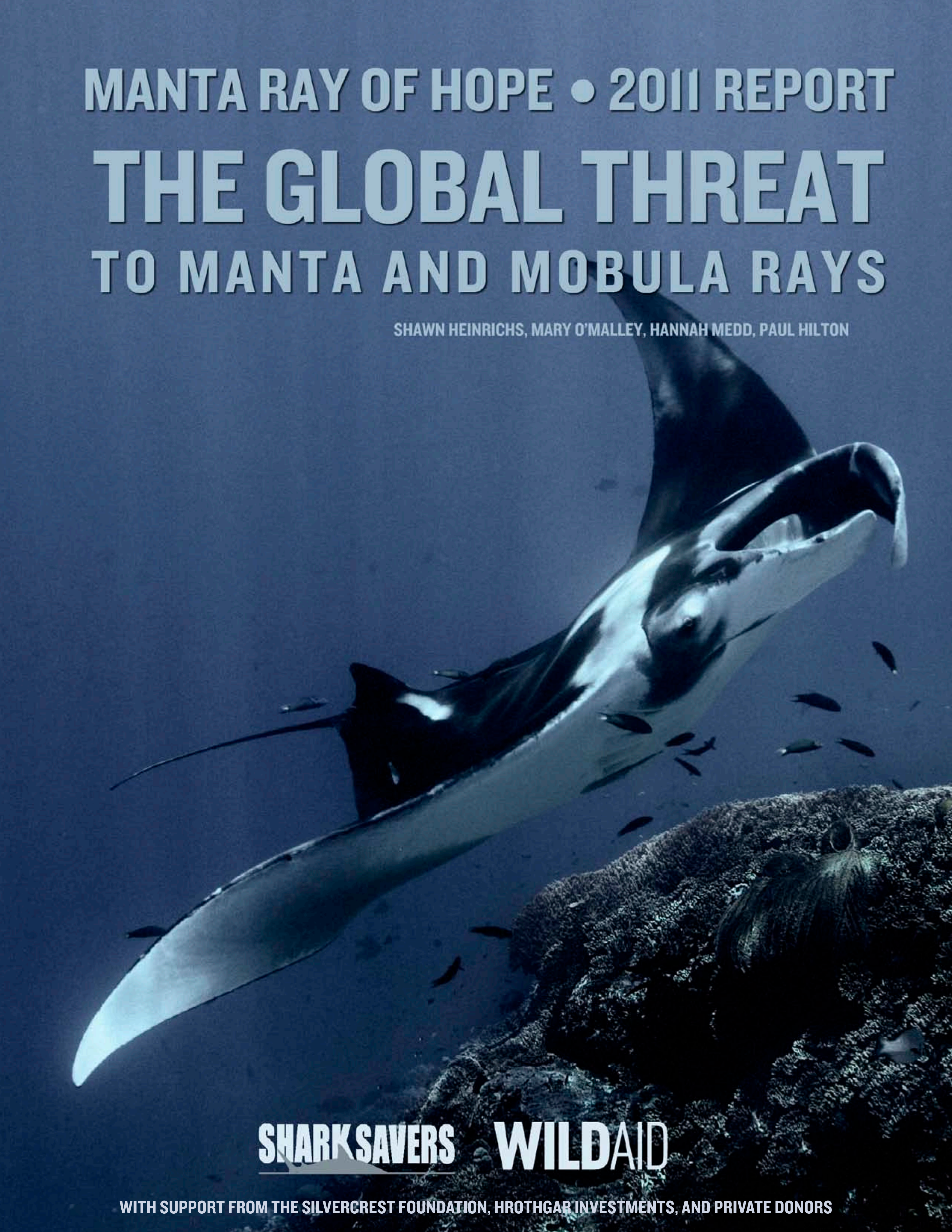
MANTA RAY OF HOPE • 2011 REPORT

THE GLOBAL THREAT TO MANTA AND MOBULA RAYS

SHAWN HEINRICHS, MARY O'MALLEY, HANNAH MEDD, PAUL HILTON



SHARK SAVERS WILDAID

WITH SUPPORT FROM THE SILVERCREST FOUNDATION, HROTHGAR INVESTMENTS, AND PRIVATE DONORS

ACKNOWLEDGEMENTS

The Manta Ray of Hope project brings together a unique set of skills and knowledge to enable the production of this comprehensive report on the conservation status of manta and mobula rays. The team includes top field investigators, leading scientists and researchers. The project was founded by Sharks Savers and WildAid, with support from the Silvercrest Foundation, Hrothgar Investments, and private donors.

REPORT WRITERS

Shawn Heinrichs, Mary O'Malley, Hannah Medd, and Paul Hilton

PROJECT TEAM

Shawn Heinrichs – Project Lead, Investigator, Report Writer
Paul Hilton – Lead Investigator, Report Writer
Mary O'Malley (Shark Savers) – Project Manager, Report Writer
Hannah Medd (Shark Savers) – Marine Biologist, Report Writer
Guy Stevens (Manta Trust) – Lead Scientific Advisor
Cassandra Brooks – Contributing Editor
John Weller – Graphics and Design
Local Investigators
Peter Knights (Executive Director of WildAid)
Michael Skoletsky (Executive Director of Shark Savers)

CONTRIBUTORS

Andres Baquero
Lydie Couturier
Daniel Fernando
Mark Harding
Shawn Heinrichs
Paul Hilton
Peter Knights
Dr. Andrea Marshall
Hannah Medd
Mary O'Malley
Briana Rivera
Naneng Setiasih
Guy Stevens

SCIENTIFIC ADVISORY TEAM

MSc Andres Baquero
Dr. Mark Deakos
Dr. Heidi Dewar
Dr. Mark Erdmann
Dr. Rachel Graham
Mark Harding
Dr. Andrea Marshall
Frazer McGregor
Dr. Mahmood Shivji
Guy Stevens
Dr. Giuseppe Notarbartolo di Sciara
Dr. Kathy Townsend
Dr. William (Will) White

SPECIAL THANKS

We would like to offer a special thank you to the all individuals and organizations contributing to this project. Without your valuable support, this project would not have been possible. We pride ourselves on our photography. All photographs are copyrighted. Credits on page 38.

AUTHORS' NOTE

This report is intended to provide all available data, including peer reviewed and published science, primary research, and unpublished studies. Data based on unpublished studies and primary research have been reviewed by the scientific advisory team, and are considered the best available at this time.

CONTENTS

AT A GLANCE

EXECUTIVE SUMMARY

Manta and mobula rays span the tropics of the world and are among the most captivating and charismatic of marine species. However, their survival is severely threatened by growing fisheries pressure driven by demand for the gill rakers that the animals use to filter feed. This report is the first global assessment of what is currently known about manta and mobula biology, the threats they face, the fisheries and trade that target them, non-consumptive and sustainable uses for communities to profit from them, current conservation measures and urgent steps recommended to prevent regional extinctions.

Global manta and mobula ray populations are currently unknown. Even the leading scientists interviewed for this report were not prepared to offer estimates on global populations for any species. Likewise, many questions remain unanswered regarding their biology and behavior. What is known, however, is that these species are slow to mature (8-10 years+), are long-lived (40 years+), and reproduce very slowly. A manta ray will give birth to as few as a single pup every two to five years. By comparison, the Great White Shark, a highly vulnerable species protected under Appendix II of CITES, may produce more young in one litter than a manta ray will in her entire lifetime. Further underscoring the vulnerability of manta rays, scientists believe that specific regional populations may be genetically different from other populations.

These characteristics make manta and mobula rays extremely vulnerable to overfishing, regional depletion and local extirpation. While they are also taken as bycatch in certain fisheries, these rays are subject to significant directed fishing pressure throughout their range. Indonesia, Sri Lanka and India have the largest documented fisheries, with targeted fisheries also reported in Peru, Mexico, Thailand, China, Mozambique, Ghana, and other locations. Total annual documented global landings are ~ **3,400** mantas (*M. birostris* only) and ~**94,000** mobulas (all species). Unreported and subsistence fisheries will mean true landings are likely much higher.

While local subsistence fisheries for meat have been carried out for centuries, in the past decade the growing markets for gill rakers have significantly increased fishing effort. A mature *Manta birostris* (oceanic manta ray) can yield up to 7 kilos of dried gills that retail for as much as US$500 per kilo in a market in China. Established shark fin trade networks have exploited the opportunity to profit from gill rakers, especially as shark populations have declined.

Historically both fisheries and markets have been largely undocumented and completely unregulated. Consequently many of these fisheries are in rapid decline. The past decade has seen significant declines in both number and size of manta rays landed in primary fishery sites in Indonesia, Mozambique, India and Thailand. *M. birostris* has all but disappeared from the Sea of Cortez. Fishermen in the Philippines reported a 50% decline in manta ray landings from the 1960s to 1990s, and in Sri Lanka, fishermen also reported declines in catches.

Manta and mobula gill rakers are promoted as a cure for a wide array of ailments from chickenpox to cancer in some Chinese communities. Gill rakers are sold primarily in Chinese markets and directly marketed by importers from the hub of the trade in Guangzhou, Southern China. Guangzhou trade is as much as 99% of the global market. Market analysis suggests total annual gill raker trade volume in excess of **61,000 kg** (and perhaps as high as 80,000 kg) with an estimated value of **US$11.3 million** per year.

Despite the marketing, a number of Traditional Chinese Medicine (TCM) practitioners stated that gill rakers are not a legitimate acknowledged component of mainstream TCM. No interviewees were able to locate any references in TCM texts, and one practitioner confirmed that gill rakers are not included in the official TCM manual. Several interviewees admitted belief that gill rakers were not effective and suggested that many alternatives were available. No vendors offered any evidence of efficacy in the product.

AT A GLANCE

Though the outlook may appear grim, manta and mobula ray tourism offers sustainable and profitable alternatives. The value of manta ray tourism based on data gathered from only seven sites is estimated to be US$27 million in direct tour operator revenue, and **US$50 million per year** when associated tourism expenditures are included. The many other current manta and mobula tourism sites around the world are expected to yield a further US$50 million per year, and other aggregation sites have yet to be exploited for tourism. A total estimated annual tourism value of over **US$100 million per year** compares favorably to the estimated market value of US$11million per year for the global gill raker trade.

Populations are currently stable, at best, around tourism sites or within marine reserves where manta rays are protected. Regionally, several nations and states have passed laws specifically prohibiting the landings of manta and mobula rays. The United Nations' Convention of Migratory Species (CMS) recently listed the giant manta ray (*M. birostris)* as a species of international concern, but there are no binding international protections for any manta or mobula species, nor are they currently regulated by the Convention on International Trade in Endangered Species (CITES).

The general public, policy makers, and even those in the ocean conservation field are largely unaware of the growing trade in gill rakers and its impact on manta and mobula ray populations throughout the world. If action is not taken immediately, these rays face imminent regional extirpations and broad-scale global depletion.

We recommend that range states immediately place a moratorium on all directed manta and mobula fisheries, and mandate measures to reduce bycatch until proper population studies are conducted. We recommend further that China and other importing/consuming countries place and maintain moratoriums on imports and sales of gill rakers, unless it can be proven that such imports are not damaging ray populations.

BY THE NUMBERS

US$100 million	The expected global tourism value of manta and mobula rays
US$11 million	The estimated global value of the gill raker trade
US$1 million	The estimated tourism value of a single manta ray over its lifetime, ALIVE
US$40 – 500	The estimated fisheries value of a single manta ray, DEAD
94,000 & 3,400	The estimated global landings of mobula and manta rays (respectively) documented in fisheries
600	The number of *Manta birostris* identified in the largest documented aggregation site
16	The maximum number of pups a manta ray produces over her LIFETIME
14	The maximum number of pups the vulnerable Great White Shark produces in one litter
Zero	Locations where manta or mobula rays have been fished sustainably

AT A GLANCE

KEY RECOMMENDATIONS

Trade Moratoriums – Given the difficulty in regulating fisheries and lack of resources in most mobulid range states, the single measure that would reduce pressure on mobulids would be an immediate moratorium on import and sales of gill rajkers. With the vast majority of the trade centered in Guangzhou, China could take a global conservation leadership role with minimal economic impact (US$ 11 Million p.a.) by enacting a moratorium on the possession, sales and import of manta and mobula gill rakers. Other governments considering legislation to protect sharks, including shark fin trade bans, should include manta and mobula rays in these bills. Including this language will prevent the gill raker trade from diversifying to new areas.

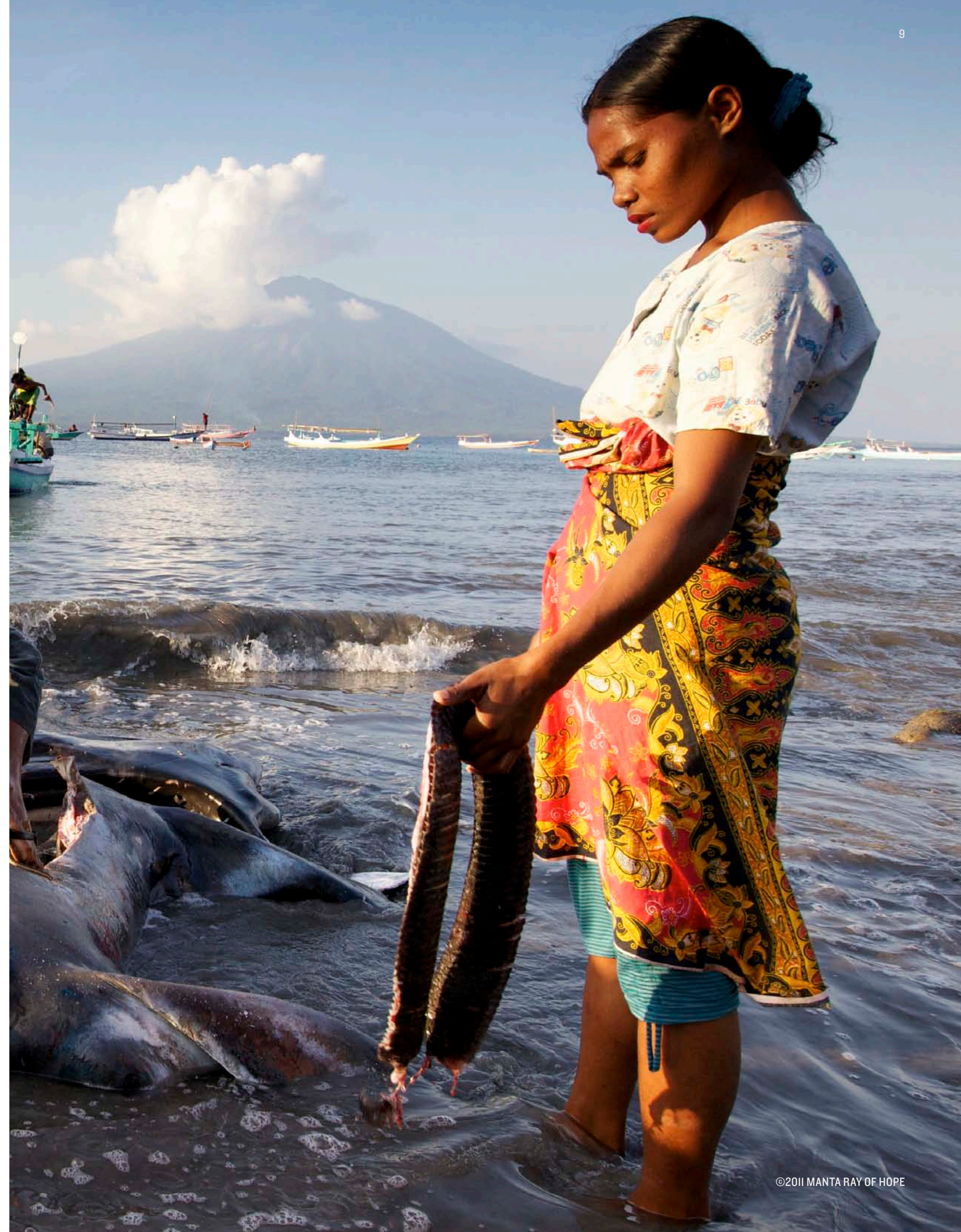
Consumer Education – To support a moratorium consumer education campaigns should inform consumers of the unproven nature of gill raker tonic claims, the extreme vulnerability of these animals, and the long-term sustainable value of keeping them alive.

