, 2018
0.79% of mobulid catch	Sri Lanka	2011	Fernando and Stevens, 2011
17% of mobulid catch	Bangladesh	2018-19	Haque *et al.* 2020
15% of the mobulids	Tamil Nadu, India	2015-20	Remya L., *pers. obs.*

Mobula mobular

The species is one among the more abundant species of devil rays and accounted for around 70% of the

total mobulid catch of Sri Lanka (Fernando, 2018). Substantial contribution to the total mobulids landings of Bangladesh and Pakistan comes from *M. mobular* (Moazzam, 2018; Haque *et al.* 2020) Table 17. Around 60% of the specimens observed along Odisha coast, India were known to be the juveniles (Subal R., *pers. obs.*).

Table 17. Catch of *M. mobular* across various localities over the years

Catch/% of mobulids	Area/country	Period	Reference
39.3% of mobulid catch	Bangladesh	2018-19	Haque *et al.* 2020
70% of mobulid catch	Sri Lanka	2017-18	Fernando, 2018
59% of total mobulids	Pakistan	2013-18	Moazzam, 2018
20% of total mobulids	Tamil Nadu, India	2015-21	Remya L., *pers. obs.*

Mobula diabolus

The species is documented to have contributed 0.75% of the total ray landings of Mumbai during the period 1990-2004 along northwest coast of India (Raje and Zacharia, 2009) and 1.96% of total mobulids from Bangladesh along northern Bay of Bengal during 2006-2010 period (Jit *et al.,* 2014). During the period 1999-2006, around 38% and 48% of the landed males and females along Chennai coast, India were juveniles (CMFRI, *unpubl. data*) (Table 18).

Table 18. Catch of *M. diabolus* across various localities over the years

Catch/% of mobulids	Area/country	Period	Reference
1.96% of total ray landings	Chittagong and Cox's Bazar, Bangladesh	2006-2010	Jit *et al.*, 2014
0.75% of total ray landings	Mumbai, India	1990-2004	Raje and Zacharia, 2009

Mobula japanica

The species is one among the more abundant species of devil rays and accounted around 86% of total mobulid catch of Sri Lanka (Fernando and Stevens 2011). Substantial contribution to the total mobulids landings of Pakistan comes from *M. japanica* (Nawaz and Khan, 2015) Table 19. Around 30% of the mobulids observed along Tamil Nadu coast, India were known to be *M. japanica* (Remya L., *pers. obs.*).

Table 19. Catch of *M. japanica* across various localities over the years

Catch/% of mobulids	Area/country	Period	Reference
30% of devil rays	Bohol Sea, The Philippines	2015-16	Rambahiniarison *et al.*, 2018
50.4% of mobulid catch	14 landing sites, Indonesia	2001-2005	White *et al.*, 2006a
97% of mobulid catch	Zorritos, Northern Peru	2015-16	Alfaro-Cordova *et al.*, 2017
99.8% of total mobulids	San Jose, Northern Peru	2015-16	Alfaro-Cordova *et al.*, 2017
60% of mobulid catch	Pakistan	2013-15	Nawaz and Khan, 2015
86% of mobulid catch	Sri Lanka		Fernando and Stevens, 2011
30% of the mobulids	Tamil Nadu, India	2015-18	Remya L., *pers. obs.*

Mobula kuhlii and *M. eregoodoo*

Mobula kuhlii is moderately abundant than some of the other congeners but contributes significantly to the mobulid landings of countries like Indonesia and Pakistan (White *et al.*, 2006a; Nawaz and Khan, 2015). Along Tamil Nadu coast of India, 13% of the landed species were identified as *M. kuhlii.* (Remya L., *pers. obs.*) (Table 20.). Data is scanty on catch of *M. eregoodoo* as its landing is mostly misidentified with *M. kuhlii. M. eregoodoo* formed 2% of mobulid catch in the Tamil Nadu coast during 2015 to 2021 (Remya L., *pers. obs.*).

Table 20. Catch of *M. kuhlii* across various localities over the years

Catch/% of mobulids	Area/country	Period	Reference
2% of devil rays	14 landing sites, Indonesia	2001-2005	White *et al.*, 2006a
27% of mobulid catch	Pakistan	2013-15	Nawaz and Khan, 2015
13% of mobulid catch	Tamil Nadu, India	2015-21	Remya L., *pers. obs.*

General information on *Mobula* spp.

