CONSERVING MOBULID RAYS

A Global Strategy & Action Plan

Manta TRUST

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CONSERVING MOBULID RAYS

INTRODUCTION

Manta and devil rays, known collectively as mobulids, are some of the most fascinating and enigmatic creatures in our oceans. Close relatives of all sharks and rays, these cartilaginous, filter feeding fish range throughout the tropical and sub-tropical oceans of the world[1,2]. Born into a life of perpetual motion, they can never stop moving as they must keep water flowing over their gills to respire. Their daily and seasonal movements are tuned to the ebb and flow of the ocean currents that breathe life into their world, bearing the planktonic food upon which they depend[3].

Manta rays are giants of their kind, with the largest individuals reaching seven metres in width and weighing up to two tonnes. Despite their colossal size, mantas are gentle creatures. They have the largest brain of all fish, and their intelligence and curiosity make encounters with manta rays a truly magical experience[4,5]. Their obvious intellect and complex social interactions set manta rays apart from most other fish, but as they have only been intensively studied in detail for around a decade, much of their life history remains a mystery[6].

Devil rays are the manta's smaller relatives, but what they lack in size they make up for in acrobatic enthusiasm. During courting events, several of the pygmy devil ray species are known to aggregate in vast shoals that number in the thousands - delivering one of the ocean's greatest spectacles[2]. Even less is known about devil rays than mantas; they are generally very shy towards divers, making it hard to observe and study their behaviour in the wild[6].

Mobulids first appear in the fossil record around 28 million years ago; evolving from bottom dwelling rays, they adapted to life in the water column[7]. They are defined by their specially modified gill plates, which they use to filter zooplankton and small fishes from the water column[8]. Mobulid rays have a conservative life history strategy; they take a long time to reach sexual maturity, are slow to reproduce, and tend to give birth to a single pup every two to five years following a nine to twelve- month pregnancy[6,9,10]. This strategy may have served them well for millions of years, but unfortunately these traits, paired with their highly migratory nature, now leave mobulids extremely vulnerable to overexploitation by humans[1,9].

A SEA OF CHANGE

The greatest threat to mobulids is excessive targeted and incidental catch in fisheries[1,9,11], increasingly driven by an international trade in gill plates that are used in an Asian health tonic[12]. As a result, some mobulid populations exhibit declines of over 90%[13–15]. Of particular concern is the exploitation of this species from within critical habitats, where numerous individuals can be targeted with relatively high catch-per-unit-effort. For such intrinsically vulnerable species, even small negative pressures exerted upon a population are likely to have severe consequences for the population's survival[9].

Due to their vulnerable life history traits, and in response to the growing threat of the gill plate trade, several significant steps have been taken in recent years to improve the conservation status of mobulids. In 2011 oceanic manta rays (*Mobula birostris*) were successfully listed on the Convention for the Conservation of Migratory Species (CMS) Appendices I and II. Concurrently, both manta species were reclassified on the IUCN Red List of Threatened Species as *Vulnerable*. In 2013, collaborative efforts between the world's nations, researchers and NGOs saw manta rays listed on Appendix II of the Convention for International Trade of Endangered Species (CITES), and in 2014 reef manta rays (*Mobula alfredi*) and all species of devil ray were listed on the CMS Appendices I and II. More recently, 2016 saw all devil ray species join manta rays on the CITES Appendix II, driven by an impressive number of co-proponent governments, conservationists and NGOs.

Despite these growing protective measures, manta and devil rays remain extremely vulnerable to exploitation. A comprehensive approach and strategic plan is therefore needed to ensure the long-term conservation and sustainable use of mobulid rays. Crucially, this plan needs to address the levels of bycatch and targeted fisheries that threaten these rays. Other threats, such as the impacts of tourism[16–18] and pollution[6,19], also need to be considered and mitigated.

Photo by Shawn Heinrichs

Photo by Guy Stevens

THE MANTA TRUST

Founded in 2011, the Manta Trust is a UK registered charity that co-ordinates global mobulid research and conservation efforts. Our team is comprised of a diverse group of researchers, scientists, conservationists, educators and media experts; working together to share and promote knowledge and expertise. The Manta Trust takes a multifaceted approach to mobulid conservation. By conducting long-term, robust scientific studies, we aim to build the solid foundations upon which governments, NGO's and conservationists can make informed and effective marine management decisions. With a network of over twenty projects worldwide, we specialise in collaborating with multiple parties to drive conservation as a collective; from businesses and governments, to individuals and local communities. Finally, we place considerable effort into raising awareness of the threats facing mobulids. As charismatic megafauna, manta rays act as a flagship species, helping to motivate and engage people with the wider message of marine ecosystem conservation. Through this multifaceted approach, the manta ray becomes the catalyst for change, educating people about the solutions needed to ensure the long-term survival of these animals and the underwater world we all rely upon.

VISION

To see all species of manta rays and their relatives protected or effectively managed for sustainable or non-consumptive use, by the people closest to them, in a means that promotes wider ocean conservation.

We measure our success in achieving this vision through metrics related to global mobulid ray landings, the amount of mobulids caught as bycatch, and the number of protective policies that are in place. We also take into consideration the number of communities involved in mobulid conservation efforts, the level of engagement of communities and the general public, and ultimately evaluate our success through an increase or stability in mobulid ray population numbers globally.

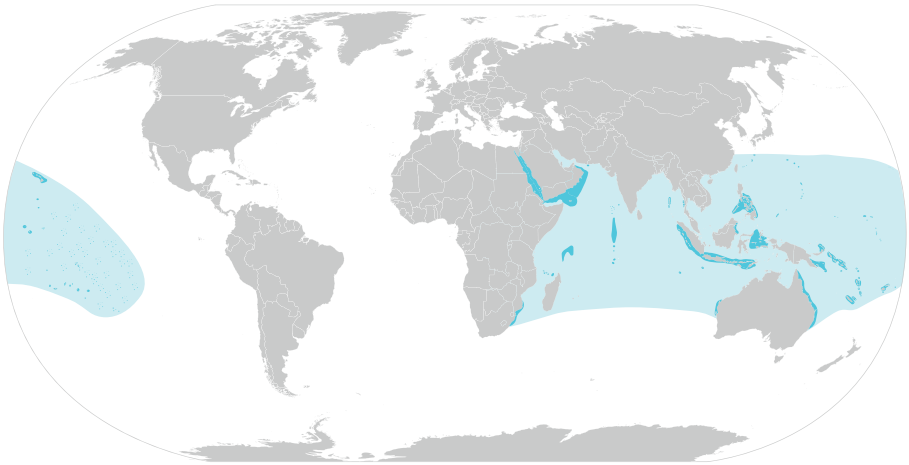
SPECIES DESCRIPTIONS

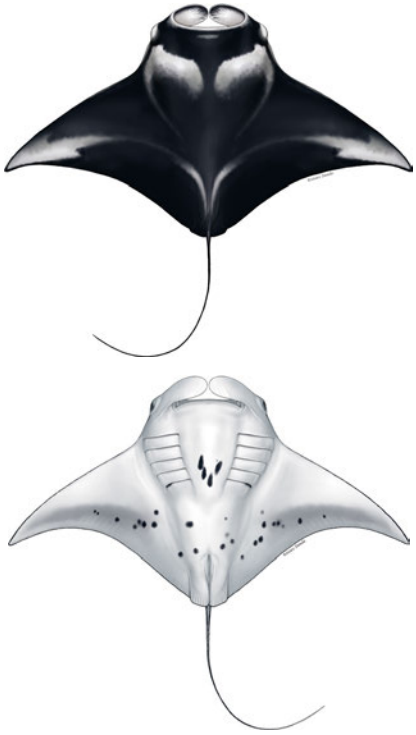
Manta and devil rays (mobulids) belong to a group of rays called the Myliobatiformes, which contains 12 families and about 370 species. Taxonomically, within the Mobulidae family there is just one genus: *Mobula*, which contains **ten species** – two (possibly three) manta species[20,21] and eight devil ray species[2,6,22].

REEF MANTA RAY - *Mobula alfredi*

Disc width: average 300-350cm (10-11.5ft)

IUCN Red List: Vulnerable

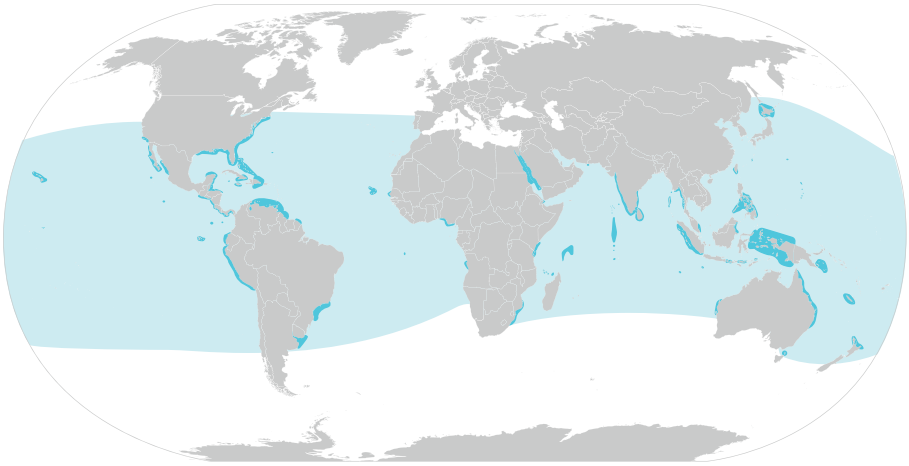


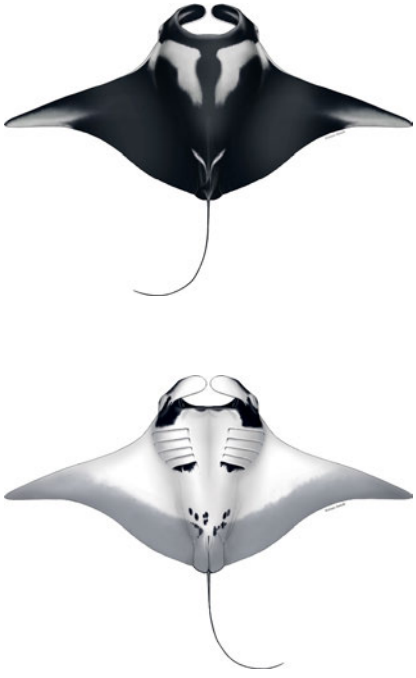


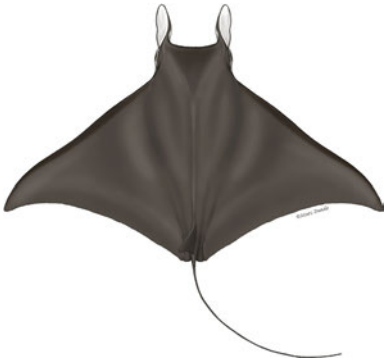
OCEANIC MANTA RAY - *Mobula birostris*

Disc width: average 400-500cm (13-16.5ft)