International Protections - Because of the broad geographic range of most mobulid species, international measures to control trade, directed fisheries and bycatch are vital to the effective protection of manta and mobula rays. Range state countries should propose all Mobulids for listing under CITES Appendix I or Appendix II. In addition, all Regional Fishery Management Organizations (RFMO's) should enact "no retention" policies for mobulids, along with mandatory bycatch reduction measures.

Range State Protections – Though certain fisheries will likely be reduced by a gill raker trade moratorium in China/Hong Kong/Singapore, range state regulations prohibiting the killing and trade of manta and mobula rays must be pursued. Protection initiatives must be focused initially on the largest known fisheries, including Indonesia, Sri Lanka, India and Peru, as well as Mozambique and other African countries. Protection of critical habitats should be a primary focus, with seasonal regulations restricting all harmful fishing practices in known aggregation areas. The recent CMS Appendix I and II listings for *M. birostris* should provide impetus to member countries, of which twenty-four are identified as *M. birostris* range states, to enact strong measures to protect manta rays and their critical habitats.

Eco-Tourism and Other Economic Alternatives - Development of economic alternatives by governments and NGOs will be vital in areas where manta and mobula rays are hunted, (e.g. Sri Lanka and Indonesia). The potential for long-term sustainable income through responsible dive eco-tourism, can provide a strong incentive for coastal communities to protect manta and mobula rays. Eco-tourism development should include appropriate legislation and marketplace organization to ensure that the rays will not be negatively impacted by uncontrolled boat and tourist traffic.

Enforcement - Enforcement strategies for all protective measures, in addition to regular monitoring of fish markets in key areas, must be developed in collaboration with fisheries departments and local partners to track effectiveness of measures and keep poachers from exploiting protected areas.



MOBULIDS

INTRODUCTION TO MOBULID RAYS

Taxonomy, Morphology and Distributions: The group of cartilaginous fish in the family *Mobulidae* (Mobulid rays) consists of two genera, *Manta* and *Mobula*, with two and nine species respectively[1] (See Table 1 and Figure 1). All mobulid rays have diamond shaped bodies, wing-like pectoral fins used for propulsion, and five pairs of gill slits. They usually inhabit pelagic zones[2]. Mobulids are often called "devil rays" because of the cephalic fins on the front of their heads that resemble "horns". The cephalic fins unfurl and help guide water into their mouths, and modified gill features filter zooplankton and small fish, their primary food sources[3].

The genus *Manta* includes the larger *Manta birostris* (oceanic manta), the smaller *Manta alfredi* (reef manta), and a possible third species, *Manta. cf birostris*[4]. Both *M. birostris* and *M. alfredi* are circumglobal in overall range, and overlap in some locations[5]. *M. cf birostris*, is likely limited to the Gulf of Mexico and Western Caribbean[6]. *Manta birostris* has a maximum wingspan (disk width, or DW) of seven to nine meters[7]. *Manta alfredi* has a maximum 4 to 5 meter disk width[8], and usually occupies tropical areas.

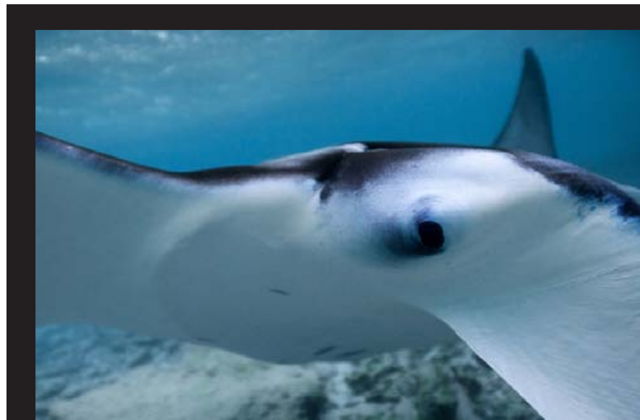
The nine *Mobula* species range in size from the largest, *Mobula mobular*, which can reach 5.2 meters DW, to the smallest, *Mobula eregoodootenkee,* which averages only 1.1 meters DW[9]. Mobulas can be found in temperate and tropical waters worldwide (See Table 1 and Figure 1). Some Mobula species are range restricted, such as *Mobula kuhlii* and *Mobula eregoodootenkee*, found only in the Indian and Western Pacific Oceans respectively. Other species, such as *Mobula tarapacana* and *Mobula thurstoni,* are thought to be circumglobal[10]. Since information on the distribution of this genus is based on sparse records and misidentification is common, the estimated ranges of individual species, and even some species classifications, will likely change in the coming years.

Population Estimates (See Table 2): Overall population sizes for mobulid species are not known, but all species for which data exist are classified as "near threatened," "vulnerable," or "endangered" by the IUCN. A great deal of data has been collected on the two manta species based on long term studies in key aggregation sites. *M. birostris* is believed to have regional subpopulations of as few as 100 to 1000 individuals[11]. *M. birostris* will cross open ocean within a region. *M. alfredi* is believed to have highly localized subpopulations of 100 to 2000 individuals[12]. *M. alfredi* are much less likely to cross open ocean within a region, and thus it is possible to have genetically distinct stocks in close geographic range[13].

Reproduction and Longevity: All mobulids are aplacental, viviparous species, meaning that they give birth to fully developed live young[14], and typically bear only a single pup with each pregnancy[15]. While the lifespan and age at sexual maturity are not yet known for many mobulid species, long-term studies of *M. alfredi* populations in various locations indicate a life history incompatible with targeted commercial fishing.

For example, female *M. alfredi* are believed to reach maturity at 8-10 years[16], however female *M. alfredi* in an extensively studied population in the Maldives showed no mating scars and did not become pregnant for a number of years after reaching mature size. These observations indicate that female *M. alfredi* in some subpopulations may not mate until an age of 15 years or more[17].

M. alfredi near a Mozambique study site and in Maui had a biennial reproductive period with some females pupping in consecutive years[18], while in the Maldives, the reproductive cycle appears to be significantly slower, with female *M. alfredi* giving birth on average to only one pup every five years[19]. *M. alfredi* have been confirmed to live at least 30 years[20] and both manta species are believed to live 40 years and possibly longer[21].



Brain Size and Anecdotal Evidence of Intelligence: Recent research has revealed that manta and mobula rays have the highest brain mass to body mass ratio of all elasmobranchs, comparable to some birds and mammals. They exhibit high maneuverability, and increased social and cognitive abilities[22]. Divers cite numerous examples of manta rays cooperating and accepting help when entangled in lines, and many report that injured manta rays even seem to seek assistance.

TABLE 1. CHARACTERISTICS OF THE FAMILY *MOBULIDAE* (IUCN 2011)

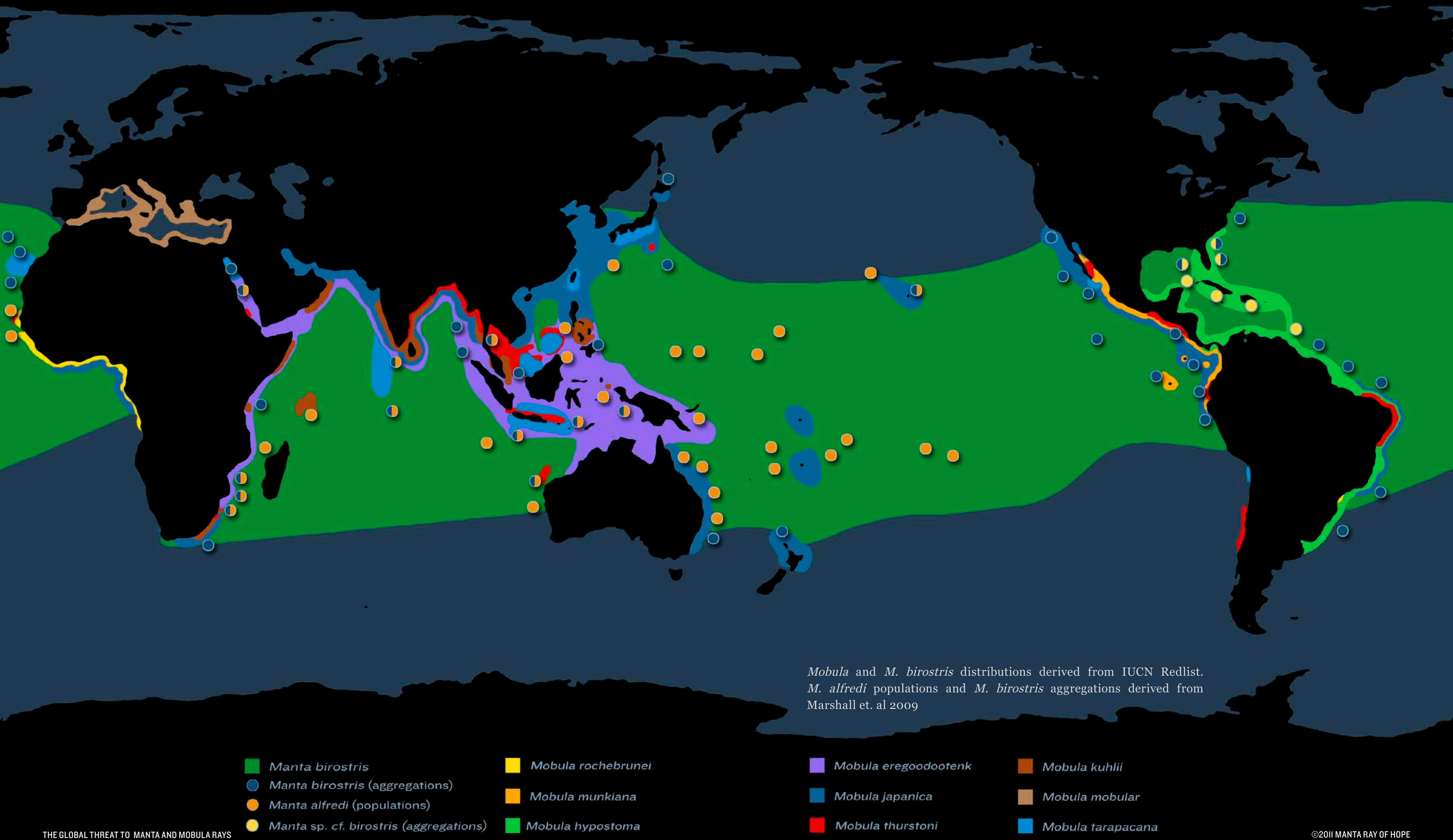
SCIENTIFIC/COMMON NAMES	IUCN CLASSIFICATION	DISTRIBUTION	SIZE (DW)	TREND	FISHERY
Manta birostris Oceanic Manta Ray	Vulnerable	Circumglobal, tropical and subtropical	680 cm	Decreasing	Targeted, Bycatch
Manta alfredi Reef Manta Ray	Vulnerable	Circumglobal, tropical and subtropical	450 cm	Decreasing	Targeted, Bycatch
Mobula eregoodootenkee Long-horned Pygmy Devilray	Near Threatened	Wide, Tropical Indo-West Pacific	100 cm	Unknown	Targeted, Bycatch
Mobula hypostoma Atlantic Devilray	Data Deficient	Western Atlantic	120 cm	Unknown	Bycatch
Mobula japanica Spine Tail Devilray	Near Threatened, Vulnerable in S.E. Asia	Circumglobal	310 cm	Unknown	Targeted, Bycatch
Mobula kuhlii Shortfin Pygmy Devilray	Data Deficient	Indian Ocean and Western Central Pacific	119 cm	Decreasing	Targeted, Bycatch
Mobula mobular Giant Devilray	Endangered	Mediterranean and possibly North Atlantic	520 cm	Decreasing	Bycatch
Mobula munkiana Pygmy Devilray	Near Threatened	Eastern Pacific	110 cm	Unknown	Targeted, Bycatch
Mobula rochebrunei Lesser Guinean Devilray	Vulnerable	Eastern and Southwestern Atlantic	133 cm	Unknown	Targeted, Bycatch
Mobula tarapacana Sicklefin Devil Ray	Data Deficient	Probably circumglobal, Indian, Pacific, Atlantic Oceans	370 cm	Unknown	Targeted, Bycatch
Mobula thurstoni Bentfin Devilray	Near Threatened, Vulnerable in S.E. Asia	Circumglobal, temperate and tropical	180 cm	Unknown	Targeted, Bycatch

TABLE 2. EXISTING REGIONAL POPULATION ESTIMATES OF MANTA SPECIES

REGION	GROUP	POPULATION ESTIMATE[1]	REFERENCE
Republic of Maldives	*M. alfredi*	5,000 - 6,000	G. Stevens pers. comm.
Ningaloo, Australia	*M. alfredi*	1,200 - 1,500	F. McGregor 2009
Southern Mozambique	*M. alfredi*	802	Marshall et al. 2011
Mozambique	*M. birostris*	600	Marshall 2009
Mexico (Revillagigedos Is.)	*M. birostris*	>350	Rubin and Kumli per. comm.
Maui, Hawaii	*M. alfredi*	350	M. Deakos pers. comm.
Yaeyama Islands, Japan	*M. alfredi*	300	Homma et al. 1999
Lady Elliot Island, Australia	*M. alfredi*	~300	K. Townsend pers. comm.
Komodo, Indonesia	*M. alfredi*	~300	KMP 2011, unpubl.
Isla de la Plata, Ecuador	*M. birostris*	~300	M. Harding pers. comm.
Kona, Hawaii	*M. alfredi*	181	MPRF 2011
Yap, Micronesia	*M. alfredi*	~ 100	Marshall et al. 2011
Mexico (Isla Holbox)	*M. birostris*	~ 100	Marshall et al. 2011a
Flower Garden Banks, US	*M. c.f. birostris*	> 70	Graham et al 2008 & unpubl.

1. *Estimates for M. birostris are maximum recorded individuals from surveys, not actual population estimates.*

FIGURE 1. ESTIMATED MOBULID DISTRIBUTIONS



BIOLOGICAL VULNERABILITY

Manta and mobula rays have biological and behavioral characteristics that greatly increase their vulnerability to overfishing.