Global fishery

The global reported catch of *Mobula* spp. (manta and devil rays) since 2000 have shown more or less increasing trend with intermittent decline in some years. The landings since 2016 have been much greater than previous year, may be indicative to increasing trade associated with these species (Ward-Paige *et al.*, 2013). This could possibly due to better reporting or market driven retention of these otherwise bycatches of most of the drift gillnetters targeting large pelagic fishes like tuna, sword fishes etc. (Fernando and Stevens 2011; Shahid *et al.*, 2018; Moazzam, 2018) (Fig. 8.).

Fishery in India

Average catch of mobulids during 2007-2020 from Indian waters is estimated at 3595.11 t (Source: NMFDC, ICAR-CMFRI). FAO estimates do not include the catch estimate from ICAR-CMFRI. As the species wise catch data was not consistent across various maritime states, total mobulid catch was compared with elasmobranch landings. The landing of mobulids shows a gradual increase over years except during 2020 as the fishing effort was restricted due to COVID -19 pandemic. The catch was in between 1300 to 3600 t during 2007 to 2012, thereafter it increased to 4600 t in 2013 with maximum catch of 5875.4 t during 2016, which decreased to 3440.5 t in 2017 (Fig 9).

Major fishing gear

The species mostly occupies the surface water column of the ocean and hence encounters gears like surface set gillnets, purse seines and longlines set to catch large pelagic fishes like tunas, sword fishes etc. Among all the gears, gillnets were the major gear catching mobulids in the tropical Indo-pacific. Along Indian coast, mechanised gillnet is the major gear by which the mobulids are caught followed by trawl net and hook and line. There is no targeted fishery of this species and it forms a bycatch in the fishery (CMFRI, 2016).