IUCN Red List: Vulnerable





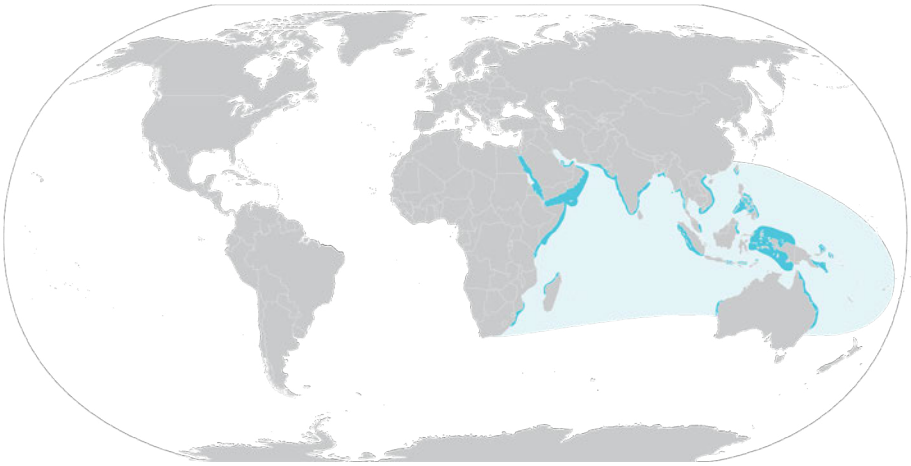


LONGHORNED PYGMY DEVIL RAY

Mobula eregoodootenkee

Disc width: average 110cm (3.6ft)

IUCN Red List: Near Threatened



WEST ATLANTIC PYGMY DEVIL RAY

Mobula hypostoma

Disc width: average 110cm (3.6ft)

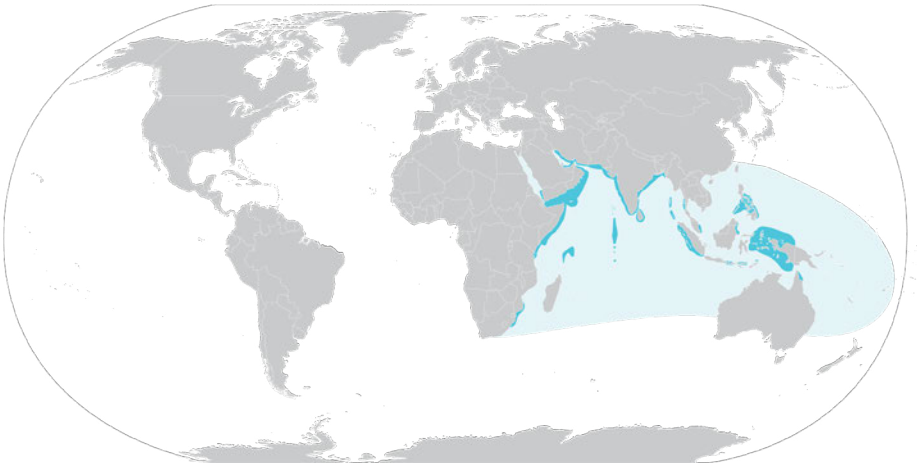
IUCN Red List: Data Deficient

SHORTHORNED PYGMY DEVIL RAY

Mobula kuhlii

Disc width: average 100cm (3.3ft)

IUCN Red List: Data Deficient

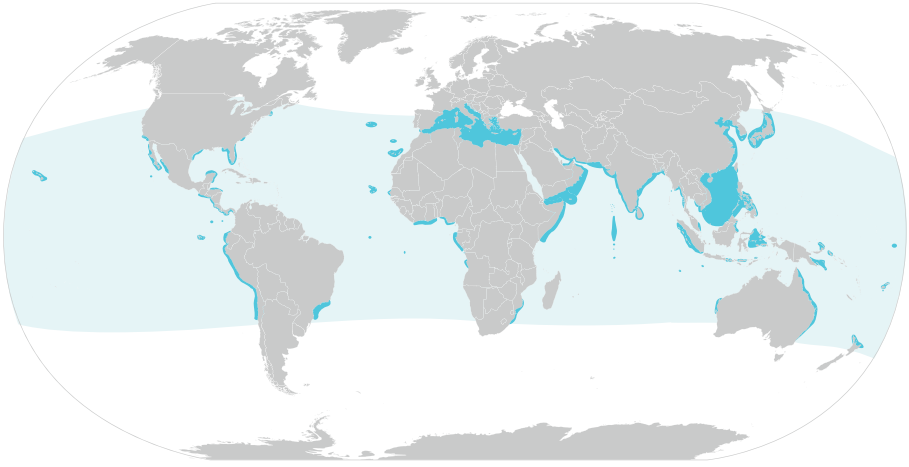


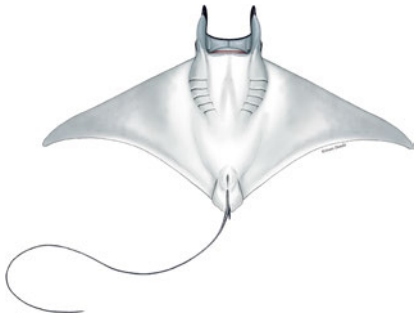
SPINETAIL DEVIL RAY

Mobula mobular

Disc width: average 180-280cm (5.9-9.2ft)

IUCN Red List: Near Threatened



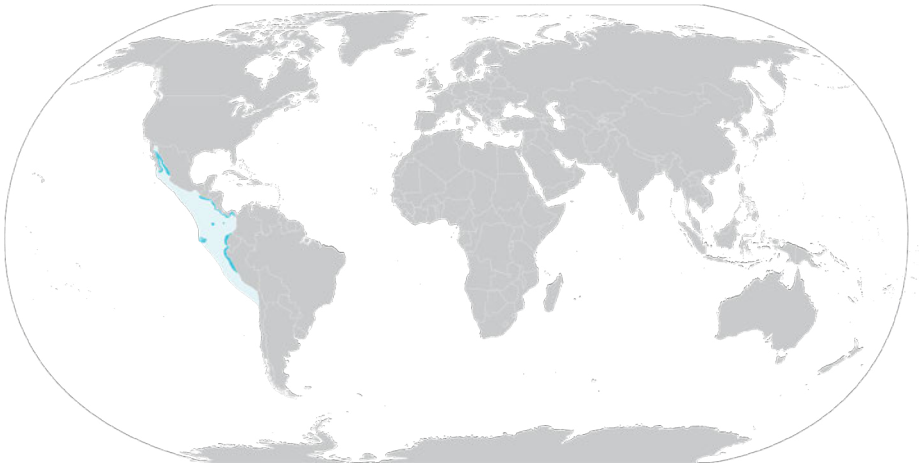


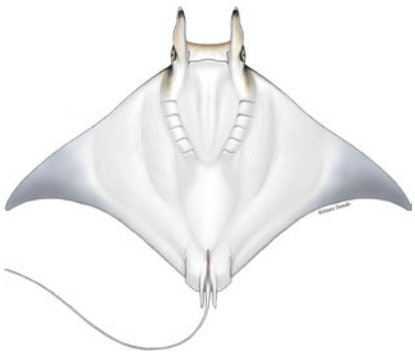
MUNK'S PYGMY DEVIL RAY

Mobula munkiana

Disc width: average 89-100cm (2.9-3.3ft)

IUCN Red List: Near Threatened





EAST ATLANTIC PYGMY DEVIL RAY

Mobula rochebrunei

Disc width: average 113cm (3.7ft)

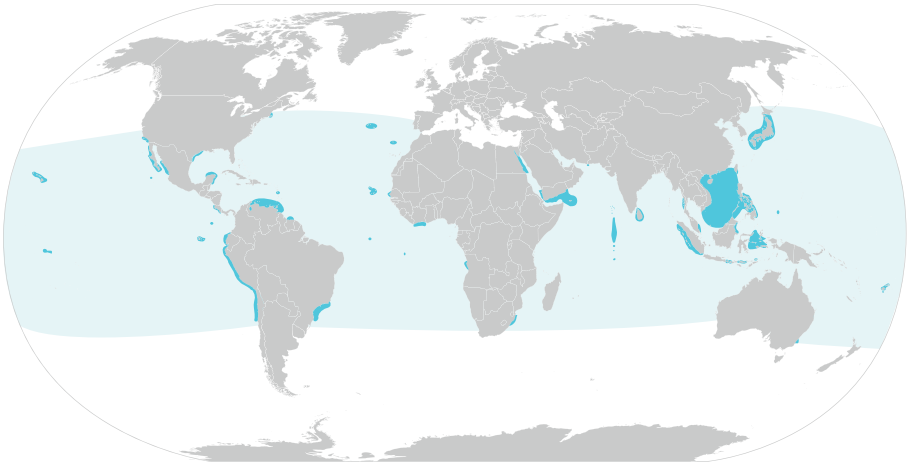
IUCN Red List: Vulnerable

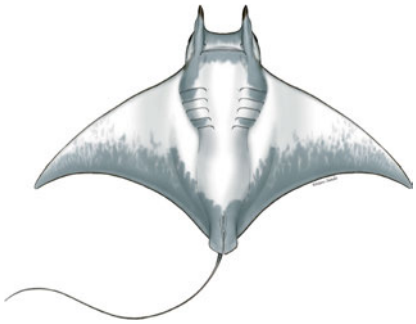
SICKLEFIN DEVIL RAY

Mobula tarapacana

Disc width: average 200-270cm (6.6-8.8ft)

IUCN Red List: Vulnerable



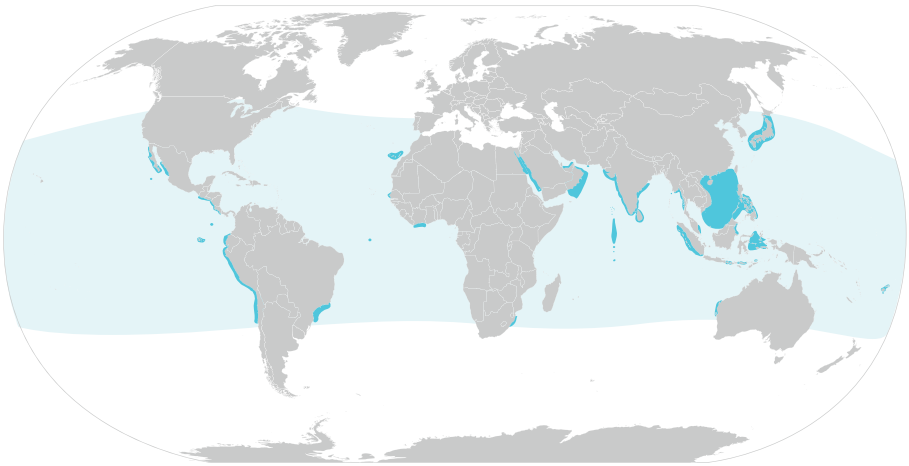


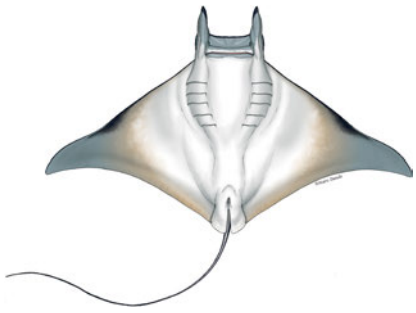
BENTFIN DEVIL RAY

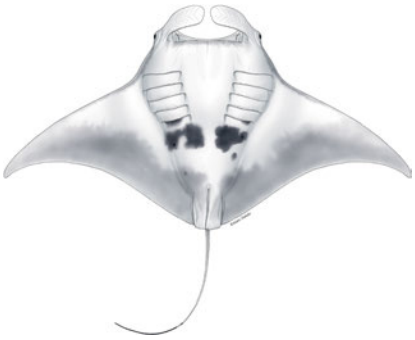
Mobula thurstoni

Disc width: average 135cm (4.5ft)

IUCN Red List: Near Threatened





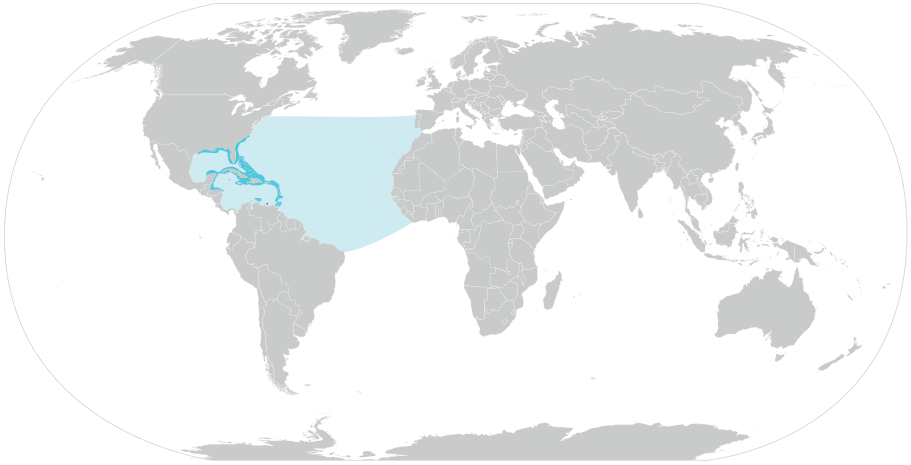


CARIBBEAN MANTA RAY

Mobula cf. birostris

Disc width: average 300-400cm (10-13ft)

IUCN Red List: Vulnerable



PROTECTIVE LEGISLATION

While international, regional, and national protective legislation has improved in recent years, there is still a need for greater protection throughout the range of all manta and devil ray species globally.

