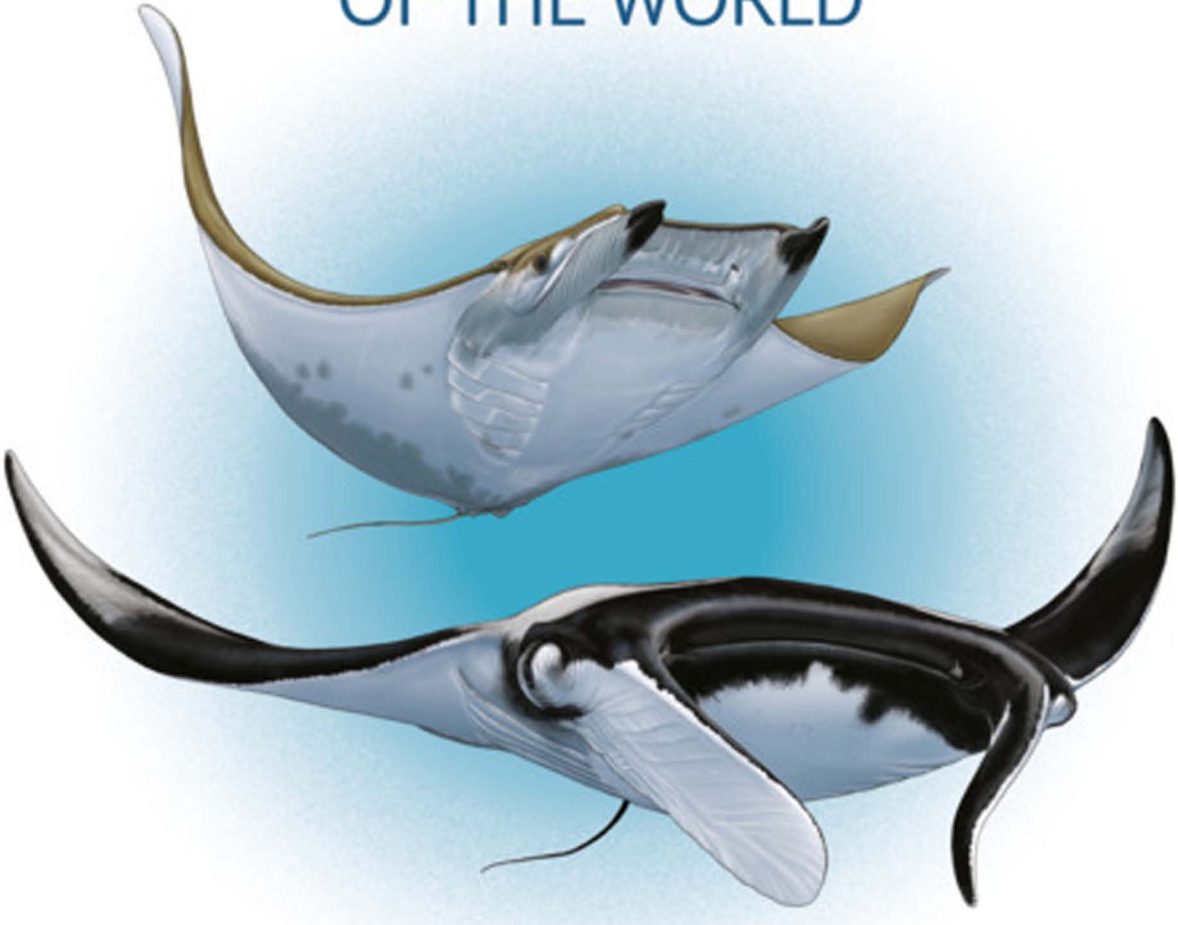
GUIDE TO THE

MANTA & DEVIL RAYS

OF THE WORLD



Guy Stevens, Daniel Fernando, Marc Dando
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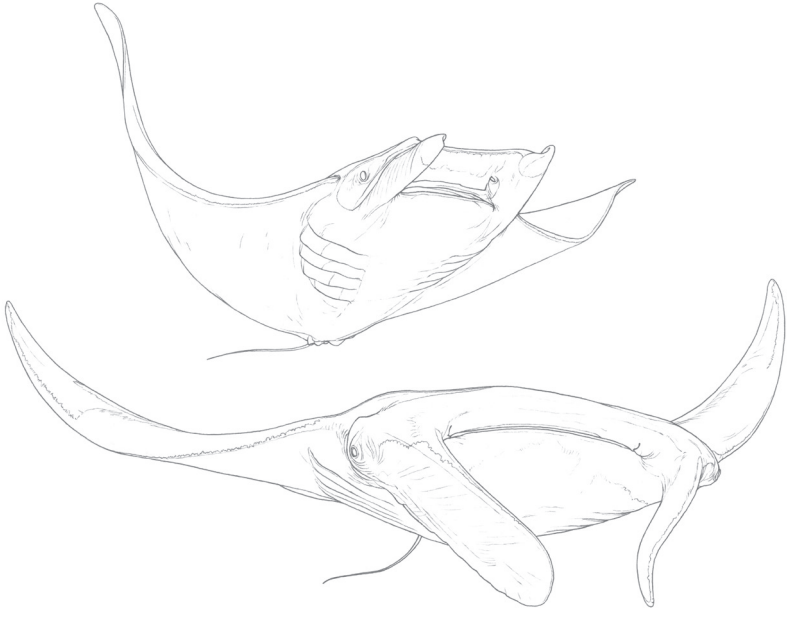

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Front cover: above – Sicklefin Devil Ray *Mobula tarapacana*, below – Oceanic Manta Ray *Mobula birostris*

Back cover: a school of Brassy Chub *Kyphosus vaigiensis* scatters as a hungry Reef Manta Ray *Mobula alfredi* powers its way through the surface waters of Hanifaru Bay in the Maldives

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Acknowledgements

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We also appreciate all the incredibly talented photographers who have very graciously donated their images for this important project (see photo credits below).

Finally, we express our thanks to all those who contributed towards this guide, their valuable insights, and unfettered enthusiasm. Our sincerest apologies to anyone we might have erroneously left out.

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The authors

Guy Stevens

Guy Stevens is the Chief Executive and Co-Founder of the Manta Trust, a UK and US registered charity dedicated to the conservation of manta rays, with collaborative projects in over 25 countries. He has spent the last 15 years studying manta and devil rays all over the world and is one of the foremost experts on these species. After completing a degree in Marine Biology and Coastal Ecology at the University of Plymouth in the UK, Guy moved to the Maldives, where he founded the Maldivian Manta Ray Project in 2005. After 11 years of research, Guy completed his PhD on the world's largest population of reef manta rays at the end of 2016. Guy's conservation efforts in the Maldives have led to the creation of several marine protected areas at key manta aggregations sites, most notably at Hanifaru Bay. Internationally, Guy is part of a team which has driven the conservation of mobulids forward, resulting in the listing of all manta and devil rays in the Appendices