Slow Reproduction: A female *M. alfredi* may not mate until 15 years of age[23], gives birth to one pup on average every 2-3 years over an estimated lifespan of 40 years or more[24], and therefore produces only a handful of pups in her lifetime[25]. If she avoids fisheries and other threats, and survives to her maximum age, she may give birth to *a maximum* of 10-16 pups over her lifetime. In contrast, even the Great White Shark (*Carcharodon carcharias*), which is listed under CITES Appendix II and gives birth to an average 7-14 pups every two to three years[26], has a greater fecundity. A Great White Shark may produce as many pups in one litter as a manta ray does over its entire lifetime.

Predictable Aggregations: Some manta and mobula rays will aggregate in a predictable coastal area to feed and visit cleaning stations, making these populations vulnerable to localized depletion or even extirpation by local fishermen[27]. They are often found feeding at the surface, making them easy to capture by net or harpoon[28].

Genetically Isolated Local Stocks: Some mobulids are extremely vulnerable to even local fisheries. For example, *M. alfredi* is believed to have small, genetically independent, island-associated stocks[29]. With little exchange between members of neighboring stocks, a fishery could deplete a single stock quite rapidly with little chance of recovery.

Highly Migratory Behavior: Other more mobile rays that cross open ocean, like *M. birostris*, can also be vulnerable to multiple fisheries – as both targets and bycatch – in the high seas between their aggregation sites[30].

EVIDENCE OF DEPLETION

Declines of *M. birostris* have been reported at known aggregation sites throughout their migratory range. Likewise, reports from fishermen, traders and retailers indicate that *M. birostris* gills are becoming harder to source, with prices escalating as the supply continues to dwindle. A longterm study of manta ray populations in *protected areas* has revealed that even these populations are only stable at best. Given these findings, we believe that even current fishing levels present a clear and immediate threat to the survival of many manta and mobula ray species.

THREATS

Fisheries: By far the greatest threat to manta and mobula rays comes from fisheries, both directed and incidental (bycatch).

Habitat Destruction: Coral reef degradation could negatively impact manta and mobula rays by disrupting feeding aggregations, cleaning station behavior, or disrupting reproductive behavior[31].

Climate Change: Most mobulid rays depend on plankton as their primary food source. As changing sea temperatures disrupt the phytoplankton's natural ecological cycles, manta and mobula rays may struggle to find adequate food supplies[32].

Marine Debris: Many manta and mobula rays die from marine debris, phantom nets, plastics and pollution from vessels. Fishing line entanglement, and resulting amputation or damage to cephalic fins, can also impair the rays' ability to feed[33]. Ingestion of plastic debris has been extensively documented to result in a range of health problems, injuries and death in several marine species, and may also pose a significant threat to manta and mobula rays[34].

Boat Strikes and Entanglement: Manta and mobula rays often fall victim to boat strikes as they pass through regions of heavy maritime traffic[35]. Manta rays can also become entangled in mooring and boat anchor lines. When these lines get caught around the cephalic fins and head, they trap the manta ray and cause it to drown[36].

Unregulated tourism: As aggregation sites become tourist attractions, unregulated interactions (i.e. a high number of boats in the vicinity and a large volume of people in the water close to or touching the rays) may cause undue stress[37].

Captivity: Although few mobulids live in captivity, the unmonitored removal of these species from the wild for the public aquarium trade may negatively impact small and geographically isolated populations[38].

Natural Predation: Natural predation, primarily from sharks and also killer whales, is not considered to be a leading threat to mobulid rays. Non-fatal injuries from shark bites have been observed on both manta and mobula rays in several parts of the world, and the impacts of these injuries on long term survival and reproduction are not known[39].

FIGURE 2. EVIDENCE OF DEPLETION; MOBULID FISHERIES AND MARKETS

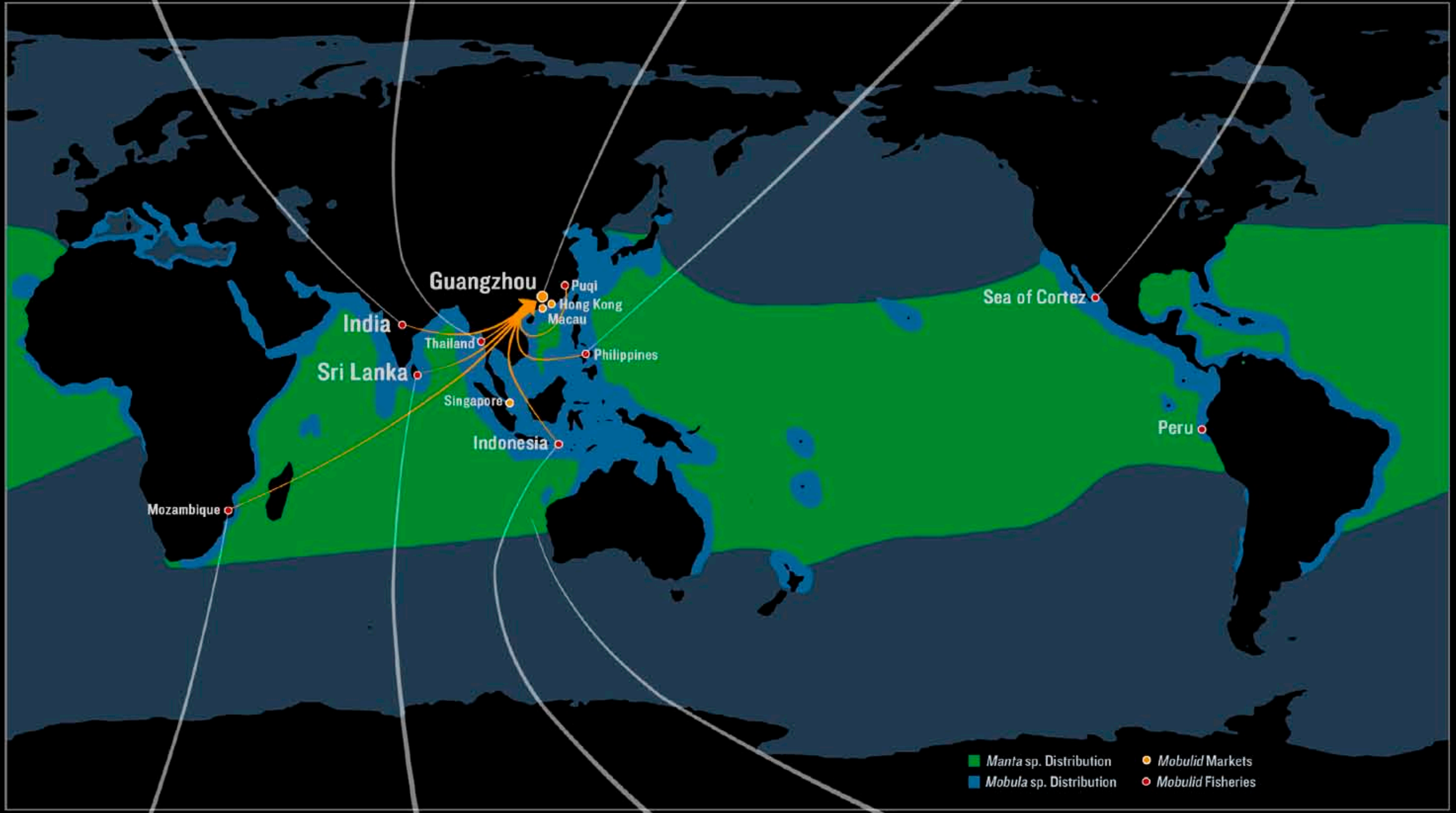
India – Mobulid catches have declined in several regions, including Kerala, along the Chennai and Tuticorin coasts and Mumbai, despite increased fishing effort (Couturier et al. in press).

Thailand – Dive operators in the Similan Islands have witnessed increased fishing for manta rays, and have reported steep declines in manta ray sightings (R. Parker pers. comm., R. Dion pers. comm.).

Guangzhou, China – This one market represents as much as 99% of the global gill raker market, with total annual trade volume in excess of 61,000 kg, with an estimated value of US$11.3 million per year.

Philippines – Fishermen reported a 50% decline in manta ray landings from the 1960s to 1990s, following directed fisheries there (Alava et al. 2002).

Sea of Cortez, Mexico – Intense fishering pressure in the 1980's led to the virtual disappearance of mantas (Homma et al. 1999, Notarbartolo di Sciara 1995, White et al. 2006).



Mozambique – A study on manta abundance reports an 80% decline in *M. alfredi* over the last 9 years. (Marshall et al. 2011).

Sri Lanka – Fishermen reported declines in manta ray catches over the past five years as targeted fishing pressure has increased (Fernando and Stevens 2011).

Indonesia – Large declines in the number and size of manta rays have been reported over the past decade (Setiasih 2011, IUCN Red List 2011).

Western Australia – Sightings of *M. birostris* have dropped precipitously over the past ten years, suggesting that Indonesian fisheries are having a significant impact (F. McGregor pers. comm.).

Bycatch – Thousands of manta and mobula rays are caught as bycatch in industrial and artisanal fisheries throughout the Mediterranean Sea and the Atlantic, Pacific and Indian Oceans.

FISHERIES

This report examines the extent of fisheries, what is driving these fisheries and the impact on manta and mobula ray populations. Mobulids are both targeted and caught incidentally as "bycatch." (See Table 3)

Bycatch: Thousands of manta and mobula rays are caught "incidentally" as bycatch in industrial and artisanal fisheries throughout the Atlantic, Pacific and Indian Oceans and the Mediterranean Sea[40]. Purse seines, gillnets and longlines, all commonly used in tuna fisheries, are most frequently responsible for manta and mobula bycatch. Unfortunately, the intensive "dolphin safe tuna" conservation campaigns that were intended to reduce dolphin bycatch, increased the bycatch of manta and mobula rays, sharks and many other marine animals[41]. Because mobulid bycatch data is rarely recorded and when recorded is not classified by species[42], the impact of incidental fishing on manta and mobula ray populations remains largely underestimated and unknown[43].

Targeted Fisheries: Historically, subsistence fishing for manta and mobula rays occurred in isolated locations with simple gear, restricting the distance and time fishers could travel to hunt. In recent years, however, fishers have begun targeting manta and mobula rays with modern fishing gear while expanding fishing range and season. The emerging market for dried gill rakers is the primary driver of *mobulid* fisheries. However, shark population declines also have boosted *mobulid* fisheries: the rays provide a cheap substitute for shark cartilage used in nutritional supplements[44].

KEY FISHERIES FINDINGS

- Manta and mobula rays are subject to significant fishing pressure throughout their key range states. Sri Lanka, India, Indonesia, Peru and China appear to have the largest targeted fisheries. Targeted fisheries have also been reported in Mexico, Thailand, the Philippines, and several locations in Africa, including Mozambique, Ghana, Tanzania, Madagascar, and Somalia, but little data exists as to the extent of many of these fisheries. Anecdotal evidence suggests that even more fisheries likely exist in isolated coastal regions throughout the Atlantic and Pacific.
- **The top five manta and mobula ray fishing nations account for more than 95% of all known mobulid landings.**
- The market for gill rakers is the primary economic driver of the commercial fisheries. Secondary markets for mobulid meat, cartilage and skins, as well as traditional hunts, also play an important role in the perpetuation of some fisheries.
- Many bycatch and small subsistence fisheries have transformed into targeted export industries in response to the gill raker trade.
- Analysis reveals that without the gill raker trade, income from directed fisheries for manta and mobula rays may not even cover the cost of fuel in many range states.
- Bycatch in both coastal and international high seas fisheries poses a significant threat.
- Large declines have been reported following directed fisheries for manta and mobula rays.

MANTA BIROSTRIS

Directed fisheries in Indonesia, Sri Lanka and India account for the largest share of recorded *M. birostris* mortality (~ 90%), with annual landings of over 3,000 animals. Global landings are reported as ~ 3,400 *M. birostris*, but actual landings are likely much higher:

- Directed and organized harpoon fisheries on both coasts of India are reported to land large numbers of M. birostris but are not represented in fisheries data.
- Additional ports in Indonesia, other than those documented in this report, have been observed to land *M. birostris* regularly but also are not represented in fisheries data.
- Potentially large fisheries for *M. birostris* in Africa have been reported, but again little to no landings data is available.
- Manta and mobula rays are frequently mentioned as bycatch in industrial and artisanal fisheries, especially in purse-seine and gillnet fisheries for tuna, however, these landings are not recorded separately by species creating further gaps in landings data.
- *M. birostris* are large and tend to feed close the surface, making them extremely vulnerable to opportunistic hunting by coastal fishermen. A quick Internet search reveals images of captured manta rays from many countries, but no data on these fisheries are available.

Large declines have been reported following increases in directed fishing for *M. birostris*:

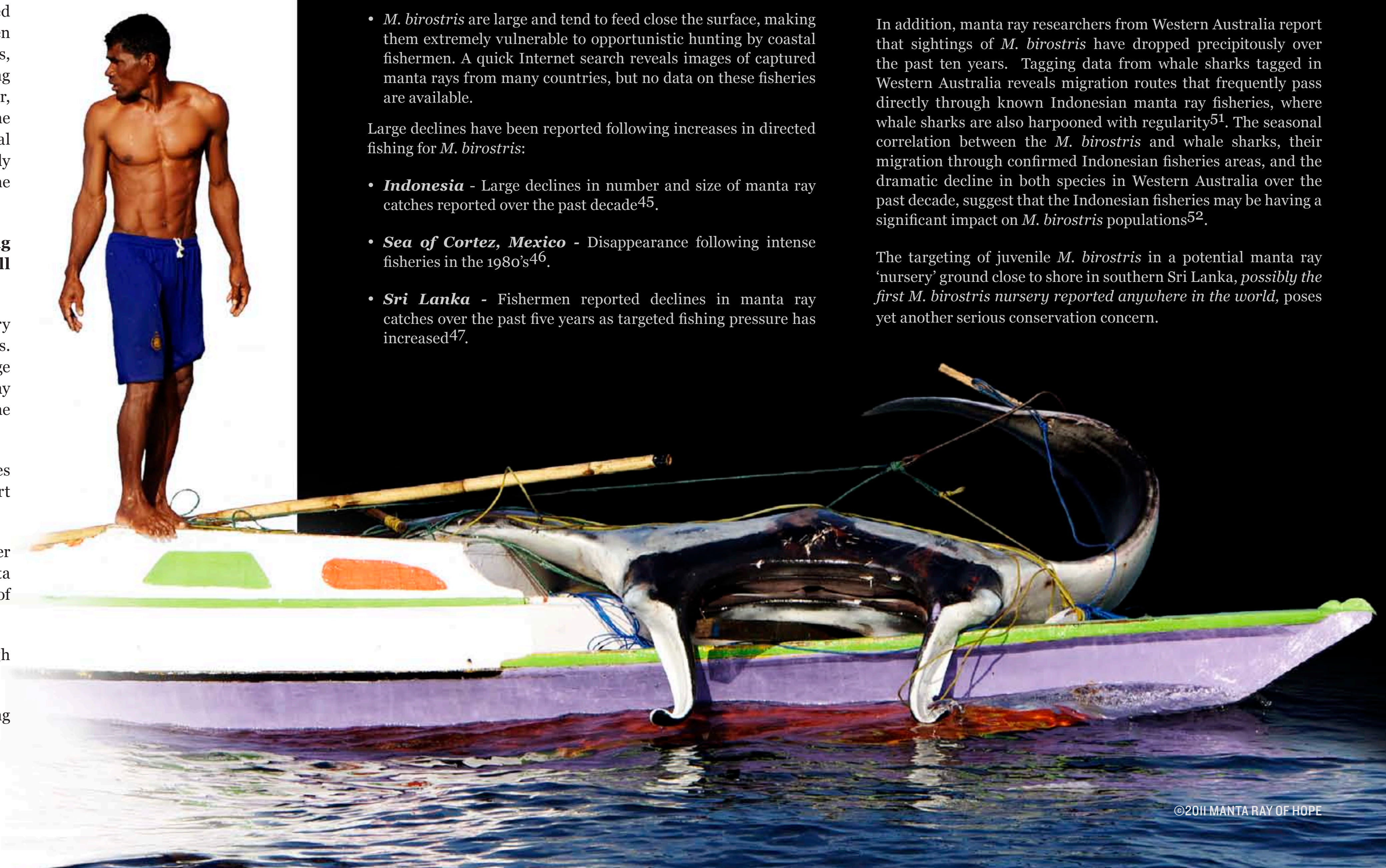
- ***Indonesia*** - Large declines in number and size of manta ray catches reported over the past decade[45].
- ***Sea of Cortez, Mexico*** - Disappearance following intense fisheries in the 1980's[46].
- ***Sri Lanka*** - Fishermen reported declines in manta ray catches over the past five years as targeted fishing pressure has increased[47].
- ***India*** - *Manta* catches have declined in several regions, including Kerala, along the Chennai and Tuticorin coasts and Mumbai, despite increased fishing effort[48].
- ***Philippines*** - Fishermen reported a 50% decline in manta ray landings from the 1960s to 1990s, following directed fisheries there[49].
- ***Thailand*** - Dive operators in the Similan Islands have witnessed increased fishing for manta rays, even in Thai national marine parks, and have reported steep declines in manta ray sightings[50].