LOCATION	SPECIES	LEGAL PROTECTION MEASURE
INTERNATIONAL		
CITES Appendix II	All mobulid species	Listing of the genus *Manta* (2013) and *Mobula* (2016) on Appendix II of the Convention on International Trade in Endangered Species (CITES).
CMS Signatories	All mobulid species	Convention on the Conservation of Migratory Species of Wild Animals (CMS), Appendix I and II; M. birostris (2011), all other mobulid species (2014).
Inter-American Tropical Tuna Commission (IATTC)	All mobulid species	Resolution C-15-04 on the Conservation of Mobulid Rays Caught in Association with Fisheries in the IATTC Convention Area.
REGIONAL		
Barcelona & Bern Conventions	*M. mobular*	Added to the Annex II 'list of strictly protected fauna species' of the Bern Convention and the Annex II 'List of endangered or threatened species' to the Protocol concerning Special Protected Areas and Biological Diversity in the Mediterranean of the Barcelona Convention, which came into force in 2001.
European Union member countries	All mobulid species	Council Regulation (EU) 2015/2014 amending Regulation (EU) No 43/2014 and repealing Regulation (EU) No 779/2014.
NATIONAL		
Australia	All mobulid species	Environment Protection and Biodiversity Conservation Act (added as protected species 2012).
Brazil	All mobulid species	Inter-ministerial Normative Instruction No. 2 of 14/3/2013.
Croatia	*M. mobular*	Law of the Wild Taxa 2006 Strictly prohibited.
Ecuador	*M. birostris*, *M. mobular*, *M. thurstoni*, *M. munkiana* & *M. tarapacana*	Ecuador Official Policy 093, 2010.
Indonesia	*M. birostris* & *M. alfredi*	KepMen National Protective Legislation, 2014.
Israel	All ray species	All sharks and all fully protected in Israel since 2005. They may not be captured, harmed, traded or kept, without a specific permit from the Israel Nature and Parks Authority (INPA).

LOCATION	SPECIES	LEGAL PROTECTION MEASURE
NATIONAL		
Maldives	All ray species	Exports of all ray products banned 1995. Environment Protection Agency rule - illegal to capture, keep or harm any type of ray; Batoidea Maldives Protection Gazette No. (IUL) 438-ECAS/438/2014/81.
Malta	*M. mobular*	Sch. VI Absolute protection.
Mexico	*M. birostris, M. mobular, M. thurstoni, M. munkiana, M. hypostoma & M. tarapacana*	NOM-029-PESC-2006 Prohibits harvest and sale.
New Zealand	*M. birostris & M. mobular*	Wildlife Act 1953 Schedule 7A (absolute protection).
Peru	*M. birostris*	Article 2 of Resolution 441-2015-PRODUCE, Jan 2016.
Philippines	*M. birostris & M. alfredi*	FAO 193 1998 Whale Shark and Manta Ray Ban.
United Arab Emirates (UAE)	*M. birostris & M. alfredi*	Fully protected in UAE waters (2014).
STATE		
Christmas Island and Cocos (Keeling) Islands, Australian Indian Ocean Territories	All ray species	Protected species. Dept. of Fisheries Western Australia 2010.
Commonwealth of the Northern Mariana Islands, USA Territory	All ray species	Public Law No. 15-124.
Florida, USA	*Manta* spp.	FL Admin Code 68B-44.008 – no harvest.
Guam, USA Territory	All ray species	Bill 44-31 prohibiting possession/sale/trade in ray parts 2011.
Hawaii, USA	*Manta* spp.	H.B. 366 2009 – no harvest or trade.
West Manggarai/Komodo	*Manta* spp.	Shark and Manta Ray Sanctuary Bupati Decree 2013.
Raja Ampat Regency, Indonesia	All ray species	PERDA (Provincial Law) Hiu No. 9 Raja Ampat 2012.
Yap (Federated States of Micronesia)	*Manta* spp.	Manta Ray Sanctuary and Protection Act 2008.

THREATS TO MOBULID RAYS

The greatest threats to mobulid rays are fisheries (both targeted and bycatch) and tourism[1,6,9,11,17,18]. These threats can be categorised as "*biological resource use*" and "*human intrusion and disturbance*", using the IUCN classification scheme of threats, and are considered direct threats caused by anthropogenic impacts.

Mobulids are also threatened by environmental changes, such as food availability, reef degradation, and pollution[6,19]. These factors fall within the IUCN categories of "*pollution*" and "*climate change*", and are considered indirect threats (www.iucnredlist.org/technicaldocuments/classification- schemes/threats-classification-scheme).

Table 1 lists the key threats to mobulid rays in order of priority (1=highest; 6=lowest), with desired goals for the threat, and metrics to measure success. In the remaining sections of this strategic document we describe how to address each of these threats so that their impact on mobulid rays is either reduced or eliminated. An overview of this approach is illustrated graphically (Mobulid Conservation Strategy & Action Plan), and a detailed plan of action for each threat is presented through the following text, infographics, and via a theory of change flowchart (see Appendix I). To address these threats and prioritise future research on these species, a complimentary publication to identify the most pressing questions in mobulid conservation research was also undertaken (see Appendix II).

Table 1: *Key threats to mobulid rays, desired goals and metrics for measuring progress.*

	PRIORITY	THREAT	GOAL	METRICS
DIRECT THREATS	1	Targeted fishing	No demand for mobulid products	Volume of landings; gill plates (in markets); other body parts (in markets).
	2	Bycatch	Limited bycatch	Levels of catch & release; mitigation measures in gear (gear, spatial, temporal); policies.
	3	Tourism	Well-managed tourism	Boat strikes; in-water interactions; code of conduct.
INDIRECT THREATS	4	Food availability	High productivity	Fecundity; plankton levels (amount & type); oceanographic variables.
	5	Reef degradation	Healthy reefs	Coral diversity; coral cover; resilience; bleaching; associated species.
	6	Pollution	Limited pollution	Water quality; pollution types.

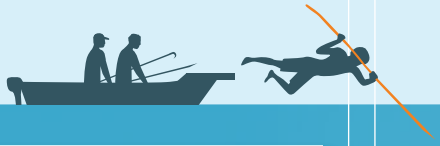
MOBULID CONSERVATION
STRATEGY & ACTION PLAN

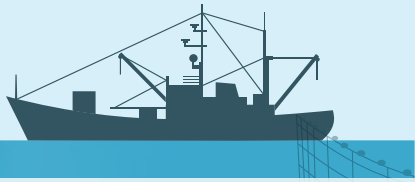
Photo by Guy Stevens

Mobulid Conservation Strategy & Action Plan

THE MANTA TRUST VISION:

All species of manta ray and their relatives are protected or effectively managed for sustainable or non-consumptive use, by the people closest to them, in a means that promotes wider ocean conservation





1 KEY THREAT: TARGETED FISHERY

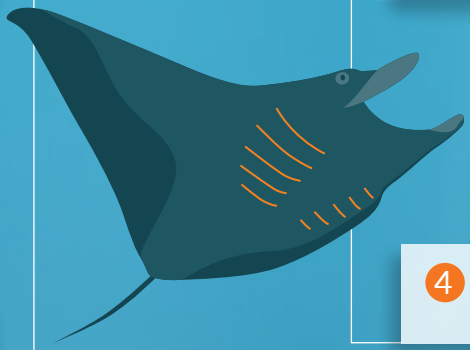
THE GOAL: NO DEMAND FOR MOBULID PRODUCTS

Targeted fishing of mobulid rays has greatly increased driven by the demand for gill plates, which are used as a Traditional Asian Medicine

2 KEY THREAT: BYCATCH

THE GOAL: LIMIT MOBULID BYCATCH WORLDWIDE

Mobulid rays are incidentally caught in at least 30 fisheries in 23 countries



3 KEY THREAT: TOURISM

THE GOAL: TO SEE WELL-MANAGED MOBULID TOURISM

Unregulated or badly managed tourism can negatively affect the animals and in turn the tourism industry

4 KEY THREATS: ENVIRONMENTAL CHANGES

THE GOAL: TO ENSURE HEALTHY ECOSYSTEMS FOR MOBULIDS

Reef degradation, pollution and lower plankton productivity limit their food supply and suitable habitat

Mobulid species IUCN Red List status

DATA DEFICIENT

Shorthorned Pygmy Devil Ray
Mobula kuhlii

West Atlantic Pygmy Devil Ray
Mobula hypostoma

NEAR THREATENED

Munk's Pygmy Devil Ray
Mobula munkiana

Longhorned Pygmy Devil Ray
Mobula eregoodootenkee

Bentfin Devil Ray
Mobula thurstoni

Spinetail Devil Ray
Mobula mobular

VULNERABLE

East Atlantic Pygmy Devil Ray
Mobula rochebrunei

Sicklefin Devil Ray
Mobula tarapacana

Reef Manta Ray
Mobula alfredi

Caribbean Manta Ray
Mobula cf. birostris

Oceanic Manta Ray
Mobula birostris

Thanks and credit to Marc Dando (Wild Nature Press) for the mobulid illustrations

Manta TRUST

save our seas foundation

Photo by Paul Hilton

STRATEGIES TO ELIMINATE TARGETED MOBULID FISHING

Goal 1 No demand for mobulid products.

Over the last decade, targeted fishing of mobulid rays has increased dramatically. This is primarily due to the rising demand for mobulid products, in particular gill plates, which are used in traditional Asian medicinal health tonics[12]. Mobulids are targeted for their gill plates in six continental and ocean regions, 13 countries, and 21 locations, making it a truly global threat to the species[12]. As a result of increasing demand, many former bycatch fisheries have become directed commercial export fisheries[13,23].