of the Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). In recognition of his contribution to ocean conservation, in 2015 Guy received an Ocean Award for his work on manta rays, and in 2017 he was awarded the UK Prime Minister's Points of Light Award. Guy is the author of the world's first book on manta rays; *MANTA – The Secret Life of Devil Rays*, published in 2017.

For more information, visit **www.mantatrust.org**

Daniel Fernando

Daniel Fernando is an Associate Director of the Manta Trust, and Co-Founder of Blue Resources Trust – a Sri Lankan NGO dedicated to promoting informed, science-based decision making to facilitate the conservation and sustainable use of marine resources, and to provide a platform for scientists to expand research in the Indian Ocean. Daniel has spent over six years investigating mobulid ray fisheries as part of his PhD research, and has helped set up data collection projects all across the world that provide essential information to increase understanding of the extent of overexploitation of these vulnerable species. In addition to field research, his drive to encourage a shift toward sustainable fisheries has resulted in his appointment as an Advisor to the Minister of Sustainable Development and Wildlife of Sri Lanka, where he represents the Government of Sri Lanka and drives policy measures forward through international conservation instruments such as the Convention on the International Trade in Endangered Species and the Convention on the Conservation of Migratory Species of Wild Animals. He is an Marine Conservation Action Fund (MCAF) Fellow and member of the IUCN Shark Specialist Group.

For more information, visit **www.blueresources.org**

Marc Dando

Marc Dando is a scientific illustrator and publisher. He has always balanced art and science, completing an honours degree in Zoology at Nottingham University then moving into a career as a graphic designer. After many successful years in commercial graphics, an opportunity arose to work on various natural history projects, initially in design, but finally in scientific illustration.