While there are no worldwide population estimates for *M. birostris*, one can put the estimated landings figure into context based on the maximum number of *M. birostris* individuals recorded in some of the largest known aggregation sites: 1) Mexico's Revillagigedos Islands (>350 animals); 2) Ecuador Isla de la Plata (~300 animals); and 3) Southern Mozambique (~600 animals population estimate).

The implications are serious: each year fisheries are extracting **6-12 times** the number of mantas documented in these sites, which are the largest known aggregations of this species.

In addition, manta ray researchers from Western Australia report that sightings of *M. birostris* have dropped precipitously over the past ten years. Tagging data from whale sharks tagged in Western Australia reveals migration routes that frequently pass directly through known Indonesian manta ray fisheries, where whale sharks are also harpooned with regularity[51]. The seasonal correlation between the *M. birostris* and whale sharks, their migration through confirmed Indonesian fisheries areas, and the dramatic decline in both species in Western Australia over the past decade, suggest that the Indonesian fisheries may be having a significant impact on *M. birostris* populations[52].

The targeting of juvenile *M. birostris* in a potential manta ray 'nursery' ground close to shore in southern Sri Lanka, *possibly the first M. birostris nursery reported anywhere in the world,* poses yet another serious conservation concern.



MANTA ALFREDI

Prior to the recent re-evaluation and splitting of the *Manta* genus[53], all manta rays were identified as *M. birostris*. It is often not possible, therefore, to determine if published landings referring to *M. birostris* might actually be *M. alfredi* or a mix of the two species in some cases. What is confirmed is that no landings of *M. alfredi* were observed in investigations of fisheries in Lamakera and Lombok in Indonesia[54] or in Sri Lanka[55].

In Mozambique it is estimated that 20 to 50 *M. alfredi* are taken by subsistence fishermen annually along a ~ 100 km area[56]. An ongoing observational study on manta abundance in Southern Mozambique also reports an 80% decline in *M. alfredi* over the last 9 years.

Local fishermen are known to opportunistically target animals belonging to small *M. alfredi* populations around islands throughout the western and central Pacific. Because of their isolation and low numbers, these local populations of *M. alfredi* are extremely vulnerable to any fishing pressure.

MOBULA SPECIES

Mobula rays are subject to even greater global fisheries pressure, yet we know even less about the state of their populations. The Sri Lankan and Indian fisheries combined land more than 79,000 mobulas per year, with Sri Lanka accounting for more than 50% of recorded global landings of over 94,000 animals. In the Sri Lanka fishery, the most frequently landed species are *M. japanica* (~ 87%), followed by *M. tarapacana* (~ 12%), and *M. thurstoni*, (~ 1%).

Factors including illegal, underreported, and unrecorded fisheries suggest that the total number of mobula rays landed in global fisheries is likely to be significantly greater than the ~94,000 accounted for in the aggregate fisheries data. For example, there are numerous anecdotal reports of large numbers of mobulas landed in parts of Mexico, despite laws prohibiting their harvest and no available landings data[57].

In Sri Lanka and Indonesia (Lombok and Lamakera), fishermen and traders reported declines in catches of mobula rays over recent years as targeted fishing pressure has increased.

Mobulid catches have declined in several regions of India, including Kerala, along the Chennai and Tuticorin coasts and Mumbai, despite increased fishing effort[58].

Swordfish fisheries in the Aegean and Levantine Seas also report bycatch of *Mobula mobular*, a species endemic to that region[59] and classified by the IUCN as "Endangered."

TABLE 3. FISHERIES FOR MANTA AND MOBULA RAYS – DIRECTED AND BYCATCH

COUNTRY	REFERENCE	YEAR	GILL RAKER TRADE	MANTAS/YR	MOBULAS/YR	ALL MOBULIDS/YR
Sri Lanka	Fernando and Stevens 2011	2011	Yes	1,055	55,497	56,552
India	Raje et al. 2007	2003-04	Yes	690	24,259	24,959
Peru	Planeta Oceano 2011	2011	No	150	8,000	8,150
Indonesia	Setiasih '11, White et al. '06b	2011, '01-5	Yes	1,320	3,505	4,825
China	Hilton 2011	2011	Yes	100	2,000	2,100
W. Central Pacific	Molony 2005	1994-04	DD	DD	DD	1,500
Brazil	Perez and Wahlrich 2005	2001	DD	DD	DD	809
Mauritania	Zeeberg et al. 2006	2001-04	DD	DD	620	620
Indian Ocean	Pianet et al 2010	2003-08	DD	36	325	361
Philippines	NPOA-Sharks 2009	2007	DD	3	80	83
New Zealand	Paulin et al. 1982	1975-81	No	DD	DD	39
Mozambique	Marshall et al. 2011	2010	Yes	35	DD	35
South Africa	Young 2001	2001	DD	20	DD	20
TOTALS				**3,409**	**94,286**	**100,053**

Note 1: Most fishery figures listed are extrapolated estimated catches. Refer to Heinrichs et al. 2011 for explanation of assumptions and calculations used to estimate total landings.

Note 2: The figures listed do not include unverified, but potentially significant fisheries in Mexico, Africa and Thailand. Bycatch figures are notoriously underreported or incorrectly classified, and therefore these numbers are expected to be substantially higher. Much of the bycatch from high seas fisheries is likely to be discarded and may not go into the gill raker trade.

DD = Data Deficient

MARKETS

MARKET AND TRADE INVESTIGATIONS

Market investigations were conducted in five locations considered to be the primary centers for the Chinese dried seafood trade: Singapore, Hong Kong (Sheung Wan District), Macau, Taiwan (Taipei, Taichung and Kaohsiung), and Mainland China (Guangzhou). Investigators canvassed dried seafood and Traditional Chinese Medicine (TCM) business districts in each location, interviewed sellers and obtained gill raker samples for DNA testing.

MARKET AND TRADE FINDINGS

Guangzhou, Guangdong Province in Southern China has been clearly identified as the epicenter for the trade and consumption of gill rakers, representing as much as 99% of the global market. Just one large supplier in Guangzhou may sell three to four times the volume of gill rakers in one month as all the secondary markets of Hong Kong, Macau and Singapore combined sell in an entire year. These secondary markets, though much smaller, still play an important role in supporting the trade. There are currently no laws regulating the trade in gill rakers in any of the locations surveyed. The countries most frequently identified as primary sources for the gill rakers were: Indonesia, India (possibly including Sri Lanka) and China.

Market investigations revealed that approximately 30% of the stock in stores was large gill rakers (*M. birostris*), 40% medium gill rakers (*M. tarapacana* and juvenile *M. birostris*) and 30% was comprised of smaller gill rakers (various Mobula species). *M. alfredi* (reef mantas) appear to be absent from the market samples (confirmed through DNA testing). Investigators also found whale shark gills (confirmed through DNA testing) in some shops that were being marketed as manta gills.

Almost without exception, retailers, wholesalers and processors of manta and mobula ray gill rakers reported dramatic decreases in supply and increasing prices, especially for *M. birostris* gill rakers. Many suppliers reported price increases of 100% over just the past few years.

Market analysis yields total annual gill raker trade volume in excess of 61,000 kg (and perhaps as high as 80,000 kg) with an **estimated value of US$11.3 million per year**. In comparison, the annual shark fin trade has been estimated at a minimum of **US$400–550 million**[60]**.** As such, the gill raker trade amounts to less than 3% of the value of the shark fin trade and does not contribute significantly to the Chinese dried seafood and TCM industries.

ESTIMATING THE VALUE OF THE MARKET

The Hilton 2011 investigations found that the median sale price in Guangzhou was US$251/kg (and up to US$500/kg) for large gill rakers, US$172/kg for medium gill rakers, and US$133/kg for smaller gill rakers. Based on the average estimate of ~ 61,000 kg of gill rakers traded annually, with an estimated 30% coming from *M. birostris*, sold at an average of US$251 per kg (US$6,600,845), plus an estimated 40% coming from medium sized gill rakers sold at an average of US$ 172 per kg (US$ 4,217,442) and the remaining 30% comprised of gill rakers from the smaller mobula species, sold at an average of US$133 per kg (US$2,44,199), the total retail market for gill rakers can be estimated to be worth, as mentioned above, US$ 11.3 million per year.

TABLE 4. ESTIMATED MARKETS FOR MANTA/ MOBULA GILL RAKERS TRADED ANNUALLY *(Hilton 2011)*

Market	Low Estimate	High Estimate	Average Estimate	% Market
Guangzhou, China	37,777 kg	79,726 kg	60,969 kg	99.61%
Singapore	66 kg	279 kg	173 kg	.28%
Hong Kong	32 kg	64 kg	48 kg	.0 8%
Macau	12 kg	24 kg	18 kg	.03%
Taiwan	0	0	0	0%
TOTALS	**37,887 kg**	**80,093 kg**	**61,208 kg**	**100.00%**

TRADITIONAL CHINESE MEDICINE: UNFOUNDED CLAIMS?

Demand for gill rakers is the largest driver for manta and mobula ray fisheries. Anecdotes gathered through investigations and literature searches suggest that gill rakers, which consist of thin filaments that manta and mobula rays use to filter food from the water column, can treat health issues ranging from chicken pox to cancer. Some practitioners claim that gill rakers, known in China as “Peng Yu Sai,” boost the immune system and help purify the body by reducing toxins and fever and enhancing blood circulation. Others claim that gill rakers will remedy throat and skin ailments, male kidney issues, and help couples with fertility problems.

Investigators interviewed TCM practitioners in Southern China, Hong Kong, Macau, and Singapore. TCM refers to an ancient and holistic system of health and healing.

Though not historically a part of Traditional Chinese Medicine, industry marketing appears to be pushing gill rakers toward greater acceptance in TCM.

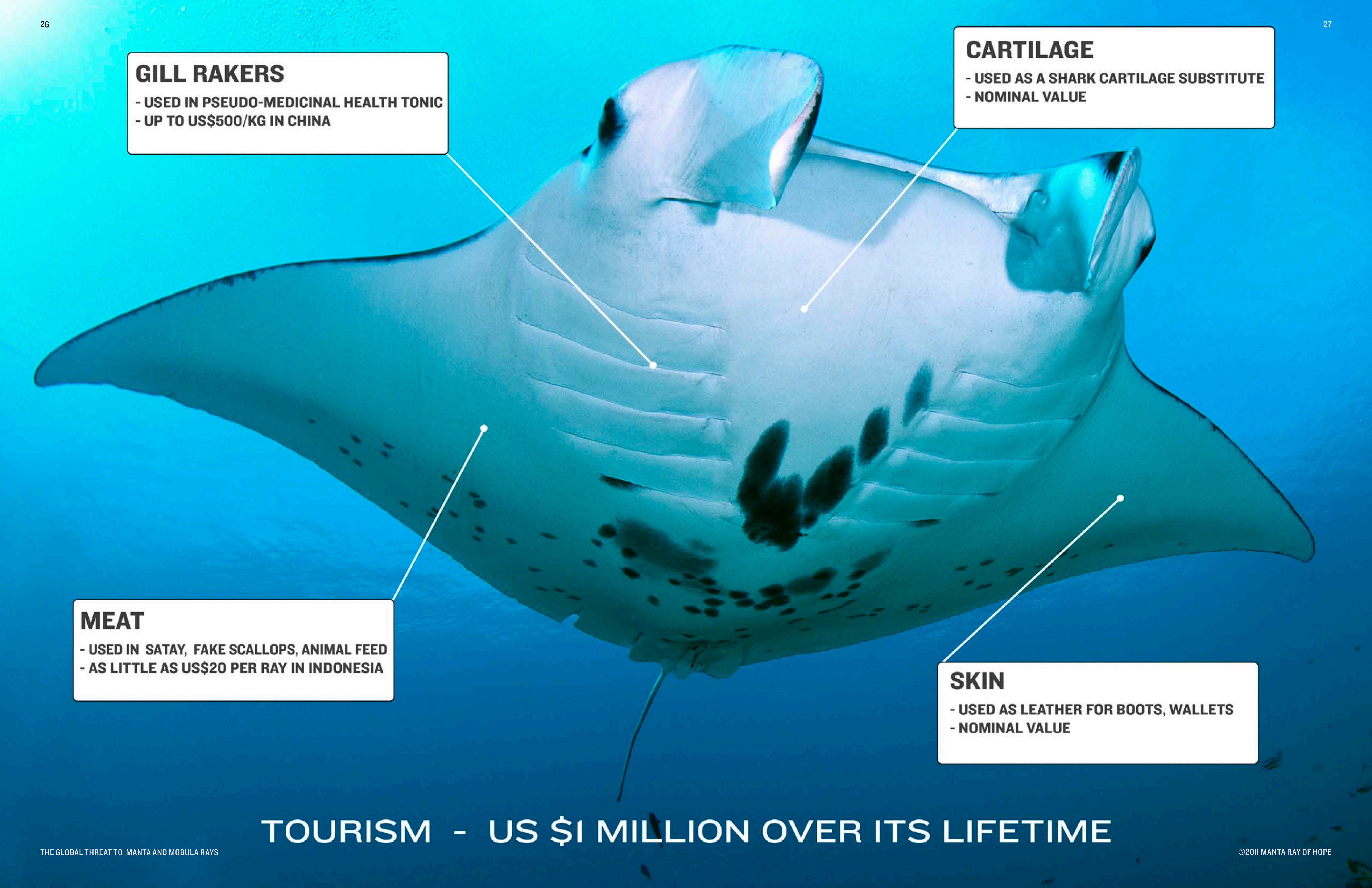
Some TCM practitioners suggested gill rakers as an effective remedy for certain ailments, but none was able to locate a specific reference in TCM texts. One TCM practitioner interviewed reviewed all 6,400 remedies of the official TCM reference manual, and found that Peng Yu Sai was not listed.