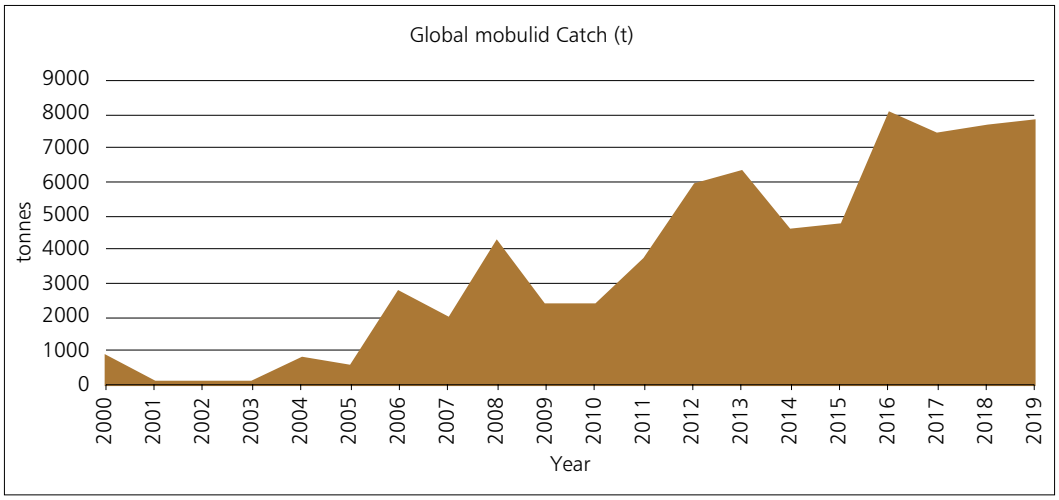

Fig. 8. Global Catch trend for *Mobula* spp. from 2000 to 2019 *[Source: FAO]*

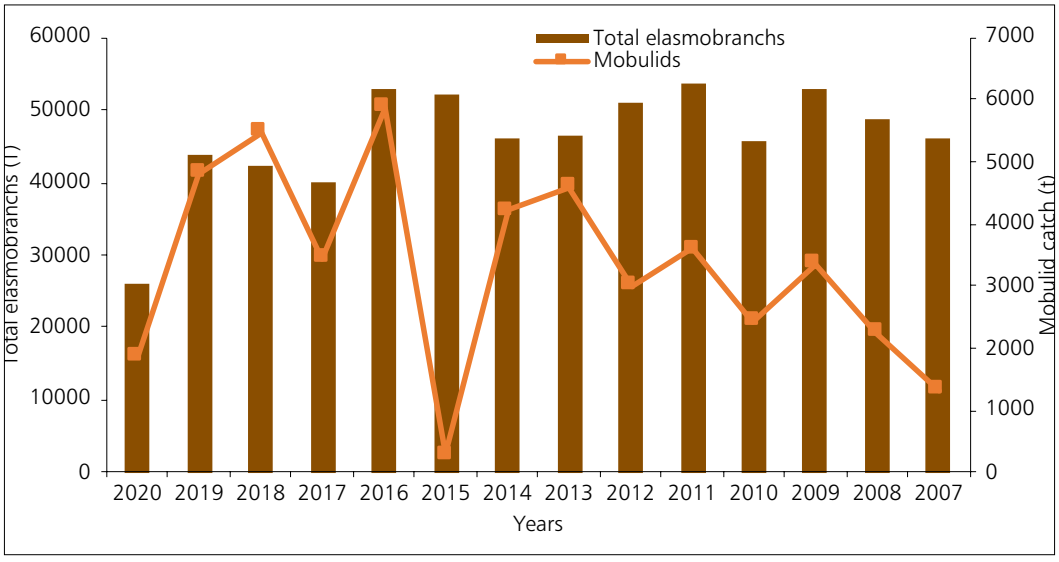

Fig. 9. All India landings of elasmobranchs and mobulids during 2007-2020 (*Source: NMFDC, ICAR-CMFRI*)

Table 21. Major gears employed in various countries for mobulids fishery

Parameters	Details	Region/Area	Reference
Major gears	Gillnets	Pakistan	Moazzam *et al.*, 2018
	Gillnets	Bangladesh	Haque *et al.*, 2020
	Gillnets and Long lines	Sri Lanka	Fernanado and Stevens, 2011
	Gillnets	Philippines	Rambahiniarison *et al.*, 2018
	Gillnets, Purse seine and Long lines	Indonesia	White *et al.*, 2006a
	Gillnets	India	Mohanraj *et al.*, 2009
	Trawls	Odisha, India	Subal R., *pers. obs.*
	Trawls and Gillnets	Pamban, Tamil Nadu, India	Remya L., *pers. obs.*
	Trawls	Calicut, Kerala, India	Mahesh V., *pers. obs.*
	Mechanised Gillnets, Hook & Line	Chennai, Tamil Nadu, India	Shoba J. K., *pers obs.*
	Gillnets	Gujarat, India	Shikha R., *pers. obs.*
	Trawls and Gillnets	West Bengal, India	Swatipriyanka S., *pers. obs.*
	Trawls and Gillnets	Karnataka, India	Sujitha T. and Purushottama G. B., *pers. obs.*

Trade and utilization (For *Mobula* spp.)

Mobulids unlike other elasmobranchs do not attract consumers for their meat or fins, but are targeted for their prized gill plates which find demand in Chinese traditional medicine and Asian dried seafood markets (White *et al.*, 2006a; Couturier *et al.*, 2009). The dried gill plates sold under the trade name of "Pengyusai" is claimed to be effective in ailments ranging from acne to cancer (Heinrichs *et al.*, 2011). Not only in China or SE Asia, even in countries like Bangladesh belief are associated with mobulids which are used to make potions or talisman (Haque *et al.*, 2020). China, Hong and Singapore were the major markets for the dried gill plates whereas the major source of the raw materials are China, Indonesia, Vietnam, Sri Lanka and India (O'Malley *et al.*, 2016). In 2013, out of the total gill plates channeled through Guangzhou market of China, 4% belong to Manta ray, 13% *M. tarapacana* and remaining 83% volume comes from smaller species like *M. japanica* and *M. thurstoni* (O'Malley *et al.*, 2016). The gill plate's price varies with species, size and country. The price for the manta ray gill plates were much higher than that devil rays (White *et al.*, 2006b; O'Malley *et al.*, 2016; Haque *et al.*, 2020). The fresh meat of the *Mobula* spp is consumed locally and not reported to enter export market, whereas the dried meat is found to be exported in addition to the local consumption. The dried skin is fried to make a product named "Kerupuk" similar to prawn crackers in Indonesia. The liver, other entrails, and other parts are used in extraction of liver oil and in tanneries for local utilization (White *et al.*, 2006b; Haque *et al.*, 2020). Like other parts of the world, the most prized commodity taken out of the mobulids in India are gill plates which are dried and exported to China and other SE Asian countries, whereas the meat either fresh or salt-dried mostly goes for domestic consumption (Pillai *et al.*, 1996; Mohanraj *et al.*, 2009, Rajapackiam *et al.*, 2007, 2011; Nair *et al.*, 2013; Kizhakudan *et al.*, 2015). Along Gujarat coast, the meat and other entrails are cut into pieces and used for extraction of oils along with other elasmobranchs (Shikha R., *pers obs.*) (Table 22).