For the past 25 years he has worked alongside many eminent scientists, especially in the field of marine biology. His first book, *Sealife: a complete guide to the marine environment,* was as a co-author, designer and illustrator; but it was *Sharks of the World,* a three-and-a-half-year project with Leonard Compagno and Sarah Fowler, that established him as an outstanding scientific illustrator. With Dave Ebert he has now worked on the updated *Sharks of the World* and has collaborated with him on further projects for the FAO and IFAW. Although his work has been seen in Monaco and The Mall Galleries in London, the majority of his work is found in books, field guide literature and magazines.

Giuseppe Notarbartolo di Sciara

Giuseppe Notarbartolo di Sciara is an Italian marine conservation ecologist who has worked for 40 years to advance knowledge of the natural history, ecology, behaviour and taxonomy of marine mammals and cartilaginous fishes. He earned a PhD degree in marine biology at the Scripps Institution of Oceanography (University of California at San Diego) in 1985 with a thesis on the taxonomy and ecology of devil rays, describing a new species, *Mobula munkiana*. In 1986 he funded the Milan-based Tethys Research Institute, which he chaired and directed until 1997 and again from 2010 to 2016. In 1991 he spearheaded the creation of the first high-seas marine protected area, the Pelagos Sanctuary for Mediterranean Marine Mammals, established in 1999 by a treaty amongst Italy, France and Monaco. He has served as the Italian Commissioner at the International Whaling Commission (1999–2004), and as Chair of the Scientific Committee of ACCOBAMS (2002–2010). Currently the CoP-appointed Councillor for aquatic mammals at the Convention on Migratory Species; co-chair of the IUCN Task Force on marine mammal protected areas; deputy chair of the IUCN Cetacean Specialist Group; member of the IUCN Shark Specialist Group; regional coordinator for the Mediterranean and Black Seas of IUCN WCPA – Marine; and Advisor, Pew Fellows in Marine Conservation. He has lectured in science and policy of the conservation of marine biodiversity at the University Statale of Milan from 2007 to 2016. Author of over 160 scientific publications, several books and popular works.

For more information, visit **www.disciara.org**

Save Our Seas Foundation

In 2007, the Manta Trust's research programme in the Maldives became one of the first conservation projects to be supported by the Save Our Seas Foundation (SOSF), and in the intervening decade this collaboration has evolved into a proud partnership. With funding and guidance from the SOSF and the authors' passionate and enduring dedication to manta and devil rays, the Manta Trust has grown into a highly influential organisation at the forefront of global mobulid conservation. We are delighted to support the creation of this field guide, which highlights the great advances in science and conservation the Trust has achieved since its inception.

The Save Our Seas Foundation has funded more than 200 projects in over 50 countries around the globe. Each project strives for deeper understanding and more innovative solutions in marine research, conservation and education. With more than a decade of experience notched up, we look forward to the next decade as an ongoing process of evolving and refining. We continue to grow and learn as a foundation, seeking out and supporting the best and brightest people whose innovative projects make a real and lasting impact for the health of our oceans – and ultimately for every person on the planet. We share science beyond the boundaries of scientific publications through online, print and multimedia channels.

RESEARCH Good science is essential because in order to conserve anything, you must begin by understanding it.

EDUCATION Learning yields understanding and inspiration, which give rise to action and ultimately lead to change.

CONSERVATION We support projects that will have a direct, measurable impact for conservation at a local or global scale.

SPECIALISATION We have carved out a niche in the world of shark and ray conservation.

COMMUNICATION We share science beyond the boundaries of scientific publications through online, print and multimedia channels.

CULTIVATION Nurturing young people and early career professionals, whom we prioritise through various funding opportunities, will sustain ocean conservation in the long term.

INNOVATION We look for innovative approaches and new technology that will help achieve research, conservation and education gains.

COMMITMENT We offer long-term support to a few select conservation projects through partnerships and to the Save Our Seas Foundation research and education centres around the world.

COLLABORATION We work closely with our project leaders during their funding period to encourage them and to facilitate collaboration between them.