To eliminate this threat, the demand for mobulid products needs to be reduced. Demand for mobulid products is complex and driven by a number of factors, which can differ depending on location. In order for demand to be reduced the following preconditions need to be met:

1. **Mobulid fisheries need to become commercially unviable; a high risk and low reward activity.**
2. **Alternative sources of protein need to be available where mobulids are used for food.**
3. **There needs to be no marketing of gill plates and other mobulid products, and there are culturally acceptable alternatives to using gill plates as medicine.**

In order to achieve these preconditions, the following actions have been identified:

- Change the balance between risk and reward for mobulid fisheries to make mobulid fishing commercially unviable through;
    a. Influencing the development of policies (national and regional) and management plans to ensure that legislation exists that supports mobulid conservation.

b. Building capacities for the enforcement of policies and management plans.

c. Monitoring and evaluating the effectiveness of enforcement. The commercial viability of mobulid fishing is also affected by access to mobulid rays, access to markets, and the cultural and livelihood compatibility for mobulid fisheries. However, we cannot directly influence these factors.

- Develop and coordinate livelihoods programmes in communities that are dependent on mobulid fisheries, so that sufficient income alternatives exist.
- Implement development projects, such as aquaculture and farming, to generate alternative sources of protein for the communities, and reduce their dependency on mobulids.
- Develop marketing campaigns that encourage consumers to choose alternatives to traditional Asian medicine, and raise awareness for reducing gill plate consumption.

The responsible party, relative priority, scale of operation, cost, and time required to carry out these actions is described in Table 2. See Appendix I for a detailed theory of change diagram.

Photo by Thomas P. Peschak

Table 2: *Action plan to address the threat from targeted fishery.*

GOAL 1: No demand for mobulid products.		PRIORITY	SCALE	COST	TIMELINE
Objective 1.1	**Mobulid fishing is high risk / low reward, therefore mobulid fishing is commercially unviable.**				
Sub-objective 1.1.1	**Policies exist to support mobulid conservation.**				
Action	Develop or influence the development of policies and management plans.	High	Nat/ Intl	$$	Med
Sub-objective 1.1.2	**There is good enforcement of policy and regulations.**				
Action	Monitor and evaluate the enforcement of policies and management plans and report to decision makers.	High	Nat/ Intl	$$	Med
Action	Build capacities for enforcement of protective policies and management plans.	High	Nat/ Intl	$$	Med
Sub-objective 1.1.3	**Sufficient alternatives exist so that mobulid fisheries are not a priority.**				
Action	Support the development of livelihood programs (including surveys, developing alternatives and socializing alternatives).	Med	Local	$$$	Long
Objective 1.2	**Alternative sources of protein.**				
Action	Introduce development projects (farming, aquaculture).	Med	Local	$$$	Long
Objective 1.3	**Accepted alternatives to traditional medicines & no marketing of gill plates.**				
Action	Marketing campaigns to educate consumers in choosing alternatives to traditional medicines.	High	Nat	$$	Med
Action	Raise awareness to reduce consumer demand for gill plates.	High	Nat	$$	Med

Purple: Actions that Manta Trust are currently undertaking, or have an interest in undertaking.
Green: Actions currently led by other NGOs, IGOs, governments, and industry.
Orange: Actions undertaken by a combination of both of the above.

Strategies to eliminate targeted mobulid fishing

Infographic design by Jessica Berliner

THE GOAL: NO DEMAND FOR MOBULID PRODUCTS

1 MOBULID FISHING IS **COMMERCIALLY UNVIABLE**

Mobulid fishing is a high risk and low reward activity –

- Policies exist to support mobulid conservation
- There is good enforcement of policy & regulations
- Sufficient alternatives exist that mobulid fisheries are not a priority
- Mobulid fishing is not profitable*
- There is limited access to fishing for mobulids*
- There is limited access to markets*
- Mobulid fishing is not compatible with local culture and livelihoods*

**Factors that the Manta Trust has no control over*

2 THERE ARE **ALTERNATIVE SOURCES OF PROTEIN**

3 THERE IS **NO MARKETING** OF MOBULID PRODUCTS

+

THERE ARE CULTURALLY ACCEPTED **ALTERNATIVES** TO **TRADITIONAL ASIAN MEDICINE**

Manta Trust's actions

- *Influence the development of national and regional policies and management plans*
- *Build capacities for enforcement of policies and management plans*
- *Develop and coordinate alternative livelihood programmes*
- *Monitor and evaluate the effectiveness of enforcement*

POLICY COMMUNITY RESEARCH

EXTERNAL ACTIONS

- *Development projects such as farming and aquaculture*
- *Marketing campaigns to encourage choosing alternatives to Traditional Asian Medicine*
- *Raising awareness to reduce consumer demand for gill plates*

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STRATEGIES TO REDUCE MOBULID BYCATCH

Goal 2 Limit mobulid bycatch worldwide.

Important milestones were achieved upon the successful listing of mobulids under the CMS and the CITES Appendices in 2014 and 2016 respectively, which has put a tighter regulation on the international trade of these species. The CMS signatories have declared their commitment to better protect mobulid rays, and several countries announced a national ban on the targeted fishery of manta and devil rays. Nevertheless, mobulid rays continue to be fished at an unsustainable level as bycatch.

A study on the vulnerabilities and fisheries impacts on manta and devil rays[11] showed that mobulids are incidentally caught in at least 30 fisheries in 23 countries, and that the annual non-discarded bycatch of mobulids in the tuna fishery was 14,000 individuals in 2015[11]. Post release mortality of mobulid rays is also likely to be high[6], demonstrated by Francis & Jones' study[24], where four out of seven spinetail devil rays (*Mobula mobular*) died shortly after being released from a purse-seine net. High levels of mobulid bycatch are caused by the use of unselective gear in both commercial and artisanal fisheries, usually because there are insufficient spatial or temporal fisheries restrictions in place, and because there is too much fishing globally.

To address this threat, the level of mobulid bycatch globally needs to be reduced. To achieve this, the following preconditions need to be met:

1. **There is selective gear use, or better gear use, in commercial and artisanal fisheries.**
2. **Effective temporal and spatial restrictions on mobulid fishing are in place.**
3. **The activity of ghost fishing is limited.**
4. **Mobulid fisheries are commercially unviable (see previous strategy), and the amount of fishing globally is reduced. We have limited influence on the latter.**

In order to achieve these preconditions, the following actions have been identified:

- Develop and implement national and regional policies, such as via Regional Fisheries Management Organisations, to support better gear use and its enforcement in artisanal and commercial fisheries.

- Monitor the effectiveness of enforcement, and provide this data to governments to ensure destructive gear use becomes high risk and low reward.

- Conduct research on post release mortality and mobulid bycatch mitigation, and education on safe release methods. This will support an improved understanding of bycatch mitigation via alternative gear use.

- Implement gear swap programmes, trade, or market incentives, to switch gear and provide subsidies to fishers to ensure they have access to affordable alternative gears. Traditional /cultural practices will influence the success of this factor.

- Encourage collaborations among governments and scientists to jointly develop fisheries management regulations. This will help to ensure informed decision making, and ensure that skills, money and people are available to enable the restriction of mobulid fishing.

- Educate governments and the general public about mobulid conservation and management, to ensure there is a political will to restrict fisheries.

- Conduct research on mobulid movement, ecology, and habitat use, to ensure spatial and temporal restrictions are developed based on scientific knowledge.

- Liaise with governments to develop protected areas, and ensure mobulids have a higher profile in management priorities.

- Conduct research on sub-lethal impacts on mobulid rays to better understand which practices are harmful, and improve management of practices that lead to ghost fishing.

- Investigate hotspots for ghost fishing and mortality to define appropriate mitigation methods that ultimately limit ghost fishing.

The responsible party, relative priority, scale of operation, cost, and time required to carry out these actions is described in Table 3. See Appendix I for a detailed theory of change diagram.

Table 3: *Action plan to address the threat from of bycatch.*

GOAL 2: Limit mobulid bycatch worldwide.		PRIORITY	SCALE	COST	TIMELINE
Objective 2.1	**Selective gear is used in commercial and artisanal fisheries.**				
Sub-objective 2.1.1	**Alternative gears are affordable.**				
Action:	Provide subsidies to fishers.	Med	Local/ Nat	$$	Med
Action:	Trade and market incentives to switch gear.	Med	Local/ Nat	$$	Med
Sub-objective 2.1.2	**Artisanal fisheries have access to alternative gears and/or appropriate mitigation.**				
Action	Gear swap programs funded by government or industry.	Med	Local/ Nat	$$	Med
Sub-objective 2.1.3	**Artisanal fishers have the knowledge and understanding of alternative gear mitigation practices.**				
Action	Develop and communicate safe release methods for mobulids accidentally caught in fisheries.	High	Nat	$	Short
Action	Conduct research on post-release mortality and reduction of bycatch in mobulid rays.	High	Nat	$	Short
Sub-objective 2.1.4	**There is a high risk and low reward to using destructive gears in both artisanal and commercial fisheries.**				
2.1.4.1	**Regulations exist to support better gear use.**				
Action	National and regional policy (RFMOs and government led).	High	Nat/ Intl	$	Med
2.1.4.2	**Effective enforcement of gear-use regulations exists.**				
Action	Provide data on enforcement levels.	High	Nat/ Intl	$$	Med
Action	Monitor and enforce via governments.	High	Nat/ Intl	$$	Med

Purple: Actions that Manta Trust are currently undertaking, or have an interest in undertaking.
Green: Actions currently led by other NGOs, IGOs, governments, and industry.
Orange: Actions undertaken by a combination of both of the above.

Table 3 (continued): *Action plan to address the threat from of bycatch.*

GOAL 2: Limit mobulid bycatch worldwide.		PRIORITY	SCALE	COST	TIMELINE
Objective 2.2	**Effective temporal and spatial restrictions on fishing exist.**				
Sub-objective 2.2.1	**The skills, money and people needed to enable restriction of fisheries are available.**				
Action	Fisheries departments, researchers and governments working together to implement fisheries restrictions.	Med	Nat	$$	Long
Sub-objective 2.2.2	**There is the political will to restrict fisheries.**				
Action	Educate governments and the general public about the need to protect mobulids and manage fisheries.	High	Nat	$$	Short
Sub-objective 2.2.3	**Good knowledge of mobulid movement and habitat use exists.**				
Action	Conduct research on mobulid movement ecology and habitat use.	High	Loc/ Nat/ Intl	$$	Long
Sub-objective 2.2.4	**Mobulids have a higher profile in management priorities.**				
Action	Liaise with governments to develop protected areas for mobulid rays.	Med	Nat	$	Long
Objective 2.3	**Limited ghost fishing.**				
Sub-objective 2.3.1	**Improved management practices that limit ghost fishing.**				
2.3.1.1	**Understanding of practices that might be harmful.**				
Action	Conduct research on sub-lethal impacts on mobulids.	Low	Intl	$	Short
2.3.1.2	**Understanding of appropriate mitigation methods.**				
Action	Understand hotspots for ghost fishing and mortality.	Low	Intl	$	Short

Purple: Actions that Manta Trust are currently undertaking, or have an interest in undertaking.
Green: Actions currently led by other NGOs, IGOs, governments, and industry.
Orange: Actions undertaken by a combination of both of the above.