Table 22. Trade and use of mobulids

Parts	Use	Study region	Trade route information	Price information	Reference
Dried gill Plates	Pengyusai (Chinese medicine & Arian dried seafood)	China & SE Asia	Major source: China, Indonesia, Vietnam, Sri Lanka & India Major market: China, Hong Kong, Macau & Singapore	USD 200-419 /kg	O'Malley *et al*., 2016
	Traditional Chinese medicine	Indonesia	Exported to Hong Kong, Taiwan & Singapore	USD 19 / kg	White *et al*., 2006b
	Traditional Chinese medicine	Bangladesh	Exported to Myanmar	USD 4.8 to 24 / kg	Haque *et al*., 2020
		Sri Lanka	Exported to Asian countries	*M. japanica* & *M. thurstoni*: USD 95.53/ kg *M. tarapacana*: USD 113.76/ kg	Fernando and Stevens, 2011
		Chennai, India	Exported to Singapore, Thailand, Malaysia & China	Rs. 500 /kg	Mohanraj *et al*., 2009
		Kochi, India	Sent to Chennai for reprocessing & export	White filter plates = Rs. 9000/kg Black filter plates = Rs. 2000/ kg *M. diabolus* up to Rs. 9000/ kg	Nair *et al*., 2013
		Chennai, India	Export	*M. diabolus* Rs. 500 /kg	Rajapackiam *et al*., 2007
		Chennai, India	Export	Rs. 2500-5000/ kg depending on size	Rajapackiam *et al*., 2011

Parts	Use	Study region	Trade route information	Price information	Reference
Fresh Meat	Local Human consumption	Indonesia		USD 0.33/ kg	White *et al*., 2006b
	Local Human consumption	Bangladesh		USD 1.44 to 6/ kg	Haque *et al*., 2020
	Fresh consumption or for drying	Sri Lanka		*M. japanica* & *M. thurstoni*: USD 1.36/ kg *M. tarapacana*: USD 1.64/ kg	Fernando and Stevens, 2011
		Kochi, India		Rs. 150/kg	Nair *et al*., 2013
		Vizhinjam, India		Rs. 2.81 to 3.38/ kg	Pillai, 1998
		Chennai, India		Rs. 5-8/ kg	Rajapackiam *et al*., 2007
		Gulf of Mannar, India		Rs. 7-9/ kg	Rajapackiam *et al*., 1994
		Kollam, India		Rs. 80/ kg	Baby, 2012
Dried meat	Export	Indonesia	Exported to west Java		White *et al*., 2006b
	Both local consumption & export	Bangladesh		USD 1.8 to 9.6/ kg	Haque *et al*., 2020
Liver & other entrails	Liver oil, tanneries, soap etc	Bangladesh		USD 0.36 to 0.6/ kg (Price of liver and other parts)	Haque *et al*., 2020
	Oil for coating wooden boat (along with other elasmobranchs)	Veraval, Gujarat		Parts are not separately sold (purchased as whole specimens by drying yards) Price of Oil: Rs. 8000-10000 per 200 L barrels	Shikha, *pers. observ.*
Skin	"Kerupuk" (a deep fried product similar to prawn crackers) consumed locally as food	Indonesia			White *et al*., 2006b
Cartilage	As filler to be mixed with low grade shark fin	Indonesia	Export	USD 2.72/ Kg	White *et al*., 2006b

Threats and conservation

Natural predation on mobulids is known to be very low and limited to opportunistic attacks by sharks. Even several of such attacks were found non-fatal and the individuals are known to carry shark inflicted scars (Couturier *et al.*, 2012). Hence, the major threat to the mobulids is fishery-based, from targeted to incidental catches mostly in pelagic gillnets, longlines and purse seining in Indian Ocean (Coelho *et al.*, 2011; Lezama-Ochoa *et al.*, 2015). These rays, owing to their large and broad morphology coupled with show movement and frequent aggregation are highly susceptible to the diverse array of fishing gear. The high incidence of juveniles (about in 20-60% of mobulid landings; ICAR-CMFRI, *unpub. data*) along the different parts of Indian coastline is a matter of concern considering low reproduction potential of the species. Most of the mobulid species have a high value gill plates used mainly in Asian medicine (Anderson *et al.*, 2011; Croll *et al.*, 2015; Lawson *et al.*, 2017). This demand driven (for dried gill plates) capture of these large bodies fishes as indicated in inclining global catches since 2006 (Ward-Paige *et al.*, 2013) could be a major potential threat. The low reproductive potential (late maturity and mostly single pups) renders them highly vulnerable to the increased fishing pressure. Further, the lack of species-specific information on catch, effort and population status forms a great barrier to the conservation and management measure of the species (Jabado *et al.*, 2017).