Practitioners interviewed admitted that gill rakers were not effective and many alternatives were available. In fact, many young TCM doctors are not even aware of this remedy, indicating that it is not included in current TCM curricula.

The use of gill rakers as a remedy is reported to have been popular in Southern China many years ago, but its use declined. Over the past ten years, however, there appears to have been an effort by traders to revive this remedy and create a new market. Some suppliers in China report an increase in demand for gill rakers. Direct to consumer marketing of this remedy appears to be driving the demand, much like the trend in recent years for pharmaceutical companies marketing drugs directly to the consumer. Because of claims that the product bolsters the immune system, marketing efforts playing on the public’s fear of outbreaks of swine and bird flu and SARS, may also be driving demand[61].

Belief in the health benefits of consuming gill rakers is largely found in a subset of the older population in Southern China, and to a lesser extent in Macau, Singapore and Hong Kong.
Gill rakers are not steeped in tradition or considered “prestigious”. These barriers faced by campaigns to curb consumption of shark fins therefore, do not generally apply with gill rakers.

Consumers and even many sellers of gill rakers are not aware that the product comes from manta or mobula rays, particularly since the name - “Peng Yu Sai” or “fish gills” – is not associated with manta or mobula rays.


GILL RAKERS
- USED IN PSEUDO-MEDICINAL HEALTH TONIC
- UP TO US$500/KG IN CHINA
CARTILAGE
- USED AS A SHARK CARTILAGE SUBSTITUTE
- NOMINAL VALUE
MEAT
- USED IN SATAY, FAKE SCALLOPS, ANIMAL FEED
- AS LITTLE AS US$20 PER RAY IN INDONESIA
SKIN
- USED AS LEATHER FOR BOOTS, WALLETS
- NOMINAL VALUE
TOURISM - US $1 MILLION OVER ITS LIFETIME

TOURISM

Manta and mobula rays are highly intelligent and social animals that have a broad appeal to divers and snorkelers. Providing encounters with these graceful animals offers a potentially lucrative and sustainable alternative to harvest in many areas. As a result, tourism has developed around seasonal manta and mobula ray aggregations in many parts of the world[63].

A survey of dive operators in manta ray range states reveals that manta rays are frequently the #1 attraction to divers and are consistently ranked in the top three of marine life that divers most often ask to see. These operations bring millions of dollars in tourism revenue annually to their local communities.

In Western Australia's shallow Bateman Bay on Ningaloo Reef, visitors come on snorkeling tours more eager to see manta rays than whale sharks[64]. Surveys conducted in the Maldives indicated that tourists are willing to pay the highest surcharge to see manta rays, even more than for turtles or sharks[65]. In Mozambique, diving, particularly to see whale sharks and rays, motivated 74% of tourists to visit the country[66].

The 'Million Dollar Manta' In Yap, where dive tourism is based almost exclusively on manta ray encounters, the annual value of manta ray dives is estimated to be US$4 million. With an estimated local population of 100 manta rays, each living an estimated 40+ years[67], each of these manta rays is worth as much as **US$ 1 million over its lifetime!** A dead manta ray in a fish market, on the other hand, brings a one-time income of US$40–$500 depending on the manta's size.

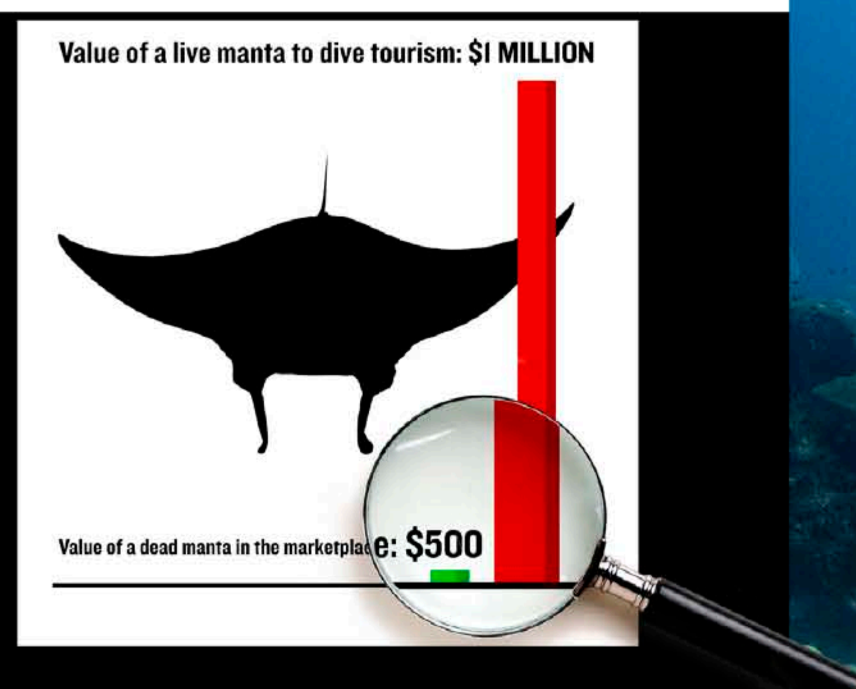
Based on data from only seven locations, the value of manta ray dive tourism is estimated at over US$27 million per year. These figures do not account for revenue generated in many popular diving locations in Mozambique, South Africa, Indonesia, Mexico, Ecuador, Costa Rica, Brazil, Japan, Solomon Islands, Azores, Australia, New Zealand, the Philippines, and Thailand. Global manta tourism may exceed US$50 million in direct dive-operation revenues annually, and with associated expenditures it may contribute as much as US$100 million. Additional opportunities exist globally for new tourism operations.

Manta ray tourism can provide ongoing sustainable income to communities for generations to come, while the gill raker trade represents short-term profits for a handful of foreign traders. Some poor fishing communities in India, the Philippines and Indonesia have shifted from hunting whale sharks to developing successful eco-tourism industries, changes that have revitalized these communities while also protecting these iconic animals. The same opportunities exist for community-based tourism development centered on manta and mobula rays. Like whale sharks, manta and mobula rays offer significant tourism appeal, and present potentially large and sustainable financial benefits to coastal communities ... if kept alive.

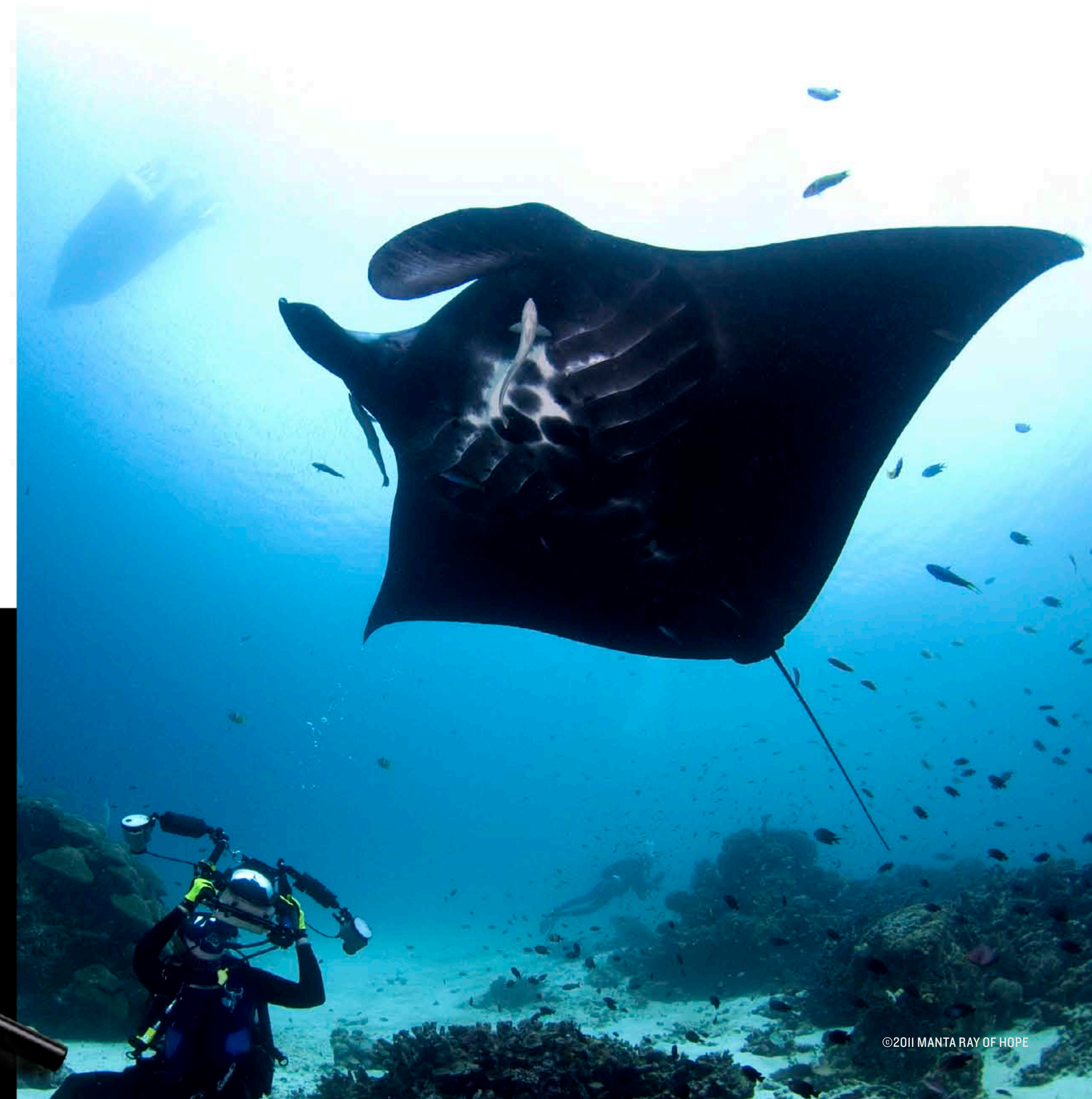
TABLE 5. INDUSTRY VALUES OF MANTA TOURISM

LOCATION	SPECIES	ANNUAL REVENUE
Kona, Hawaii	Manta Sp.[a]	US$ 3.4 million[1]
Ningaloo, Australia	M. alfredi	US$ 1.8 million[2]
Nusa Penida, Indonesia	M. alfredi	US$ 3.5 million[3]
Palau	M. alfredi	US$ 2.25 million[4]
Republic of Maldives	Manta Sp.[a]	US$ 8.1 million[5]
Socorro, Mexico	M. birostris	US$ 5 million[6]
Yap	M. alfredi	US$ 4 million[7]

a) Mainly M. alfredi; 1) MPRF 2007; *2)* F. McGregor pers. comm.; *3) Does not include revenue from numerous snorkeling trips organized by local fishermen and hotels in Nusa Lembongan costing ~ US$22 per person.* C. Guillevic pers. comm., L. Harding pers. comm.; *4)* J. Denby pers. comm., T. Bornovski, pers. comm.; *5)* Anderson et al. 2010 (2006-7); *6)* Dive operator interviews, website research; *7)* B. Acker pers. comm.



MANTA RAYS ARE WORTH MUCH MORE ALIVE THAN DEAD...



CONSERVATION

With a vulnerable life history and potential for over-harvesting throughout their range, manta and mobula rays urgently need international protection.

International: Most of these rays migrate through international waters, and the international trade in their gill rakers is a primary threat to their survival. Listing under the Convention on International Trade in Endangered Species (CITES) would be the most effective conservation tool. In 2010, the US CITES delegation considered proposing all mobulids for listing on CITES Appendix II, but did not submit the proposal due to insufficient data on fisheries and trade.

In November of 2011, the Government of Ecuador's proposals to the Convention on the Conservation of Migratory Species of Wild Animals (CMS) to add *M. birostris* to Appendices I and II of the treaty were overwhelmingly approved, thereby obligating all *M. birostris* range states that are party to CMS to endeavor to provide immediate protection for this species. Even though many range states with manta fisheries are not party to this convention (Indonesia, for example), the addition of *M. birostris* to the CMS Appendices marks the first international agreement to protect manta rays.

Local and Regional: Some nations and states have passed laws specifically prohibiting the harvest of manta and mobula rays, and protection is afforded in some marine park zones (See Table 5). Two regional conservation bodies in Europe, the Bern Convention and the Barcelona Convention, have listed *Mobula mobular* as a species requiring strict protection. However, only Croatia and Malta have implemented protective measures[62]. Currently, none of the Regional Fishery Management Organizations (RFMOs) have passed resolutions to protect manta and mobula rays.

Legislation enacted in Guam in 2011 prohibits the possession, sale, trade and distribution of shark fins and ray parts. In July, Pacific Island leaders passed a resolution to establish the first Regional Shark Sanctuary during the 15th Micronesia Chief Executive Summit. This resolution, which applies to the Federated States of Micronesia, Palau, the Republic of the Marshall Islands, Guam and the Commonwealth of the Northern Marianas Islands, and covers an area of more than 3 million square miles, states that all members will adopt legislation prohibiting the possession, sale, distribution and trade of shark fins, rays and ray parts.

TABLE 6. LOCAL AND REGIONAL LEGAL PROTECTION / CONSERVATION MEASURES*

LOCATION	SPECIES	LEGISLATION/ CONSERVATION MEASURE
Australia (Western)	Mantas	Fishing; harassment prohibited in marine parks
Croatia	*Mobula mobular*	Law of the Wild Taxa 2006 Strictly prohibited
Ecuador	Mantas /Mobulas	Ecuador Official Policy 093, 2010
Guam, USA Territory	Mantas	Bill 44-31 prohibiting sale/trade in ray parts 2011
Honduras	All elasmobranches	Full ban on fishing elasmobranches 2010
Indonesia – Raja Ampat	Mantas /Mobulas	Regency Bupati Decree October 2010
Maldives	Mantas	Exports of all ray products banned 1995
Malta	*Mobula mobular*	Sch. VI Absolute protection
Mexico	Manta/mobula spp.	NOM-029-PESC-2006 Prohibits harvest and sale
New Zealand	*M. birostris, M. japanica*	Wildlife Act 1953 Schedule 7A (absolute protection)
Philippines	Mantas	FAO 193 1998 Whale Shark and Manta Ray Ban
Revillagigedo Islands	Mantas	Marine Protected Area
USA – Florida	Mantas	FL Admin Code 68B-44.008 – no harvest
USA - Flower Garden Banks	Mantas	US Dept of Commerce 2010
USA – Hawaii	Mantas	H.B. 366 2009 – no harvest or trade
Yaeyama Islands, Japan	Mantas	Marine Protected Area
Yap (FSM)	Mantas	Manta Ray Sanctuary and Protection Act 2008

** The above is not a complete list of all marine protected areas where mobulids are protected.*

APPENDIX

INVESTIGATIONS OF LARGEST KNOWN MOBULID FISHERIES

To better understand the magnitude of manta and mobula ray fisheries, investigators went on-site to conduct in depth assessments of some of the most significant known manta and mobula ray fisheries – Lombok and Lamakera in Indonesia, Sri Lanka, Peru, and Southern China. Research into fisheries in India and other parts of Indonesia, as well as Thailand, the Philippines, Mexico, Ecuador, and Africa was carried out through extensive review of published literature and personal interviews.