Strategies to reduce mobulid bycatch

THE GOAL: LIMIT MOBULID BYCATCH WORLDWIDE

1 FISHERIES USE **SELECTIVE GEAR**

- Artisanal fisheries have access to alternative gear and appropriate mitigation
- Artisanal fisheries have an understanding of alternative gear mitigation and use
- Alternative gears for fisheries are affordable
- There is high risk and low reward in using destructive fishing gears
- Artisanal fishery traditional and cultural practices align with use of selective gear*

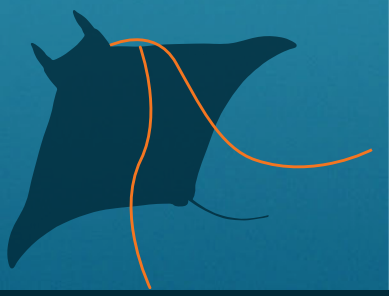
2 THERE ARE EFFECTIVE **TEMPORAL & SPATIAL RESTRICTIONS** ON FISHING

- The skill, money and people are available to enable restriction of fisheries
- Good knowledge about mobulid movement and habitat use exists
- There is a political will to restrict fisheries
- Mobulids have a higher profile in management priorities
- The scale of global fishing is reduced*

3 **GHOST FISHING** IS **LIMITED**

- Improved management practices are in place that lead to reduced ghost fishing
- There is an understanding of practices that might be harmful
- There is an understanding of appropriate mitigation methods

**Factors that the Manta Trust has no control over*



Manta Trust's actions

- *Develop and implement national and regional policies e.g. via RFMOs*
- *Encourage collaboration among governments and scientists to develop fisheries restrictions*
- *Develop protected areas by liaising with governments*
- *Educate fishers about safe release methods for mobulid rays*
- *Educate governments and the general public about mobulid conservation and management*
- *Conduct research on mobulid movement ecology and habitat use*
- *Conduct research on post-release mortality and mobulid bycatch mitigation*
- *Monitor the effectiveness of enforcement and provide data to governments*
- *Conduct research on sub-lethal impacts on mobulid rays*
- *Investigate hotspots for ghost fishing and mortality*

EXTERNAL ACTIONS

Trade or market incentives to switch gear exist, gear swap programmes are introduced and there are subsidies to fishers for switching gear funded by government or industry

POLICY
COMMUNITY
RESEARCH

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STRATEGIES TO SUPPORT RESPONSIBLE TOURISM

Goal 3 To see well-managed mobulid tourism worldwide.

Tourism focused on charismatic marine megafauna, such as whales, sharks and rays, has become increasingly popular over the last two decades[16,25]. Wildlife watching tourism offers a variety of benefits. For tourists, these include recreational and educational values[26,27]. For local communities, wildlife tourism supports the economy by providing jobs and income[28]. The global manta-watching tourism is estimated to be worth US$ 73 million per annum[16], thus contributes substantially to the economy. However, unregulated or badly managed tourism may negatively affect the animals, and in turn the tourism industry, by disturbing the species' natural behaviour, degrading their habitat, and potentially reducing their fitness[17,18,29]. Increased human presence may induce animal stress[30], and higher boat traffic may increase the rate of injuries[31].

To see well-managed mobulid tourism, the following preconditions need to be met:

1. **Tourists and operators are aware of, and comply with, responsible practices.**
2. **There is management at key mobulid tourism sites.**
3. **Mobulid rays have a higher profile in management priorities.**

To achieve these preconditions, the following actions have been identified:

- Identify key sites for mobulid tourism through conducting research.
- Support the creation of management plans for key tourism sites; for instance, by providing data on tourism interactions and sightings to governments.
- Monitor enforcement and compliance with regulations.

- Create educational materials for operators and tourists that clearly communicate how to sustainably interact with the species.
- Educate operators, governments, and tourists about mobulid rays and their conservation needs.

The responsible party, relative priority, scale of operation, cost, and time required to carry out these actions is described in Table 4. See Appendix I for a detailed theory of change diagram.

Table 4: *Action plan to address the threat from tourism.*

GOAL 3: To see well-managed mobulid tourism worldwide.		PRIORITY	SCALE	COST	TIMELINE
Objective 3.1	**Tourists and operators are aware of, and comply with, responsible practices.**				
Action	Create educational materials for operators and tourists.	Med	Intl	$	Short
Action	Monitor enforcement and compliance.	Med	Nat	$$	Short
Action	Effective enforcement by government and industries, and compliance by tourists (through education).	Med	Local/ Nat	$$	Short
Objective 3.2	**Key mobulid-tourism sites are managed.**				
Sub-objective 3.2.1	**Regulations for/of mobulids in tourism exist.**				
Action	Identify key sites for mobulid tourism.	High	Local/ Nat	$	Short
Action	Create management plans for tourism.	High	Local/ Nat	$	Short
Sub-objective 3.2.2	**Enforcement of regulations related to mobulid tourism.**				
Action	Monitoring of enforcement to ensure it exists and persists.	High	Local/ Nat	$$	Short
Objective 3.3	**Mobulids have a higher profile in management priorities.**				
Action	Educate operators, governments and industry about mobulids and the need for their conservation.	Med	Local	$	Med

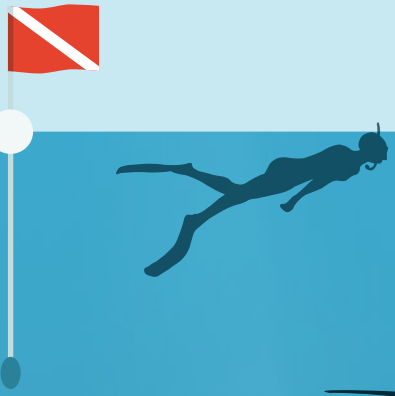
Purple: Actions that Manta Trust are currently undertaking, or have an interest in undertaking.
Green: Actions currently led by other NGOs, IGOs, governments, and industry.
Orange: Actions undertaken by a combination of both of the above.

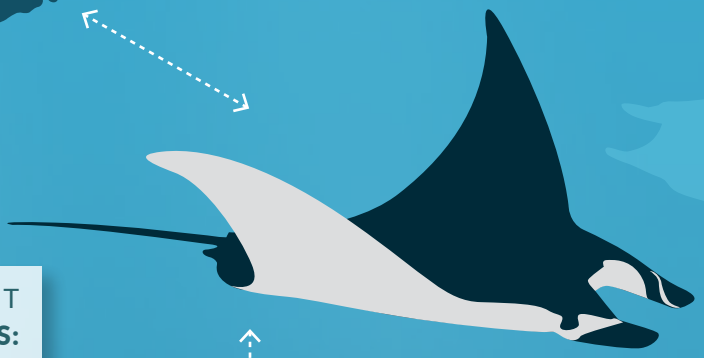
Strategies to support responsible tourism

Infographic design by Jessica Berliner

THE GOAL: TO SEE WELL-MANAGED MOBULID TOURISM

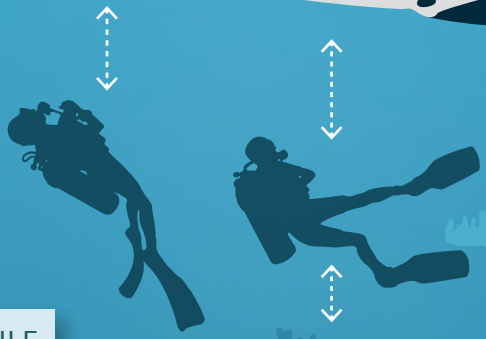
1 TOURISTS AND OPERATORS ARE **AWARE OF** AND **COMPLY WITH** RESPONSIBLE PRACTICES





2 THERE IS MANAGEMENT OF **KEY TOURISM SITES:**

- Mobulid tourism is regulated
- Regulations related to mobulid tourism are enforced



3 MOBULIDS HAVE A HIGHER PROFILE IN **MANAGEMENT PRIORITIES**

Manta Trust's actions

- *Support the creation of management plans for key tourism sites*
- *Educate operators, government and tourists about mobulid rays and their conservation need*
- *Create educational materials for tourists and operators*
- *Monitor enforcement and compliance with regulations*
- *Identify key sites for mobulid tourism*

EXTERNAL ACTIONS

- *Enforce regulations via government and industry commitment*
- *Educated tourists comply with regulations*

POLICY COMMUNITY RESEARCH

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STRATEGIES TO MAINTAIN HEALTHY MOBULID HABITATS

Goal 4 To ensure healthy ecosystems exist for mobulid rays.

The health of marine environments is dependent on a suite of diverse factors, which also vary with location. Mobulid rays need healthy oceans to thrive as the ocean provides habitat and food for these animals. A key goal thus is to ensure there is a high amount of prey in the water. Food availability for mobulids is affected by plankton productivity and plankton type. Plankton productivity may be impacted by changes in global climate; the productivity and type are likely to become more variable and potentially limited as climate change progresses[32–34]. While there are limited actions that can be taken to address the linkages between plankton productivity and climate change, activities to better understand this relationship should be undertaken and are described below.

To ensure healthy ecosystems, it is also essential to maintain or rebuild coral reefs. Reefs provide, for example, cleaning stations for mobulid rays that are essential for mobulid health and socializing among the population[35]. The principal factors that lead to coral reef degradation are sedimentation, reef destruction, unmanaged fisheries, destructive fishing, as well as climate change, invasive species, and pollution[36,37]. These activities destroy and pollute the oceans, thus making it more difficult for mobulid rays to thrive.

To ensure healthy ecosystems for mobulid rays, the following preconditions need to be met:

1. **There is high plankton productivity in the oceans.**
2. **There are healthy coral reef ecosystems worldwide.**
3. **There is limited pollution in the oceans.**

Recognizing that we have limited influence on the myriad of factors that affect ecosystem health, there are fewer actions that can be undertaken:

- Provide data on mobulid rays to ensure informed decision-making of planning and management of coastal developments.
- Conduct research on the effect of climate change and plankton productivity on mobulid fitness and population health.
- Conduct research into the potential effects of pollutants on mobulid rays.

The responsible party, relative priority, scale of operation, cost, and time required to carry out these actions is described in Table 5. See Appendix I for a detailed theory of change diagram.

Table 5: *Action plan to address the threat from reef degradation, pollution, and food availability.*

GOAL 4: To ensure healthy ecosystems exist for mobulid rays.		PRIORITY	SCALE	COST	TIMELINE
Objective 4.1	**There is high plankton productivity.**				
Action	The effects of climate change on plankton productivity are better understood.	High	Intl	$$$	Long
Objective 4.2	**Coral reefs are healthy.**				
Action	Provide data for better planning & management.	Med	Local	$$	Short
Action	Agricultural activities and coastal development are well-managed.	Med	Local	$$	Short
Action	Reef destruction is minimal, and there is limited sedimentation.	Med	Local	$$	Short
Action	Fisheries are well managed and there is reduced destructive fishing.	High	Local/ Nat	$$	Med
Objective 4.3	**There is limited pollution.**				
Action	Conduct research into the potential effects of pollutants on mobulids.	Med	Intl	$$	Med

Purple: Actions that Manta Trust are currently undertaking, or have an interest in undertaking.
Green: Actions currently led by other NGOs, IGOs, governments, and industry.
Orange: Actions undertaken by a combination of both of the above.