Mobulids are species of high conservation concern owing to their intrinsic biological characteristics and high vulnerability of fishing activities. All the five species reported from Indian waters fall into the category of endangered (EN) species as per the IUCN assessment. The regional assessment done for the Arabian Seas Region (ASR) finds all species as endangered except *M. kuhlii*, which was found near threatened. All the mobilid species feature in International protective legislations: Convention on International Trade in Endangered species (CITES), Convention on the conservation of Migratory species of Wild Animals (CMS) and Inter-American Tropical Tuna Commission (IATTC). In the Indian Ocean, all mobulids along with other rays enjoys legal protection in Maldivian waters since 2014 (https://saveourseas.com/update/all-ray-species-now-protected-in-the-maldives/) and *M. birostris* and *M. alfredi* in UAE (Lawson *et al.*, 2017). *M. mobular* is legally protected in Bangladesh under Schedule II of Wildlife (Conservation and Security) Act, 2012 (Haque *et al.*, 2020) (Tables 23 and 24).

Table 23. Protective legislations for mobulids

Legal protection	*M. tarapacana*	*M. mobular*	*M. thurstoni*	*M. japanica*	*M. kuhlii*	*M. eregoodoo*
CITES	Yes	Yes	Yes	Yes	Yes	Yes
CMS	Yes	Yes	Yes	Yes	Yes	Yes
Inter-American Tropical Tuna Commission (IATTC)	Yes	Yes	Yes	Yes	Yes	Yes
Western and Central Pacific Fisheries Commission (WCPFC)	Yes	Yes	Yes	Yes	Yes	Yes
Indian Ocean Tuna Commission (IOTC)						
Barcelona convention		Yes				
Bern convention		Yes				
Maldives	Yes	Yes	Yes	Yes	Yes	Yes
Bangladesh		Yes				

Source: Flounder, 2020

Table 24. Global and regional conservation status of mobulids

Species	Global conservation status	Regional conservation status (Arabian Sea Region)
M. tarapacana	Endangered (Marshall *et al*., 2019a)	Endangered in ASR (Jabado *et al*., 2017)
M. thurstoni	Endangered (Marshall *et al*., 2019b)	Endangered in ASR (Jabado *et al*., 2017)
M. mobular	Endangered (Marshall *et al*., 2020)	Endangered in ASR (Jabado *et al*., 2017)
M. diabolus	Assessed as *M. mobular*	Assessed as *M. mobular*
M. japanica	Assessed as *M. mobular*	Assessed as *M. mobular*
M. kuhlii	Endangered (Rigby *et al*., 2020a)	Near threatened (Jabado *et al*., 2017)
M. eregoodoo	Endangered (Rigby *et al*., 2020b)	Near threatened (Jabado *et al*., 2017)

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India Non-Detriment Finding for Devil Rays *Mobula* spp. in the Indian Ocean | 2022 to 2024

Mobulids are medium to large migratory batoid fishes, represented by a single genus *Mobula,* with 9 extant species including two mantas and seven devil rays. These highly specialized groups of fishes have circumglobal tropical and subtropical distribution. These species warrant conservation management as they are highly vulnerable to increased fishing pressure including higher incidence of bycatch. Mobulids contribute significantly to India's elasmobranch and are popular for their prized gill plates which find a market in Chinese traditional medicine and Asian dried seafood trade. All mobulids were included in Appendix II of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) (other than manta rays which were listed earlier) at the 17th Meeting of the Conference of the Parties (CoP17, Johannesburg) in 2016. This Mobulid (all mobulid species except *M. brisotris* and *M. alfredi*) NDF for India is "Positive with Conditions" to enable trade of non-fin commodities (within the permits of existing national legislations on trade in shark commodities and existing CITES regulations) to continue, while improvements are made to existing fisheries and trade management and monitoring systems and while additional research activities and management measures are adopted. This NDF, for the period 2022-2024 will be re-evaluated and updated after three years.

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