SRI LANKA

Through May to September 2011 the Manta Trust conducted surveys at the Negombo and Mirissa fish markets to evaluate the extent of the manta and mobula ray fishery in Sri Lanka. Total landings were estimated at 1,055 manta rays (*M. birostris*) and 55,497 mobula rays (various species) per year, making Sri Lanka responsible for over 55% of known global manta and mobula ray catches.

The overwhelming majority (at least 87%) of the *M. birostris* recorded were juveniles and sub-adults, indicating a potential manta ray 'nursery' ground close to shore in southern Sri Lanka that is being heavily targeted. It is extremely rare to observe juvenile *M. birostris* in the wild, and if this area is indeed an important aggregation site for juvenile *M. birostris*, it would be the first of its kind reported anywhere in the world.

Fishermen report that catches have decreased over the past three to five years, coinciding with the increase in the gill raker trade over this period. In line with Indonesian investigations, it's clear that the demand for gill rakers is driving this fishery where per kilo prices for gill rakers are as much as 250 times the price of meat, meat that is frequently sold as animal feed (mainly chicken and shrimp farms).

Historically in Sri Lanka, mobulid rays were caught primarily as by-catch or were avoided altogether by the fishermen, due to their propensity to destroy or entangle fishing nets and because their meat is hard to keep fresh for long periods at sea. While the middlemen in the mobulid supply chain still take the bulk of local profits, recent massive increases in gill raker demand, and dwindling supplies of other more desirable catches (such as sharks, tuna and billfish), now give fishermen ample incentive to actively target mobulids.

INDIA

India has the second largest elasmobranch fishery in the world, with reported landings of 70,000t per year, representing ~ 10% of the global elasmobranch catch[68]. While the full extent of mobulid landings in India is not known, numerous published references document significant manta and mobula ray landings from the Indian coastal trawl, gillnet and longline fisheries. The available fishery reports account for at least 690 manta rays (*M. birostris*) and an estimated 24,260 mobula rays (various species).

Given the vast size of the Indian trawl and gillnet fleets targeting sharks, skates and rays, and limited fisheries oversight, the landings of mobulids in these fisheries may be significantly underreported. Likewise, with well-organized harpoon fisheries for *M. birostris* reported on both east and west coasts of India with no landings data available, there is again the strong possibility of significant landings not accounted for in the fisheries data. To properly estimate total manta and mobula ray landings in India, further investigation is required.

PERU

In March and September of 2011, Planeta Oceano, conducted rapid assessments of the mobulid fisheries along the north coast of Peru in the Tumbes & Piura regions. One family of fishermen (one boat crewed by a father and his grown sons) directly targets *M. birostris*, while two other fishermen are said to occasionally target mantas. The family estimates annual total landings of 100 to 120 *M. birostris,* with other targeted and incidental catches estimated at 50 to 100 manta rays, for a total of 100 to 220 *M. birostris*. Mobula landings are estimated at ~ 8,000 based on observed catches, bringing total mobulid landings to ~ 8,150 per year.

Across the border in Ecuador, manta and mobula species are protected under Ecuadorian law, but these same animals are targeted when they migrate south to Peru. Because the family that targets manta rays has expressed willingness to participate in future conservation programs for manta rays, the outlook for protection here (at least for manta rays) is promising. Peru is also a party to the CMS Convention, which now lists *M. birostris* on its Appendices I and II and obligates parties to pursue measures to protect this species.

INDONESIA

Directed manta and mobula ray fisheries are confirmed to exist in Lombok, Lamakera, Lamalera, as well as in other villages in Alor and perhaps in many other areas[69]. Manta and mobula rays are also landed as bycatch in local gillnet fisheries for tuna, and have been observed at markets in Pelabuhanratu in West Java, Cilacap in Central Java, and Kedonganan in Bali[70]. Species found in Indonesian fisheries include *M. birostris, M. alfredi, M. japanica, M. tarapacana, M. thurstoni,* and *M. kuhlii*[71]. Landings estimates from all Indonesian mobulid fisheries combined are more than 1,300 manta rays (*M. birostris*) and more than 3,500 mobula rays (various species). Indonesia appears to have the largest landings of *M. birostris* of any of the documented fisheries.

Lamakera Investigation: In June to July 2011, a rapid assessment of the fishery was conducted in Lamakera, a village on Lembata Island in the Alor region. This investigation relied on direct observation and interviews with a wide variety of community members from Lamakera and surrounding villages, and is the first known assessment since Dewar's description of the fishery published in 2002.

When manta rays are spotted in the area, villagers go out en-masse, aided by mobile phones to facilitate communications on the locations of the sightings. As soon as a boat gets into range of a manta, a crewmember plunges a steel, barbed spearhead attached to a long bamboo shaft into the manta ray's back. A rope is connected to the barbed spearhead, which releases from the shaft and line is given out for the manta ray to run. The manta ray takes about a half hour to tire during which time the crew chants an ancestral song they believe will stop the manta from escaping. They insert long knives into the head region and then push a long metal rod into the brain or heart to kill the animal. The body is secured with ropes and gaffs and the entire crew hauls the manta ray onboard, where they cut off the pectoral fins, remove the gills and cut off the head.

Lamakera's annual catch for 2010 based on all sources interviewed was 660 manta rays (*M. birostris*) and 330 mobula rays (*M. tarapacana*), for a combined catch of 990 mobulids. The catch trend appears to have declined significantly since the Dewar 2002 estimates of 1,050 to 2,400 manta rays landed each year, a strong indication that overfishing has significantly depleted manta ray populations that migrate along this corridor.

Lombok Investigation: The Lombok assessment of manta and mobula ray fisheries and trade was conducted in the Tanjung Luar market over six visits during varying seasons in 2007, 2009, 2010 and 2011. Both fishermen and the local processing facility reported that manta and mobula ray catches had declined dramatically in recent years and that the average manta ray size was now less than half of what it used to be. Based on these surveys, approximately 300 manta rays (*M. birostris*) and 1,000 mobula rays (various species) are landed annually in this port. A survey conducted in Tanjung Luar from 2001 to 2005 reported landings of ~ 1,600 mobulids per year and sales of adult manta rays from 4.4m to 4.8m DW[72], confirming the fishermen's reports of decreases in both numbers and size of manta rays landed over the past few years.

Fishermen and processors indicated that the gills were the primary value, with manta gills more valuable than the smaller mobula gills. Trade routes point to Chinese buyers in Surabaya and Jakarta. The rest of the animal is of nominal value and without the gill raker revenue, the income from meat and skin sales would not even cover the fuel expended to hunt these animals.

In Lamakera, where villagers have hunted these animals for many years, tradition also plays a role in the ongoing exploitation of manta and mobula rays, even prior to the gill raker trade. The excitement of the hunt and of returning with a large conquered sea animal was evident in recent investigations. The advent of the gill raker trade, however, transformed this fishery from a small-scale artisanal practice to a large-scale commercial enterprise.

INVESTIGATIONS OF LARGEST KNOWN MOBULID FISHERIES

SOUTHERN CHINA (PUQI)

In 2011, investigators visited a shark processing plant in Puqi, Zhejiang Province of China, which had been suspected as a major processor of manta and mobula ray gill rakers. This plant processes whole manta and mobula rays shipped from a nearby port in Shipuzhen, and sells dried gill rakers directly to buyers in Guangdong (estimated 500 kg *M. birostris*; 1000 kg *M. japanica* annually). The manta and mobula ray carcasses are sent to a plant in Shangdong, where the meat is ground up for fishmeal and the cartilage is processed to make chondroitin sulfate supplements, for export to Japan and Britain.

The plant manager reported that 500 kg of large manta (whole) yields ~ 2.5 kg of dried gill rakers. Based on conversion calculations (5 kg of dried gill raker per average mature *M. birostris* and .5 kg per average small mobula), an estimated 100 manta rays (*M. birostris*) and 2,000 mobula rays (*M. Japanica*) are processed annually in this port.

AFRICA

While little published data is available for African mobulid fisheries, significant threats to manta and mobula rays may exist in several countries on the east and west coasts of Africa.

In Mozambique it is estimated that 20 to 50 *M.alfredi* are taken by subsistence fishermen annually just along a ~ 100 km area[73]. An extensive and ongoing observational study on manta abundance in Southern Mozambique also reports an 80% decline in Manta alfredi over the last 9 years. In 2003 and 2004 there was an 83% chance of seeing a manta ray on a dive, but sighting frequency has steadily declined over time to only a 31% chance of seeing mantas on dives in 2011. The number of individuals seen per dive has declined drastically as well, from an average of 6.8 individuals in 2003 and 2004 to 0.6 individuals per dive in 2011[74].

In Ghana, Dixcove is known for its seasonal harvest of manta rays[75]; and a year round large mesh drift gillnet fishery targeting tuna, sharks, billfish, manta rays and dolphins, has also been reported[76]. Additional investigation to determine the extent of fisheries and trade for manta and mobula species in Africa is critically needed.

THAILAND

Dive operators in the Similan Islands located in the Andaman Sea, have witnessed increased fishing for manta and mobula rays, even in Thai national marine parks, and have reported steep declines in manta ray sightings[77].

Review of the largest manta ray photo identification database for this region has revealed a significantly higher proportion of individuals with net and line injuries than anywhere else in the world, except for mainland Ecuador (due to illegal fishing for wahoo in a major *M. birostris* aggregation area). This photographic evidence strongly supports anecdotal reports that fishing is having a major impact on the manta ray population in the area[78].

These observations present the possibility of significant population declines of *M. birostris* and *M. alfredi* in the Similan Islands due to targeted fishing. With fisheries data lacking on manta and mobula ray landings, further investigation is required to properly assess the extent and impact of mobulid fisheries in Thailand.

PHILIPPINES

Some areas, such as Pamilacan Island in Bohol, have a long history of hunting manta rays along with whales and whale sharks[79]. Following the passage of a ban on catching dolphins and whales in late 1992, whaling communities in the Bohol Sea area shifted more of their efforts to whale sharks and manta rays, and in 1998 twenty six villages were involved in manta and mobula ray fisheries. During the 1995-6 season, 1,000 manta and mobula rays were landed. Interviews with fishermen during a 1996 survey revealed that manta ray catches had declined by 50% over the past 30 years[80].

Today the ban on catching and selling of manta rays is still in place, but enforcement varies and the cultural practice of eating manta ray meat persists in some areas[81]. Traders in Hong Kong continue to report the Philippines as a supplier of dried gill rakers, indicating that an active gill raker trade may still continue in the Philippines[82]. Further investigation is required to properly assess the extent of mobulid fisheries and the connection to the gill raker trade.

MEXICO

In May 2007, Mexican Official Standard Rules NOM–029–PESC–2006 was enacted, providing specific protection for mobulid rays (*M. birostris*, *Mobula* spp.). No current reports were identified relating to targeted fisheries for giant manta rays (*M. birostris*) in the Sea of Cortez, but fisheries for mobula species are reported to be prevalent, particularly in El Sargento and Santa Rosalia, where thousands of mobulas are reportedly taken every summer[83].

Further investigation to determine the extent of exploitation of manta and mobula rays in Mexico is needed. Bycatch may be significant due to the high volume of commercial fisheries using drift gillnets and longlines. No definitive evidence of a gill raker trade has been reported in Mexico, but further investigation is warranted to confirm this.

ECUADOR

During the first half of 2010, prior to Ecuador's ban on fishing manta and mobula rays, landings of 6,946 mobula rays were recorded[84].

The Ecuadorian government has been a leader in manta and mobula conservation, evidenced by the strict ban on the landing and sale and manta and mobula rays enacted in August 2010 and their successful proposal to list *M. birostris* on Appendices I and II of the international CMS convention. Since enactment of the 2010 ban, landings of manta and mobula rays appear to have stopped.

In a major *M. birostris* aggregation area where illegal drift gillnet and longline fisheries targeting wahoo are still prevalent, researchers have observed large numbers of manta rays with life threatening or debilitating injuries from entanglement[85]. Further investigation and monitoring is recommended to better understand the current level of mobulid bycatch mortality associated with these fisheries.

REFERENCES

1 Marshall et al. 2009, Notarbartolo DiSciara 1987.
2 Compagno and Last 1999, Deakos 2010a
3 Maigret and Ly 1986, Notarbartolo di Sciara and Hillyer 1989, Compagno and Last 1999
4 Marshall et al. 2009
5 Kashiwagi et al. 2011
6 Marshall et al. 2009
7 Marshall et al. 2009, Compagno 1999
8 Marshall et al. 2011c
9 Bizarro et al. 2006
10 Notarbartolo di Sciara 1987a, Clark et al. 2006a, 2006b
11 Marshall et al. 2011a
12 Marshall et al. 2011c
13 Marshall et al. 2009, Deakos et al. 2011
14 Compagno and Last 1999, Marshall et al. 2006, Deakos 2010a
15 Marshall et al. 2006, Marshall and Bennett 2010
16 Marshall et al. 2011c
17 G. Stevens pers. comm.
18 Marshall and Bennett 2010, Deakos in press
19 G. Stevens pers. comm.
20 Clark 2010
21 Marshall et al. 2011a, Marshall et al. 2011c
22 Ari 2011
23 G. Stevens pers. comm.
24 Marshall et al. 2011c
25 G. Stevens pers. comm.
26 Smith et al. 1998, Cox and Francis 1997, Fergusson et al. 2009
27 Dewar et al. 2008, Homma et al. 1999
28 Dewar 2002
29 Deakos et al. 2011
30 Stevens et al. 2000
31 Deakos 2010b
32 Chin and Kyne 2007
33 Deakos 2010a
34 Couturier et al. in press
35 Notarbartolo di Sciara 2005, Deakos et al. 2011
36 Deakos et al. 2011, A. Marshall pers. comm.
37 Deakos et al. 2011
38 Deakos et al. 2011
39 Couturier et al. in press
40 Molony 2005, Perez and Wahlrich 2005, White et al. 2006, Zeeberg et al. 2006, Pianet et al. 2010
41 Lack and Sant 2006
42 Lack and Sant 2009, Camhi et al. 2009
43 G. Stevens, pers. comm.
44 Hilton 2011, Setiasih 2011.
45 Setiasih 2011, IUCN Red List 2011
46 Homma et al. '99, Notarbartolo di Sciara 1995, White et al. 2006.
47 Fernando and Stevens 2011.
48 Couturier et al. in press.
49 Alava et al. 2002.
50 R. Parker pers. comm., R. Dion pers. comm.
51 Pet-Soede 2002, Setiasih 2011.
52 F. McGregor pers. comm.
53 Marshall et al. 2009,
54 Setiasih 2011
55 Fernando and Stevens 2011.
56 Marshall et al. 2011.
57 M. McGettigan, SeaWatch pers. comm.
58 Couturier et al. in press
59 Alkyol and Ceyhan 2011
60 Clarke et al. 2007.
61 Hilton 2011.
62 Abdulla 2004, Cavanagh and Gibson 2007.
63 Anderson et al. 2010.
64 Daw and McGregor 2008.
65 Waheed 1998.
66 Tibirica et al. 2009.
67 Marshall et al. 2011c
68 FAO 2009; Lack & Sant 2009
69 Dewar 2002, White et al 2006, Barnes 2005, Setiasih 2011, A. Miners pers. comm.
70 White et al. 2006b.
71 White et al 2006, Setiasih 2011, G. Stevens pers. comm.
72 White et al. 2006b,
73 Marshall et al. 2011.
74 A. Marshall pers. comm.
75 Essumang 2010;
76 Reeves et al. 2003.
77 R. Parker pers. comm.
78 A. Marshall pers. comm.
79 Acebes 2009.
80 Alava et al. 2002.
81 Gamil and Gamil 2010.
82 P. Hilton pers. comm.
83 M. McGettigan, SeaWatch pers. comm.
84 A. Baquero, Equilibrio Azul, unpubl.
85 A. Marshall pers. comm.