Strategies to build healthy mobulid habitats

Infographic design by Jessica Berliner

THE GOAL: TO ENSURE HEALTHY ECOSYSTEMS FOR MOBULIDS

1 THERE IS HIGH **PLANKTON PRODUCTIVITY**

- The effects of climate change on plankton productivity are better understood

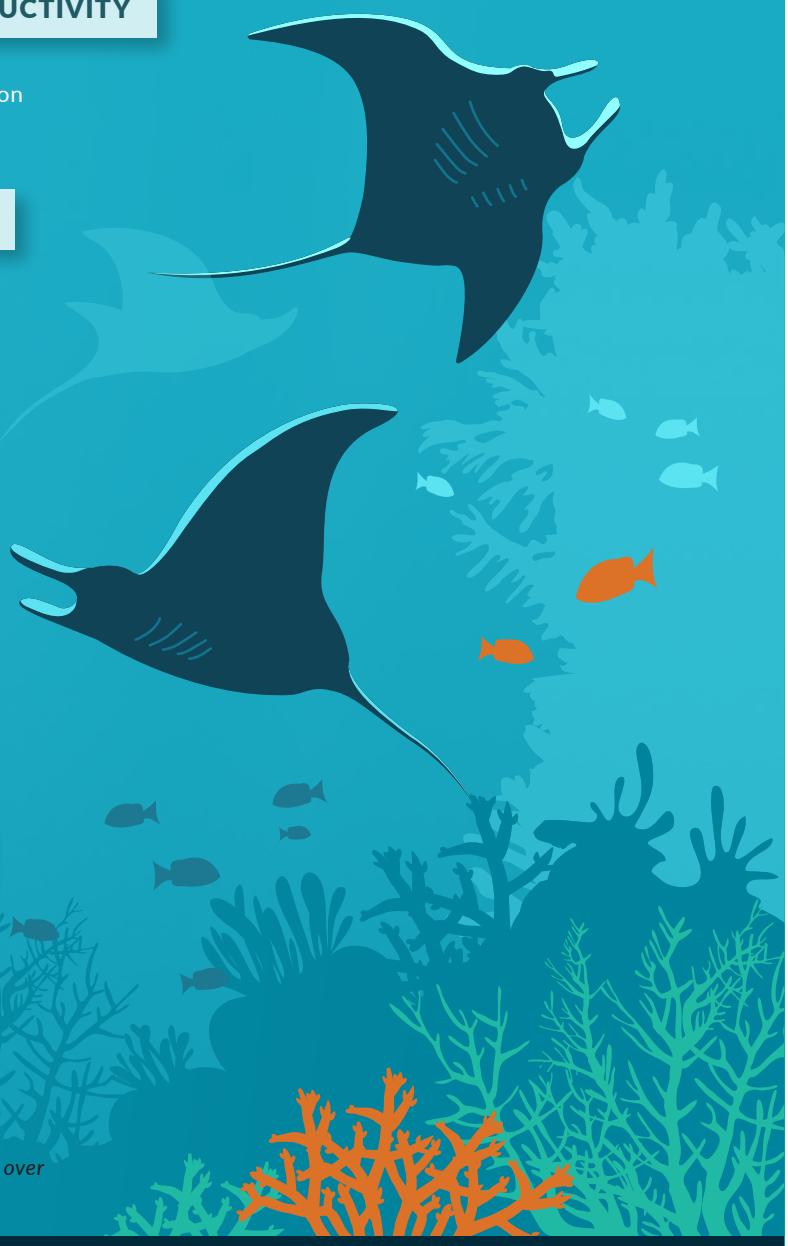
2 THE CORAL **REEFS ARE HEALTHY**

- There is limited sedimentation
- Agricultural activities and coastal development are well-managed
- Reef destruction is minimal
- Fisheries are well-managed and there is reduced destructive fishing
- There are minimal invasive species*
- The effect of climate change is mitigated*

3 THERE IS **LIMITED POLLUTION**

- Waste products, including use of plastics are reduced
- There is limited run-off*
- Agricultural practices are well-managed*

**Factors that the Manta Trust has no control over*



Manta Trust's actions

- *Provide data for informed decision-making of planning and managing coastal developments*
- *Conduct research on effect of climate change on plankton productivity, and anatomical changes related to these*

POLICY RESEARCH

EXTERNAL ACTIONS

- *Conduct research into the potential effects of pollutants on mobulid rays*

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PRIORITIES FOR ACTION

A comprehensive approach to conserving mobulid rays with distinct goals, based on a theory of change, has been defined here. Whilst all goals and actions are relevant and important, some should be addressed with more urgency than others.

As identified above, the threats to mobulids in order of priority are as follows:

1. Targeted fishery
2. Bycatch
3. Tourism
4. Food availability
5. Reef degradation
6. Pollution

The scale of each of these threats differs geographically. The section below details locations which need action most urgently, in addition to high priority actions described in the tables. It is hoped the following section will serve as a guide for allocating resources and capacities most effectively.

PRIORITY ONE

Focus Areas to Address the Threats from Targeted & Bycatch Fisheries.

A study on the vulnerabilities and fisheries impacts on manta and devil rays[11] identified 13 fisheries in 12 countries targeting mobulids, and 30 fisheries in 23 countries recording mobulid bycatch. Individuals are reported as targeted or bycatch in both recreational and commercial harpoon, gill net, longline, trawl, purse seine, and trap fisheries throughout their range[11]. This information can be overlaid with recorded decline data for mobulid rays, as well as information on source countries for the gill plate trade. By combining these data, priority areas emerge; 1.) where mobulid fisheries occurs, 2.) which are sources for the gill plate trade, and 3.) where serious declines have occurred, and consequently action is immediately required (see map on page 35).

The **Indo-West Pacific Ocean** region ranks highest in terms of catch decline and gill plate source countries:

- **77-99%** declines in mobulid ray landings have been reported in **Indonesia**, despite increased fishing efforts[13]. Whilst manta rays are now nationally protected in Indonesia, there are currently no restrictions on fishing or trade in devil rays, which constitute a large proportion of the mobulid landings.

- A study characterising the trade in mobulid gill plates ranked countries in terms of the volume of gill plates supplied to this trade[12]:

- » **Indonesia** ranked as the second highest source country after **China**.
- » **Sri Lanka** and **India** rank as the fourth and fifth highest source countries, with recorded declines in mobulid landings and no national protection or fisheries management in place.
- » **Malaysia** and the **Philippines** also each provide significant proportions of the total traded gill plates.
- » Whilst not an identified source for the trade, **>90%** declines in sightings of both manta and devil rays have been documented in **Mozambique**[15] and **Pakistan**[38], also making these priority locations for action.

The **Eastern-Pacific Ocean** emerges as a second priority region:

- **89%** declines in landings of devil rays have been recorded in the north of **Peru**[39,40].
- A **78%** decline in sightings of devil rays have been reported from Cocos Island, **Costa Rica**[14].
- More than **50%** declines in the Inter-American-Tropical-Tuna-Commission catch data for devil rays have been recorded from purse seine fisheries in the **Eastern Pacific** region[41].

Within the **Atlantic Ocean** fisheries data is sparse:

- In **Guinea**, West Africa a **61%** decrease in landings of devil rays has been recorded[42].

PRIORITY TWO

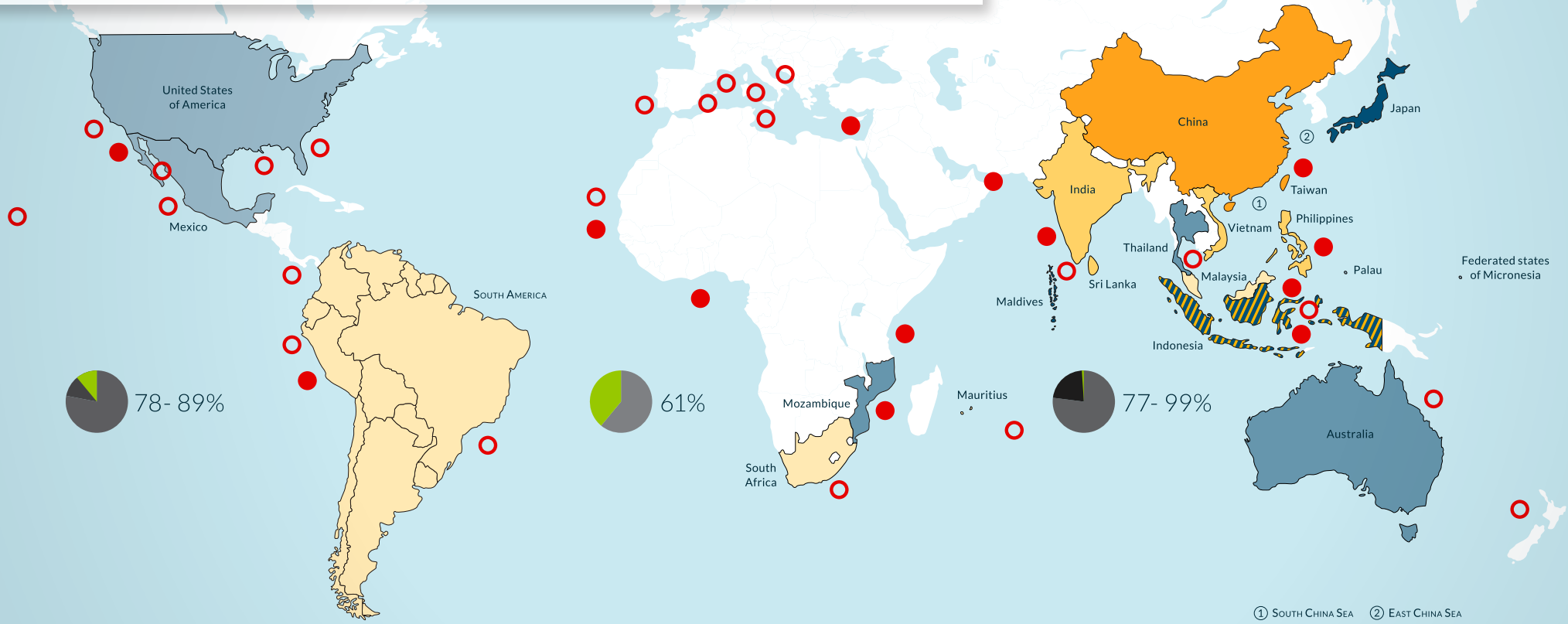
Focus Areas to Address the Threat from Tourism Worldwide.

It is crucial to ensure that mobulid tourism is managed sustainably. Shark and ray watching tourism can provide a sustainable alternative to fishing, with economic returns to the country and an incentive to their conservation[25,43]. This is based on the principle that an animal is worth much more alive than dead[17]. Willingness to pay and tourist satisfaction is also linked to the extent that healthy populations are encountered, and conservation activities are in place[44].

A study on the global impact of manta ray tourism identified the key locations of manta tourism and the associated economic returns[16]. The **Indo-West Pacific Ocean** region ranked highest in terms of revenue generated. In **Japan**, manta watching tourism contributes 11.4m USD per annum to the local economy, followed closely by **Indonesia** (10.7m USD/year), and the **Maldives** (8.1m USD/year). In **Mozambique**, manta tourism is worth 7.6m USD/year, similar to the amount recorded for **Thailand** (7.4m USD/year). Manta tourism also creates significant revenue in **Australia** (6.5m USD/year), **Mexico** (5.1m USD/year), the **USA** (4.7m USD/year), within the **Micronesian** region (4.1m USD/year), and in **Palau** (2.5m USD/year).

Whilst limited information is available on the revenue generated from devil ray tourism, a study on the occurrence of mobulids in the **Azores** highlights this region as a key location for tourism dedicated towards these species[45] (see map on page 35).