ABOUT

SHARK SAVERS

Shark Savers' programs focus on action and result in saving the lives of sharks and rays. By leveraging professional experience and expertise, Shark Savers brings this important issue to the masses in many compelling forms, motivating people to stop consuming sharks and shark fin soup, and working for the creation of shark sanctuaries and other protections. www.sharksavers.org

WILDAID

WildAid's mission is to reduce consumer demand for endangered wildlife products and to encourage responsible energy consumption behavior. This is achieved through global public awareness campaigns, field conservation programs and enforcement of marine protect areas. WildAid is headquartered in San Francisco, with programs in the United States, China, India, Ecuador, Canada, UK and Indonesia. www.wildaid.org

MANTA RAY OF HOPE

The Manta Ray of Hope project is a joint initiative that includes top field investigators, leadings scientists and researches, all working together to further the conservation of manta and mobula rays. The project was founded by Sharks Savers and WildAid, with support from the Silvercrest Foundation, Hrothgar Investments, and private donors. www.mantarayofhope.com

PHOTOGRAPHIC CREDITS

MARK HARDING
©2011 – PAGE 35 (LOWER)

DOUGLAS SEIFERT
©2011 – BACK COVER

JOHN WELLER
Photographs ©2011 – COVER, PAGES 2-3, 21, 30-31; Graphics ©2011 – PAGES 12-13, 15, 28

PAUL HILTON ©2011
SHAWN HEINRICHS ©2011
MARY O'MALLEY ©2011
ALL OTHERS

RESOURCES

Abdulla, A. 2004. Status and Conservation of Sharks in the Mediterranean Sea. IUCN Global Marine Programs.

Acebes, J.M.V. 2009. Historical whaling in the Philippines: origins of 'indigenous subsistence whaling', mapping whaling grounds and comparison with current known distribution: a HMAP Asia Project Paper. Asia Research Center/HMAP, 161. 37pp.

Akyol, O. and Ceyhan, T. 2011. The Turkish swordfish fishery. Collective Volume of Scientific Papers ICCAT, 66(4): 1471-1479.

Alava, E.R.Z., Dolumbaló, E.R., Yaptinchay, A.A., and Trono, R.B. 2002. Fishery and trade of whale sharks and manta rays in the Bohol Sea, Philippines. In: Fowler, S.L., Reed, T.M., Dipper, F.A. (eds) Elasmobranch Biodiversity, Conservation and Management: Proceedings of the International Seminar and Workshop. Sabah, Malaysia, July 1997, pp 132–148

Alexander RL (1996) Evidence of brain-warming in the mobulid rays, Mobula tarapacana and Manta birostris (Chondrichthyes: Elasmobranchii: Batoidea: Myliobatiformes). Zoological Journal of the Linnean Society 118:151-164.

Anderson, R.C. and Ahmed, H. 1993. Shark Fisheries of the Maldives. Ministry of Fisheries and Agriculture, Male, Maldives and FAO, Rome, Italy.

Anderson, R.C., Adam, M.S., Kitchen-Wheeler, A., and Stevens, G. 2010. Extent and economic value of manta ray watching in Maldives. Tourism in Marine Environments, 7 (1): 15-27.

Anon,1997. Fisheries Conservation Crisis in Indonesia: massive destruction of marine mammals, sea turtles and fish reported from trap nets in pelagic migratory channel. URL: http://darwin.bio.uci.edu/"sustain/bio65/ indonesia/ indon97e.htm

Arevalo 2006 in Norman, B. and Catlin, J. 2007. Economic importance of conserving whale sharks. Report for the International Fund for Animal Welfare, Australia. 1-18 pp

Ari, C. 2011. Encephalization and brain organization of Mobulid Rays (*Myliobatiformes, Elasmobranchii*) with ecological perspectives. The Open Anatomy Journal, 3: 1-13.

Arumugam, G. 2002. On a giant devil ray Manta birostris (Walbaum) landed at Tuticorin fishing harbor. Marine Fisheries Information Service, Technical and Extension Series, 171: 986.

Ayala, L. 2008. Catch and by-catch of albatross and petr`el in longline and gillnet fisheries in northern Peru. Final Report to the Rufford Small Grants for Nature Conservation, 30 pp.

Bachtiar, P., Mawardi, S., and Marbun, D., 2009. Iklim Usaha di Kabupaten Flores Timur: Kajian Kondisi Perekonomian dan Regulasi Usaha. Laporan Penelitian. Jakarta: Lembaga Penelitian, SMERU Institute, 98 pp.

Barnes, R.H. 2005. Indigenous use and management of whales and other marine resources in East Flores and Lembata, Indonesia. Senri Ethnological Studies, 67: 77-85.

Bennett M, Dearden P, Rollins R. 2003. The sustainability of dive tourism in Phuket, Thailand. In: Landsdown H, Dearden P, Neilson W (eds), *Communities in SE Asia: challenges and responses*. Victoria, BC: University of Victoria, Center for Asia Pacific Initiatives. pp 97–106.

Bigelow, H.B. and Schroeder, W.C. 1953. Sawfish, guitarfish, skates and rays. In: Bigelow, H.B. and Schroeder, W.C. (Eds) Fishes of the Western North Atlantic, Part 2. Sears Foundation for Marine Research, Yale University, New Haven, pp. 508-514.

Bizzaro, J. J., Smith, W.D., Marquez-Farias, J.F., Tyminski, J., Hueter, R.E. 2009. Temporal variation in the artisanal Elasmobranch fishery of Sonora, Mexico. Fisheries Research, 97: 103-117.

Bizzarro, J., Smith, W., Baum, J., Domingo, A. & Menni, R. 2009. *Mobula hypostoma*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>.

Bizzarro, J.J., Smith, W.D. & Clark, T.B. 2006. *Mobula munkiana*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>.

Bizzarro, J., Smith, W., White, W.T. & Valenti, S.V. 2009. *Mobula kuhlii*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>.

Bourdon, J. 1999. A fossil manta ray from the early Pliocine (Zanclean) of North America. Tertiary Research 19: 79-84.

Bradshaw, C. J. A., Mollet, H. F., and Meekan, M. G. (2007). Inferring population trends for the world's largest fish from mark-recapture estimates of survival. Journal of Animal Ecology 76, 480-489.

Camhi, M.D., Valenti, S.V., Fordham, S.V., Fowler, S.L. and Gibson, C. 2009. The Conservation Status of Pelagic Sharks and Rays: Report of the IUCN Shark Specialist Group Pelagic Shark Red List Workshop. Newbury, UK: IUCN Species Survival Commission Shark Specialist Group, x +78 pp.

Casey, J.M. and Myers, R.A. 1998. Near extinction of a large widely distributed fish. *Science*, 281: 690–692.

Cavanagh, R.D. and Gibson, C. 2007. Overview of the Conservation Status of Cartilaginous Fishes (Chondrichthyans) in the Mediterranean Sea. The World Conservation Union (IUCN), Gland, Switzerland and Malaga, Spain.

Chaudhary, R. G. Joshi, D., Mookerjee, A., Talwar V., and Menon, V. 2008. Turning the tide: the campaign to save Vhali, the whale shark (Rhincodon typus) in Gujarat. Wildlife Trust of India, NOIDA, Uttar Pradesh.

Chin, A., Kyne, P.M. 2007. Vulnerability of chondrichthyan fishes of the Great Barrier Reef to climate change. In: Climate Change and the Great Barrier Reef: A Vulnerability Assessment, Johnson, J.E., and Marshall, P.A. (eds). Great Barrier Reef Marine Park Authority and Australian Greenhouse Office, Townsville, Australia. P 393-425.

Clark, T.B. 2001. Population structure of *Manta birostris* (Chondrichthyes: Mobulidae) from the Pacific and Atlantic Oceans. MS thesis, Texas A&M University, Galveston, TX

Clark, T.B., Smith, W.D. & Bizzarro, J.J. 2006. *Mobula tarapacana*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>.

Clark, T.B., Smith, W.D. & Bizzarro, J.J. 2006. *Mobula thurstoni*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>.

Clarke, S., Milner-Gulland, E.J., Cemare, T.B. 2007. Social, economic, and regulatory drivers of the shark fin trade. Marine Resource Economics, 22: 305-327.

Cline,W. 2008. Shark diving overview for the islands of the Bahamas (p. 11). Nassau, Report of the Bahamas Ministry of Tourism. Nassau, Bahamas: Cline Marketing Group.

Clua, E., Buray, N., Legendre, P., Mourier, J., Planes, S., 2011. Business partner or simple catch? The economic value of the sicklefin lemon shark in French Polynesia. In: Marine and Freshwater Research, 2011, 62, 764-770.

Compagno, L.J.V. 1999. Checklist of living elasmobranchs. In: Hamlett, W.C. (ed). Sharks, skates, and rays: the biology of elasmobranch fishes. Maryland: John Hopkins University Press. p 471–498

Compagno, L.J.V. and Last, P. 1999. Mobulidae. In: Capenter, K.E. and Niem, V.H. (eds), FAO species identification fuide for fishery purposes. The living marine resources of the western Central Pacific (Volume 3. Batoid Fishes, Chimeras and Bony Fishes. Part 1 (Elopidae to Linophymidae)). Rome: FAO.

Couturier, L.I.E., Marshall, A.D., Jaine, F.R.A., Kashiwagi, T., Pierce, S.J., Townsend, K.A., Weeks, S.J., Bennett, M.B., and Richardson, A.J. In Press. The Biology and Ecology of the Mobulidae. In: Journal of Fish Biology.

Cox, G. and M. Francis 1997 Sharks and rays of New Zealand. Canterbury Univ. Press, Univ. of Canterbury. 68 p.

Davis D, Banks S, Birtles A, Valentine P, Cuthill M. 1997. Whale sharks in Ningaloo Marine Park: managing tourism in an Australian.

Daw, B., and McGregor, F. 2008. Management of Manta Ray *(M.birostris)* Interactive Tours in the Shallow Lagoonal Waters of Ningaloo Reef, Western Australia – A Global Benchmark for Tourism Interactions, Paper presented at the 2008 Joint Meeting of Ichthyologists and Herpetologists, Montreal, Canada

Deakos, M.H. 2010a. Ecology and social behavior of a resident manta ray (*Manta alfredi*) population off Maui, Hawai'i. PhD thesis, University of Hawai'i, Manoa, Hawai'i.

Deakos, M. H. 2010b. Paired-laser photogrammetry as a simple and accurate system for measuring the body size of free-ranging manta rays *Manta alfredi*. Aquatic Biology, 10: 1-10.

Deakos, M., Baker, J., and Bejder, L. 2011. Characteristics of a manta ray (*Manta alfredi*) population off Maui, Hawaii, and implications for management. Marine Ecology Progress Series, 429: 245-260.

De la Cruz Modino, R., Esteban, A., Crilly, R., Pascual-Fernandez, J. 2010. Bucear con tiburones y rayas en Espana. Analisis de su potencial en Espana y en las Islas Canarias., Instituto Universitario de Ciencias Politicas y Sociales NEF-The New Economics Foundation: 8-16.

Devadoss, P. 1984. On the incidental fishery of skates and rays off Calicut. Indian Journal of Fisheries, 31(2):285-292.

Dewar, H. (2002). Preliminary report: Manta harvest in Lamakera. p. 3 p. Oceanside, USA: Report from the Pfleger Institue of Environmental Research and the Nature Conservancy.

Dewar, H., Mous, P., Domeier, M., Muljadi, A., Pet, J., and Whitty, J. 2008. Movements and site fidelity of the giant manta ray, *Manta birostris*, in the Komodo Marine Park, Indonesia. Marine Biology, 155(2): 121-133.

RESOURCES (CONTINUED)

Dicken, M.L. and Hosking, S.G. 2009. Socio-economic aspects of the tiger shark diving industry in the Aliwal Shoal Marine Protected Area, South Africa. African Journal of Marine Science, 31(2): 227-232.

Donnelly, R., Neville, D., and Mous, P.J. 2003. Report on a rapid ecological assessment of the Raja Ampat Islands, Papua, Eastern Indonesia, held October 30 – November 22, 2002. The Nature Conservancy – Southeast Asia Center for Marine Protected Areas, 250 pp.

Dulvy, N. K., Sadvoy, Y., and Reynolds, J. D. 2003. Extinction vulnerability in marine populations. Fish and Fisheries, 4: 25-64.

Essumang, D. 2010. First Determination of the Levels of Platinum Group Metals in *Manta birostris* (Manta Ray) Caught Along the Ghanaian Coastline. Bulletin of Environmental Contamination and Toxicology, 84(6): 720-725.

FAO (2009). FAO Fishstat Capture Production Database 1602 1950-2007. Available at www.fao.org/fishery/statistics/global-capture-production/en.

FAO. 2000. The International Plan of Action for the Conservation and Management of Sharks. Rome: FAO.

Fergusson, I., Compagno, L.J.V. & Marks, M. 2009. Carcharodon carcharias. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>.

Fernando, D. and Stevens, G. 2011 A study of Sri Lanka's manta and mobula ray fishery. The Manta Trust, 29 pp.

Fowler, S. 2005. The international and national frameworks for conservation and management of sharks: Recommendations for Ecuador. Contribution to Ecuador's Draft National Plan of Action for the Conservation and Management of Sharks. IUCN, Quito, Ecuador. 51 pp.

Frisk, M., Miller, T., and Fogarty, M. 2001. Estimation and analysis of biological parameters in elasmobranch fishes: a comparative life history study. Canadian Journal of Fish and Aquatic Science, 58:969–981.

Gallagher, A.J. and Hammerschlag, N. 2011. Global shark currency: the distribution, frequency, and economic value of shark ecotourism. Current Issues in Tourism, 1-16.

Gamil, J.T. and Gamil, A.P. 2010. Rescuer of manta rays. Philippine Daily Inquirer, November 3, 2010.

Graham, R.T. 2004. Global Whale Shark Tourism: A "Golden Goose" of Sustainable Lucrative Tourism. *Shark News* 16, (October).

Graham, R.T., Hickerson, E., Castellanos, D, Nuttall, M. 2008. Site Fidelity and Movements of Juvenile Manta Rays in the Gulf of Mexico. AES Devil Ray Symposium, Joint Ichths and Herps Conference Presentation.

Handwerk, B. 2010. Little-known Gulf manta rays affected by oil spill? National Geographic News. Published Oct. 15, 2010. http://news.nationalgeographic.com/news/2010/10/101015-new-manta-rays-gulf-bp-oil-spill-science-animals/ accessed Sept 1, 2011.

Hanfee, F. 2001. Gentle Giants of the Sea. TRAFFIC-India/WWF-India. 40pp.

Hara M, Maharaj I, Pithers L. 2003. Marine-based tourism in Gansbaai: A socio-economic study. Final report for the Department of Environmental Affairs and Tourism (DEAT), South Africa.

Heinrichs, S. 2011. Singapore Market Investigation. Manta Ray of Hope, 15 pp.

Hilton, P. 2011. East Asia Market Investigation. Manta Ray of Hope, 49pp.

Homma, K., Maruyama, T., Itoh, T., Ishihara, H., and Uchida, S. 1999. Biology of the manta ray, *Manta birostris* Walbaum, in the Indo-Pacific. In: Seret, B. and Sire, J.Y. (eds) Indo-Pacific fish biology: Proc 5th Int Conf Indo-Pacific Fishes, Noumea, 1997. Ichthyological Society of France, Paris, p 209–216

Kashiwagi, T. Marshall, A. D., Bennett, M. B., and Ovenden, J. R. 2011. Habitat segregation and mosaic sympatry of the two species of manta ray in the Indian and Pacific Oceans: *Manta alfredi* and *M. birostris*. Marine Biodiversity Records: 1-8.

Kitchen-Wheeler, A. 2010. Visual identification of individual manta ray (*Manta alfredi*) in the Maldives Islands, Western Indian Ocean. Marine Biology Research, 6(4):351-363

KMP (Komodo Manta Project). 2011. Manta population estimations from photographs. Unpublished Data.

Lack, M. and Sant, G. 2006. Confronting Shark Conservation Head on! TRAFFIC International. 35 pp.

Lack, M and Sant, G. 2009. Trends in global shark catch and recent developments in management. TRAFFIC International, 33 pp.

Maigret, J. and Ly, B. 1986.. Les poissons de mer de Mauritanie. Science Nat., Compiègne.

Marshall, A. D. 2009. Biology and population ecology of *Manta birostris* in southern Mozambique. PhD Thesis, University of Queensland

Marshall, A.D. and Bennett, M.B. 2010. Reproductive ecology of the reef manta ray *Manta alfredi* in southern Mozambique. Journal of Fish Biology, 77(1): 169-190.

Marshall, A., Ishihara, H., Dudley, S.F.J., Clark, T.B., Jorgensen, S., Smith, W.D., and Bizzarro, J.J. 2006. *Manta birostris*. In: IUCN 2010. IUCN Red List of Threatened Species, Version 2010.4 www.iucnredlist.org. Downloaded 12 February 2011.

Marshall, A. D., Pierce, S. J., and Bennett, M. B. 2008. Morphological measurements of manta rays (*Manta birostris*) with a description of a foetus from the east coast of Southern Africa. Zootaxa, *1717*, 24-30.

Marshall, A.D., Compagno, L.J.V. and Bennett, M.B. 2009. Redescription of the genus *Manta* with resurrection of *Manta alfredi* (Krefft, 1868) (Chondrichthyes; Myliobatoidei; Mobulidae). Zootaxa, 2301: 1-28.

Marshall, A.D., Dudgeon, C.L. and Bennett, M.B. 2011. Size and structure of a photographically identified population of manta rays *Manta alfredi* in southern Mozambique. Marine Biology, 158 (5): 1111-1124.

Marshall, A., Kashiwagi, T., Bennett, M.B., Deakos, M., Stevens, G., McGregor, F., Clark, T., Ishihara, H. & Sato, K. 2011. *Manta alfredi*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>.

Marshall, A., Bennett, M.B., Kodja, G., Hinojosa-Alvarez, S., Galvan-Magana, F., Harding, M., Stevens, G. & Kashiwagi, T. 2011. *Manta birostris*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>.

Martin, R.A., Hakeem, A.A.A., 2006. Development of Sustainable Shark Diving Ecotourism Industry in the Maldives: Challenges and Opportunities. Maldives Marine Research Bulletion, Volume 8, 10 December 2006.

McGregor, F. 2009. The Manta Rays of Ningaloo Reef: baseline population and foraging ecology. Presentation, Murdoch University.

Mohanraj, G., Rajapackiam, S., Mohan, S., Batcha, H., and Gomathy, S. 2009. Status of elasmobranchs fishery in Chennai, India. Asian Fisheries Science, 22: 607-615.

Molony, B. 2005. Estimates of the mortality of non-target species with an initial focus on seabirds, turtles and sharks. 1st Meeting of the Scientific Committee of the Western and Central Pacific Fisheries Commission, 84 pp.

MPRF (Manta Pacific Research Foundation). 2007. Manta Economics: survey of Kailua-Kona, Hawaii Dive and Snorkel operators. Unpublished Data. www.mantapacific.org.

MPRF (Manta Pacific Research Foundation). 2011. Manta ray photo-identification catalogue. www.mantapacific.org/identification/index.html. Accessed September 14, 2011.

Musick, J.A. 1999. Ecology and Conservation of Long-Lived Marine Animals. Pages 1-10

Musick, J. A. (ed). Life in the slow lane: ecology and conservation of long-lived marine animals. American Fisheries Society Symposium 23, Bethesda, Maryland.

Norman, B. and Catlin, J. 2007. Economic importance of conserving whale sharks. Report for the International Fund for Animal Welfare, Australia. 1-18 pp.

Notarbartolo di Sciara, G. 1987. A revisionary study of the genus Mobula Rafineque, 1810 (Chondrichthyes: Mobulidae) with the description of a new species. Zoological Journal of the Linnean Society, 91: 1-91.

Notarbartolo di Sciara, G. 1988. Natural history of the rays of the genus Mobula in the Gulf of California. Fishery Bulletin, 86 (1): 45-66.

Notarbartolo di Sciara, G. and Hillyer, E.V. 1989. Mobulid rays off eastern Venezuela (Chnodrichthyes, Mobulidae). Copeia, 3: 607-614.

Notarbartolo di Sciara, G. 1995. What future for manta rays? Shark News, 5: 1.

Notarbartolo di Sciara, G. 2005. Giant devilray or devil rays *Mobula mobular* (Bonnaterre, 1788). In: Sharks, Rays and Chimaeras: The Status of Chondrichthyan Fishes. Fowler, S.L., Cavanagh, R.D., Camhi, M., Burgess, G.H., Caillet, G.M., Fordham, S.V., Simpendorfer, C.A. and Musick, J.A. (eds). Gland, Switzerland and Cambridge, UK: IUCN / SSC Shark Specialist Group, pp. 356–357.

Notarbartolo di Sciara, G., Serena, F. & Mancusi, C. 2006. *Mobula mobular*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>.

Paulin, C.D., Habib, G., Carey, C.L., Swanson, P.M., Voss, G.J. 1982. New records of *Mobula japanica* and *Masturus lanceolatus*, and further records of *Luvaris imperialis* (Pisces: Mobulidae, Molidae, Louvaridae) from New Zealand. New Zealand Journal of Marine and Freshwater Research, 16: 11-17.

Perez, J.A.A. and Wahrlich, R. 2005. A bycatch assessment of the gillnet monkfish *Lophius gastrophysus* fishery off southern Brazil. Fisheries Research, 72: 81-95.

Pet-Soede, L (Ed.). 2002. The Solor and Alor islands: Expedition Results, data collected during 2 reconnaissance trips: 9-12 September, 2001 and 7-19 May, 2002, Report from WWF Wallacea Bioregional Program and The Nature Conservancy Southeast Asia Center for Marine Protected Areas, Bali, Indonesia. 110 p.

Philippine NPOA-Sharks. 2009. National Plan of Action for the Conservation and Management of sharks in the Philippines. Department of Agriculture, Bureau of Fisheries and Aquatic Resources, 161 pp.

Pianet, R., Chavance, P., Murua, H., Delgado de Molina, A. 2010. Quantitative estimates of the by-catches of the main species of the purse seine fleet in the Indian Ocean, 2003-2008. Indian Ocean Tuna Commission, WPEB-21.

Pierce, S.J. & Bennett, M.B. 2003. *Mobula eregoodootenkee*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>.

Pillai, S. K. 1998. A note on giant devil ray Mobula diabolus caught in Vizhinjam. Marine Fisheries Information Service, Technical and Extension Series, 152 . pp. 14-15.

Pine, R. 2007. Donsol: Whale shark tourism and coastal resource management, A Case Study of the Philippines. WWF-Philippines, Quezon City, Philippines. 41 pp.

Planeta Oceano 2011. Preliminary report of the state of coastal mobulid fisheries in Peru.

Purvis, A., Gittleman, J.L., Cowlishaw, G., and Mace, G.M. 2000. Predicting extinction risk in declining species. Proceedings of the Royal Society B, 267: 1947-1952.

Rajapackiam, S., Gomathy, S. and Jaiganesh, P. 2007a. Devil ray *Manta birostris* landed at Chennai fishing harbor. Marine Fisheries Information Service Technical and Extension Series, 191: 29-30

Rajapackiam, S. Mohan, S. and Rudramurthy, N. 2007b. Utilization of gill rakers of lesser devil ray *Mobula diabolus* – a new fish byproduct. Marine Fisheries Information Service, Technical and Extension Series, 191: 22-23.

Raje, S. G., Sivakami, S., Mohanraj, G., Manojkumar, P.P., Raju, A. and Joshi, K.K. 2007. An atlas on the Elasmobranch fishery resources of India. CMFRI Special Publication, 95. pp. 1-253.

Rane, U.H. 2002. On a female devil ray Manta birostris (Walbaum) entangled in bottom set gill net at Kelwa-Dandarpada, Maharashtra. Marine Fisheries Information Service, Technical and Extension Series, 174: 14.

Reeves, R.R., Smith, B.D., Crespo, E.A., and Notarbartolio di Sciara, G. (eds) 2003. 2002-2010 Conservation Action Plan for the World's Cetaceans: Dolphins, Whales and Porpoises. IUCN/SSC Specialist Group, 147 pp.

Resolution of the 15th Micronesian Chief Executive Summit, July 25-28, 2011, Palikir, Pohnpei State, Federated States of Micronesia. http://www.pewenvironment.org/uploadedFiles/PEG/Newsroom/Press_Release/15th_MCES_Resolution_-_Establishing_the_Regional_Shark_Sanctuary_in_Micronesia.pdf

Roa, G. S. 1986. Note on the occurrence of the Whale Shark off Veraval coast. Marine Fisheries Information Service, T & E series No. 66. CMFRI, Cochin: pp.30

Rowat D, and Engelhardt U. 2007. Seychelles: A case study of community involvement in the development of whale shark ecotourism and its socio-economic impact. *Fisheries Research* 84: 109–113.

Rubin, R. D and Kumli. 2002. Manta Rays: not all black and white. *Shark Focus, 15*, 4-5.

Sampson, L. Galvan-Magana, F. de Silva-Davila, R., Aguiniga-Garcia, S., and O'Sullivan, J.B. 2010. Diet and trophic position of the devil rays *Mobula thurstoni* and *Mobula japonica* as inferred from stable isotope analysis. Journal of the Biological Association of the United Kingdom, 90(5): 969-976.

Setiasih, N. 2011. Indonesia Fishery Investigation. Manta Ray of Hope, 15 pp.

Sivaprakasam, T.E. 1964. On the capture of two giant devil rays (*Manta birostris* (Walbaum)) at Veravel, Saurashtra. Journal of the Marine Biological Association of Indi, 7(1): 204-205.

Smith, S.W., D.W. Au and C. Show 1998 Intrinsic rebound potential of 26 species of Pacific sharks. Mar. Freshwat. Res. 49:663-678.

Smith, W.D., Bizzaro, J.J. and Cailliet, G.M. 2009. The artisanal Elasmobranch fishery on the east coast of Baja California, Mexico: Characteristics and management considerations. Ciencias Marinas, 35(2): 209-236.

Sommer, C., Schneider, W., Poutiers, J. 1996. FAO Species Identification Field Guide for Fishery Purposes: The Living Marine Resources of Somalia. FAO of the United Nations, Rome. 422 pp.

Stevens, J.D., Bonfil, R., Dulvy, N.K. and Walker, P.A. 2000. The effects of fishing on sharks, rays and chimaeras (chondrichthyans), and the implications for marine ecosystems. ICES Journal of Marine Science, 57: 476-494.

Suraji, A., Surarso, G.W., and Supriyatna, Y. 2009. The construction sector of Indonesia. Proceedings of the 15th Asiaconstruct Conference, Kuala, Lumpur, Malaysia, October 2009, 17 pp.

Tibirica, Y. Birtles, A. Valentine, P., and Miller, D.K. 2009. Diving tourism in Mozambique-An opportunity at risk. Proceedings of Congress on Coastal and Marine Tourism, Nelson Mandela Bay, South Africa, 12 pp.

Topelko, K.N., and Dearden, P. 2005. The shark watching industry and its potential contribution to shark conservation. Journal of Ecotourism, 4(2): 108-128.

Valenti, S.V. & Kyne, P.M. 2009. *Mobula rochebrunei*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>.

Vianna G,M,S., Meekan, M.G., Pannell, D., Marsh, S., Meeuwig, J. 2010. Wanted Dead or Alive? The relative value of reef sharks as a fishery and an ecotourism asset in Palau. Australian Institute of Marine Science and University of Western Australia, Perth.

Vidthayanon, C. 2002. Elasmobranch diversity and status in Thailand. In: Fowler, S.L., Reed, T.M., Dipper, F.A. (eds) Elasmobranch Biodiversity, Conservation and Management: Proceedings of the International Seminar and Workshop. Sabah, Malaysia, July 1997, pp 104-113.

Vivekanandan, E. and Zala, M. S. 1994. Whale shark fishery off Veraval. Indian Journal of Fisheries, 41(1): 37-40.

Waheed, A. 1998. Economic value of 'marine ecotourism' in the Maldives. Bay of Bengal News, 12(2): 23.

White, W., and Kyne, P. 2010. The status of chondrichthyan conservation in the Indo-Australasian region. Journal of fish biology, 76(9), 2090-2117

White, W. T., Giles, J., Dharmadi, and Potter, I. C. 2006 b. Data on the bycatch fishery and reproductive biology of mobulid rays (Myliobatiformes) in Indonesia. Fisheries Research, 82(1-3), 65-73.

White, W.T., Clark, T.B., Smith, W.D. & Bizzarro, J.J. 2006. *Mobula japanica*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>

Young, N. 2001. An analysis of the trends in by-catch of turtle species, angelsharks and batoid species protective gillnets off KwaZulu-Natal, South Africa. Msc. Thesis, University of Reading.

Zeeberg, J. Corten, A. and de Graaf, E. 2006. Bycatch and release of pelagic megafauna in industrial trawler fisheries off Northwest Africa. Fisheries Research, 78: 186-195.

POPULATIONS OF MANTA AND MOBULA RAYS ARE FACING EXTREME THREATS.

WE MUST ACT BEFORE THEY ARE LOST FOREVER.

WWW.MANTARAYOFHOPE.COM