Mobulid conservation – priority areas for action



Infographic design by Jessica Berliner

TOP 10 REPORTED GILL PLATE SOURCES FROM VENDOR INTERVIEWS [12]

% of vendors reporting this location as a source of gill plates

40% –	China	40.3%
13% – 15%	China Seas	14.4%
	Indonesia	13.8%
5% – 8%	Vietnam	7.2%
	Sri Lanka	5.5%
	India	5.0%
3% – 5%	South America	4.4%
	Malaysia	4.4%
	South Africa	3.3%
	Hong Kong	3.3%

TOP 10 COUNTRIES FOR MANTA RAY TOURISM INTERACTIONS [16]

Estimated expenditure, in US$

$8m - $12m	Japan	$11.4m
	Indonesia	$10.7m
$5m - $8m	Maldives	$8.1m
	Mozambique	$7.6m
	Thailand	$7.4m
$2m - $5m	Australia	$6.5m
	Mexico	$5.1m
	USA	$4.7m
	Micronesia	$4.1m
	Palau	$2.5m

ESTIMATED DECLINE OF MOBULID POPULATIONS

INDO-WEST PACIFIC OCEAN

Cilacap, Indonesia	77% [13]
Tanjung Luar, Indonesia	99% [13]
Pakistan	>90% [38]
Mozambique	>90% [15]

EASTERN PACIFIC OCEAN

Cocos Islands, Costa Rica	78% [14]
Tumbes, Peru	89% [40, 39]

ATLANTIC OCEAN

Guinea	61% [42]

KEY

- *Targeted mobulid fishing locations*
- *Mobulid bycatch locations*
- *Estimated population declines*
- *Countries reported to sell mobulid gill plates*
- *Countries that benefit from manta tourism*
- *Countries reported to sell mobulid gill plates and also benefit from manta tourism*

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CONCLUSIONS

A comprehensive approach and strategic plan is needed to ensure the long-term conservation and sustainable use of mobulid rays. Crucially, this plan needs to define the pathways and actions that will lead to the desired end-state: to see all species of manta rays and their relatives protected or effectively managed for sustainable or non-consumptive use, by the people closest to them, in a means that promotes wider ocean conservation.

In this document we define a strategic, comprehensive approach towards tackling the direct threats which these species face, from fisheries (target and bycatch) to tourism. The document also tackles the indirect threats which mobulids are exposed to as a result of environmental changes, such as reef degradation and pollution. A theory of change diagram has been created for each threat, showing the range of factors that contribute to each, what it would look like if these threats were eliminated, and consequently what actions need to occur to achieve this change.

For each action that can be influenced by parties (such as the Manta Trust, other NGOs, governments, or researchers), we have defined the time-frame, level of investment, priority, and responsible party. To more effectively use the limited resources available, we have identified priorities for actions for practitioners, donors and policy makers. We trust that the recommendations will guide future actions to ensure these incredible species have the best chance of surviving in our oceans for future generations.

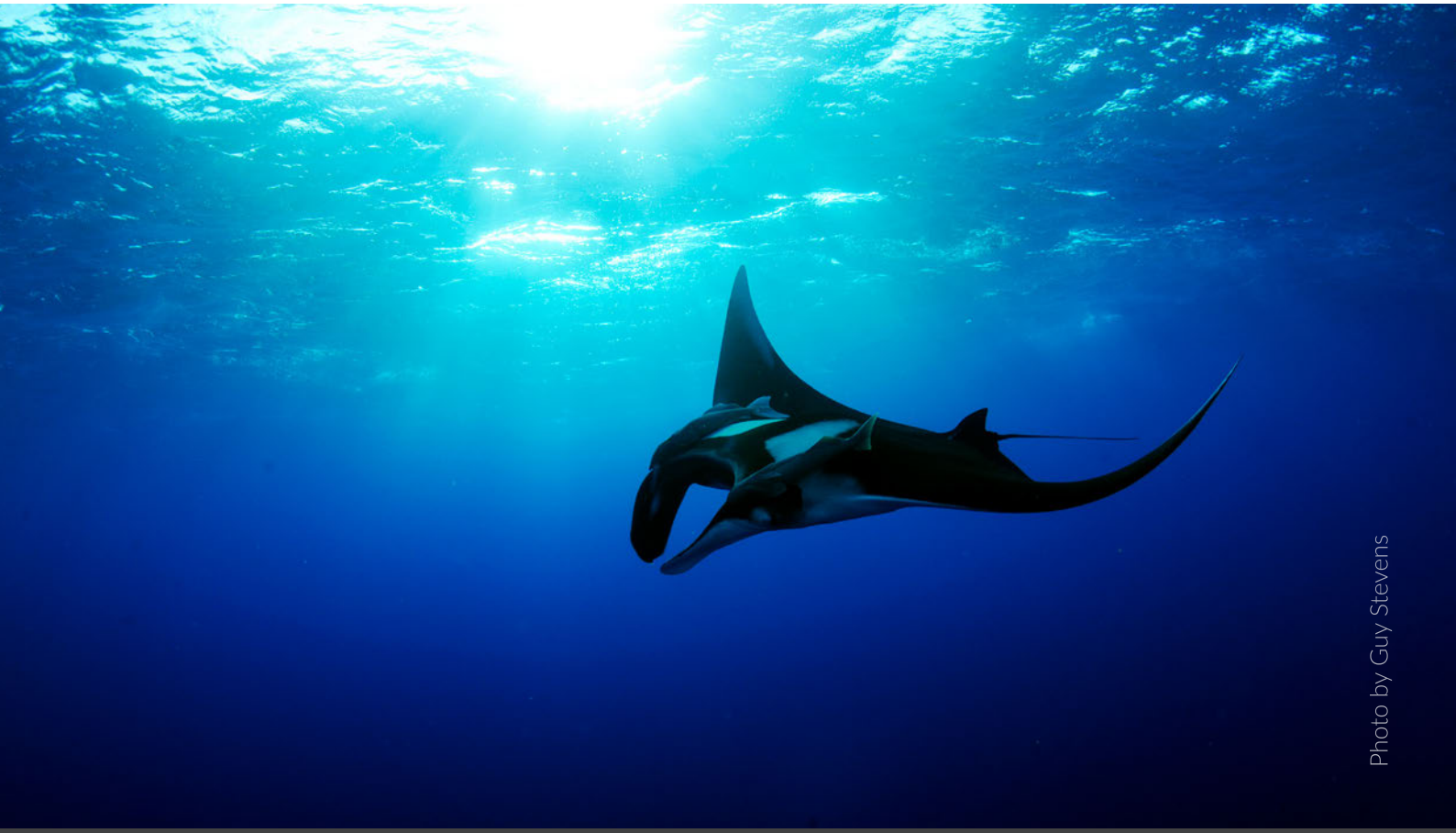
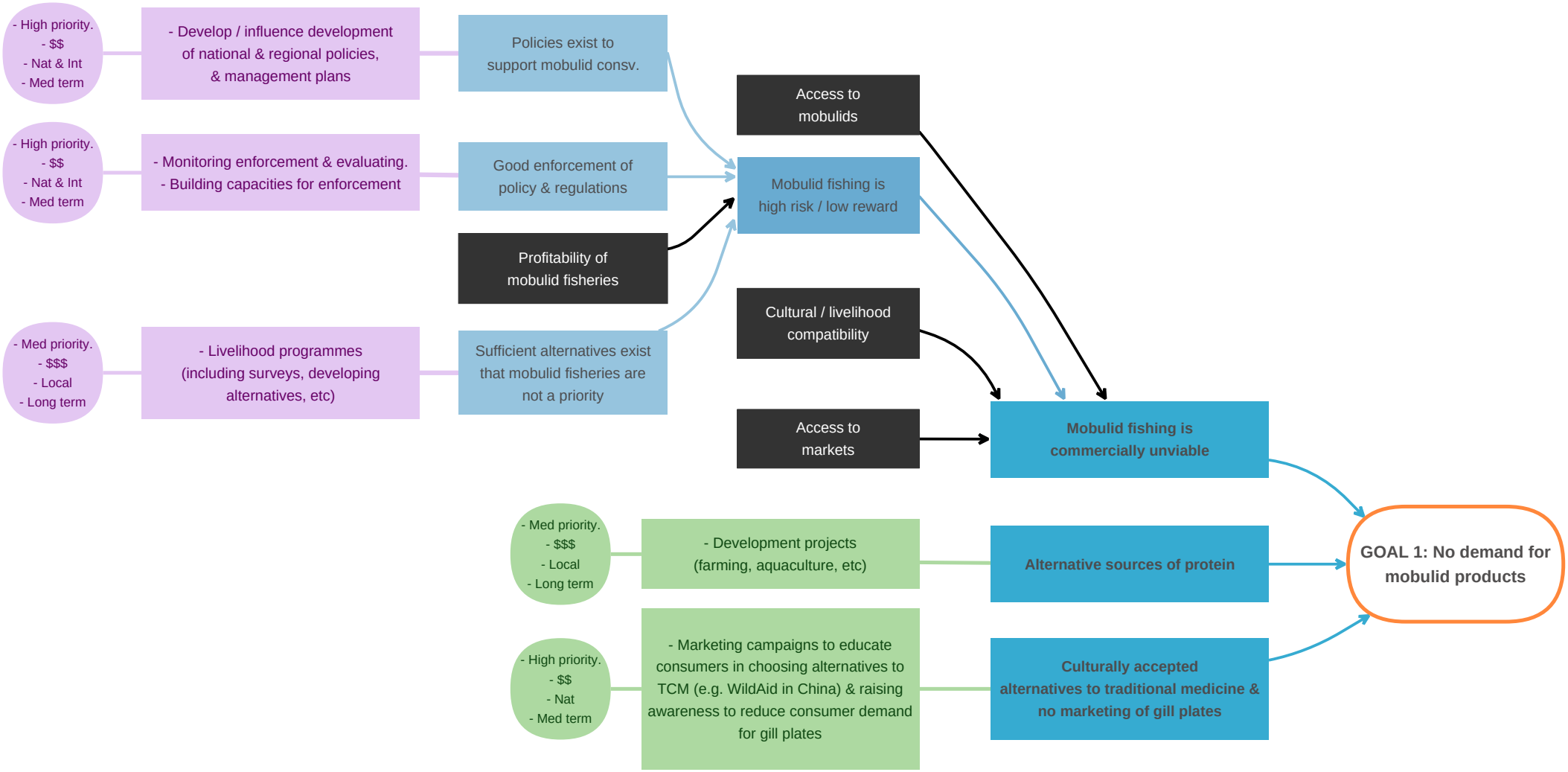


Photo by Guy Stevens

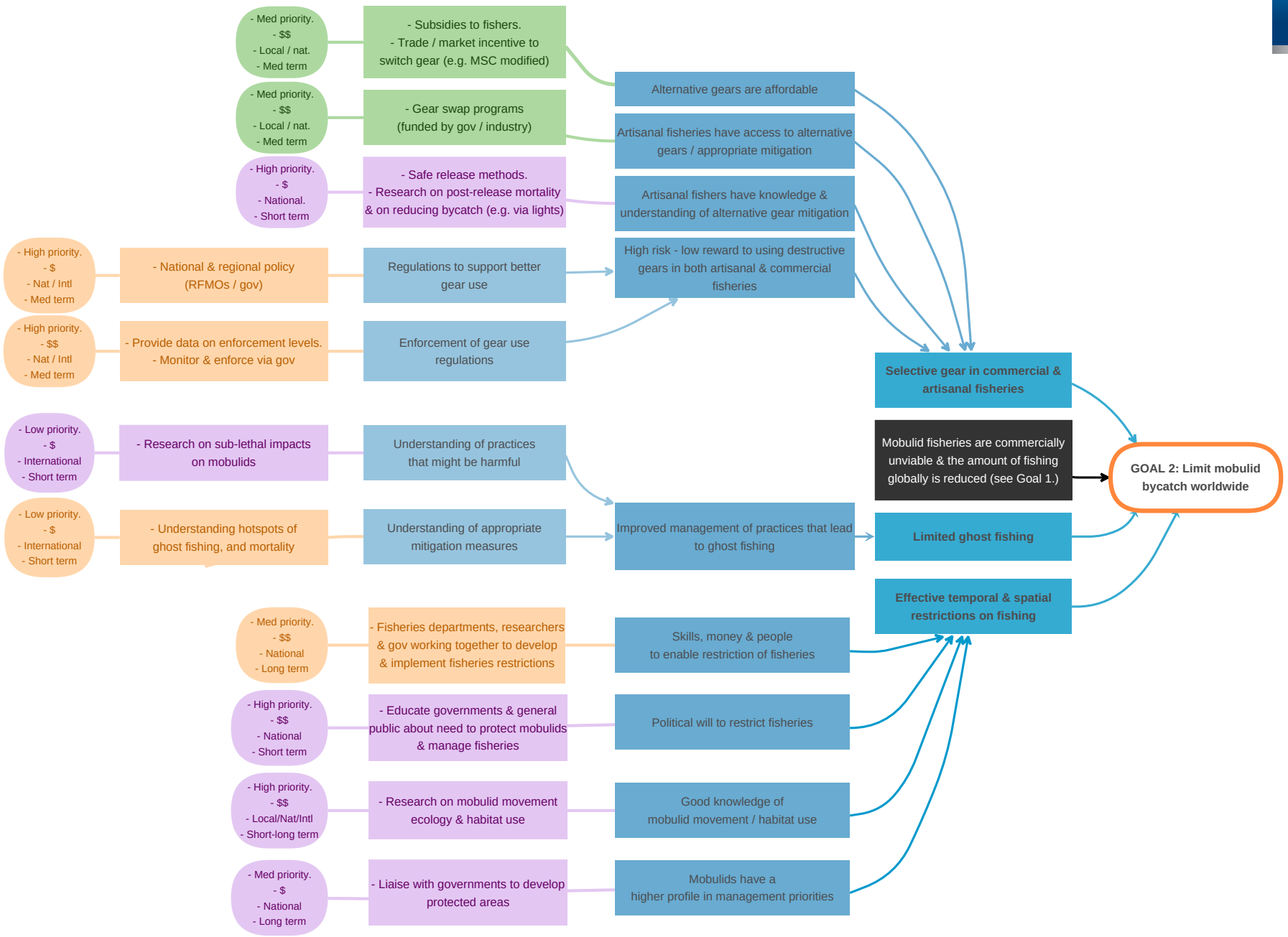
APPENDICES

APPENDIX I

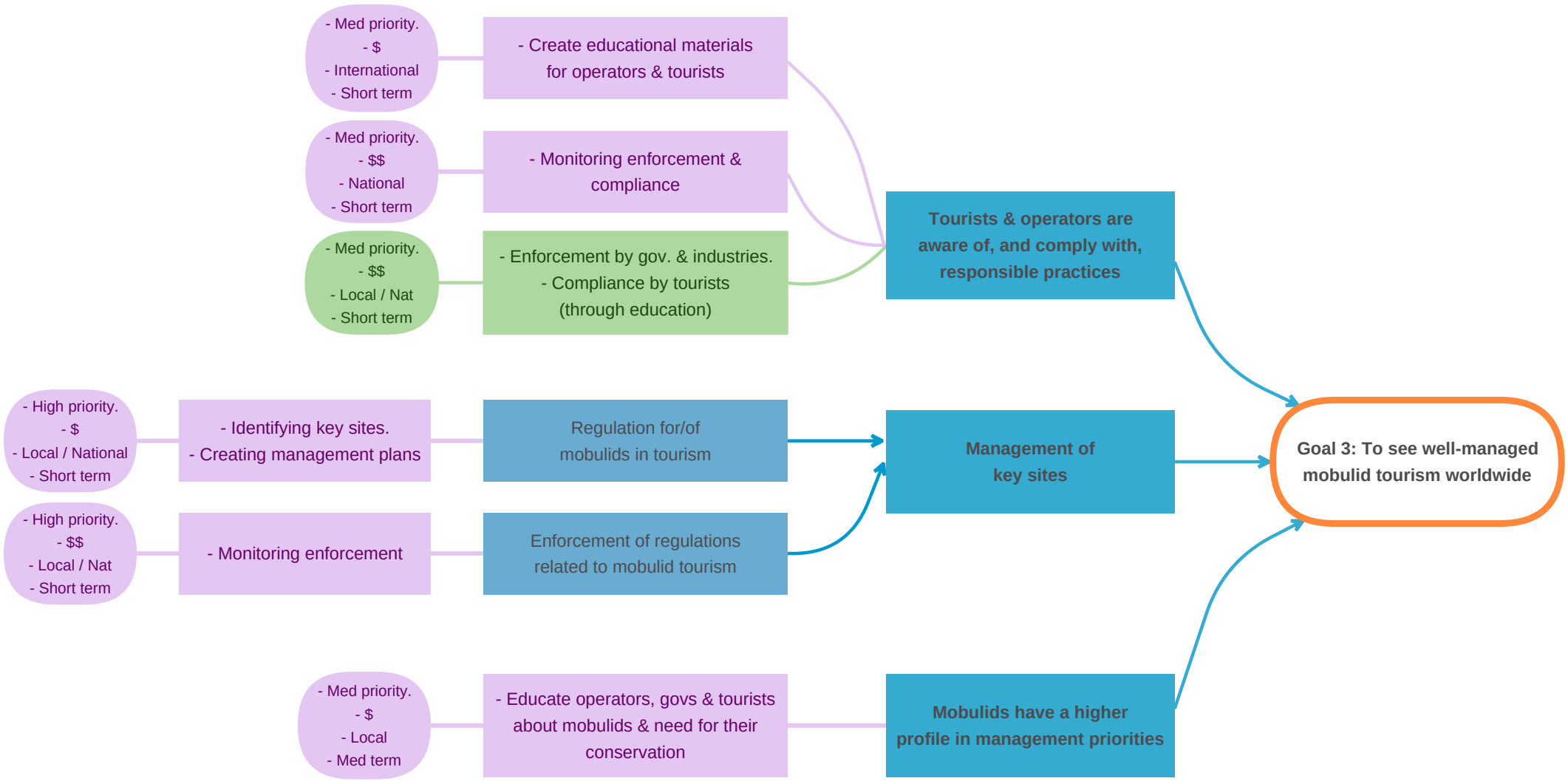
Theory of change to eliminate threat from targeted fisheries.



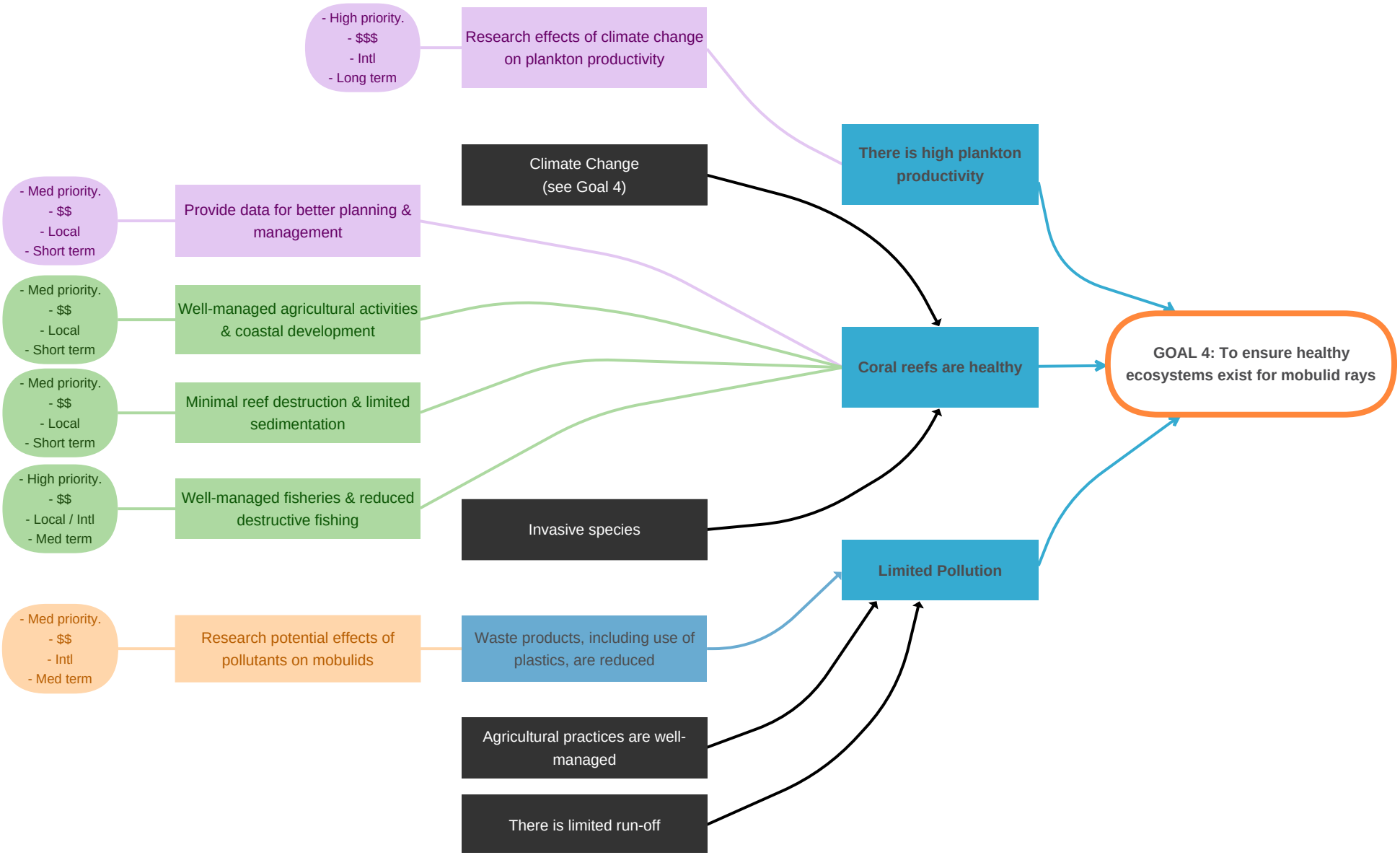
Theory of change to address threat from mobulid bycatch fisheries.



Theory of change to address threat from tourism.



Theory of change to address threat from environmental changes.



Appendix II: Research Priorities to Support Effective Manta & Devil Ray Conservation

Stewart JD, et al (2018) Research Priorities to Support Effective Manta and Devil Ray Conservation. Front. Mar. Sci. 5:314. doi: 10.3389/fmars.2018.00314

In the last ten years, a huge amount of progress has been made in manta and devil ray research. However, threats remain to these vulnerable species and there are many knowledge gaps that continue to hinder effective conservation and management. To prioritise future research on these species and support conservation action, 30 experts from 27 organisations put their heads together to identify the most pressing questions in mobulid conservation research.

Led by the Manta Trust, this open access paper gives a detailed overview of previous research on mobulid rays, and which knowledge gaps most urgently need to be filled to support conservation action.

Available via: http://bit.ly/2D3h8Se.

ABSTRACT

Manta and devil rays are filter-feeding elasmobranchs that are found circumglobally in tropical and subtropical waters. Although relatively understudied for most of the Twentieth century, public awareness and scientific research on these species has increased dramatically in recent years. Much of this attention has been in response to targeted fisheries, international trade in mobulid products, and a growing concern over the fate of exploited populations. Despite progress in mobulid research, major knowledge gaps still exist, hindering the development of effective management and conservation strategies. We assembled 30 leaders and emerging experts in the fields of mobulid biology, ecology, and conservation to identify pressing knowledge gaps that must be filled to facilitate improved science-based management of these vulnerable species. We highlight focal research topics in the subject areas of taxonomy and diversity, life history, reproduction and nursery areas, population trends, bycatch and fisheries, spatial dynamics and movements, foraging and diving, pollution and contaminants, and sub-lethal impacts. Mobulid rays remain a poorly studied group, and therefore our list of important knowledge gaps is extensive. However, we hope that this identification of high priority knowledge gaps will stimulate and focus future mobulid research.

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