The Manta Trust

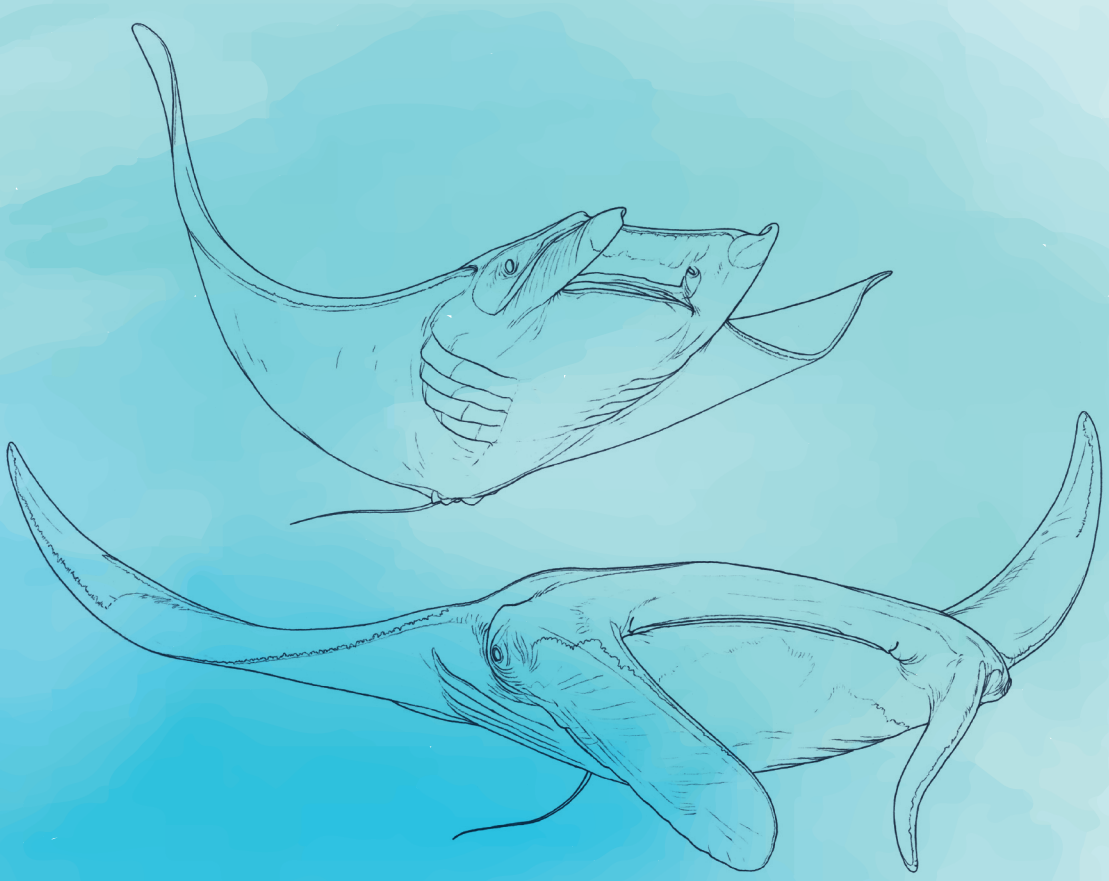
The Manta Trust is a UK- and US-registered charity (US = Action for Mantas) that co-ordinates global research and conservation efforts for mobulids, to better protect these vulnerable animals and the habitats on which they depend. Since its formation in 2011 with projects in five locations, the Manta Trust has grown in reputation and size, developing robust relationships at local, regional, and national levels in over 25 mobulid range states. Our international network is comprised of a diverse group of researchers, scientists, conservationists, educators and media experts.

Our vision is a sustainable future for the oceans, where mobulids and their relatives thrive in healthy, diverse marine ecosystems. The Manta Trust's unique, multifaceted approach to achieving this vision enables us to maximise the conservation opportunities. We bring together international expertise on mobulid rays and marine ecosystems to achieve effective, global conservation solutions. We also utilise the manta ray's charisma as a flagship species to promote and engage people with wider marine conservation issues. In this way, mobulids have become a catalyst for change; engaging and motivating the public, governments and local communities alike with the preservation of ocean life more generally.

We work with partner NGOs and scientific institutions to examine the spatial ecology, population dynamics and susceptibility of manta and devil ray populations to mankind's impact on the planet, while developing real-world strategies for public involvement in mobulid ray protection, ecotourism and management. We also consider people in our approach. Citizen science and the engagement of the general public in our work is a large part of what we do, from encouraging the submission of photo identification images and making our results publicly available, to writing about our work in books and magazines, and using our social media outlets to engage our audience in our research. We encourage volunteers and students to participate in our programmes. Most importantly, we always partner with local initiatives to ensure that any practices we put into place have lasting results for the wider communities in which we work.

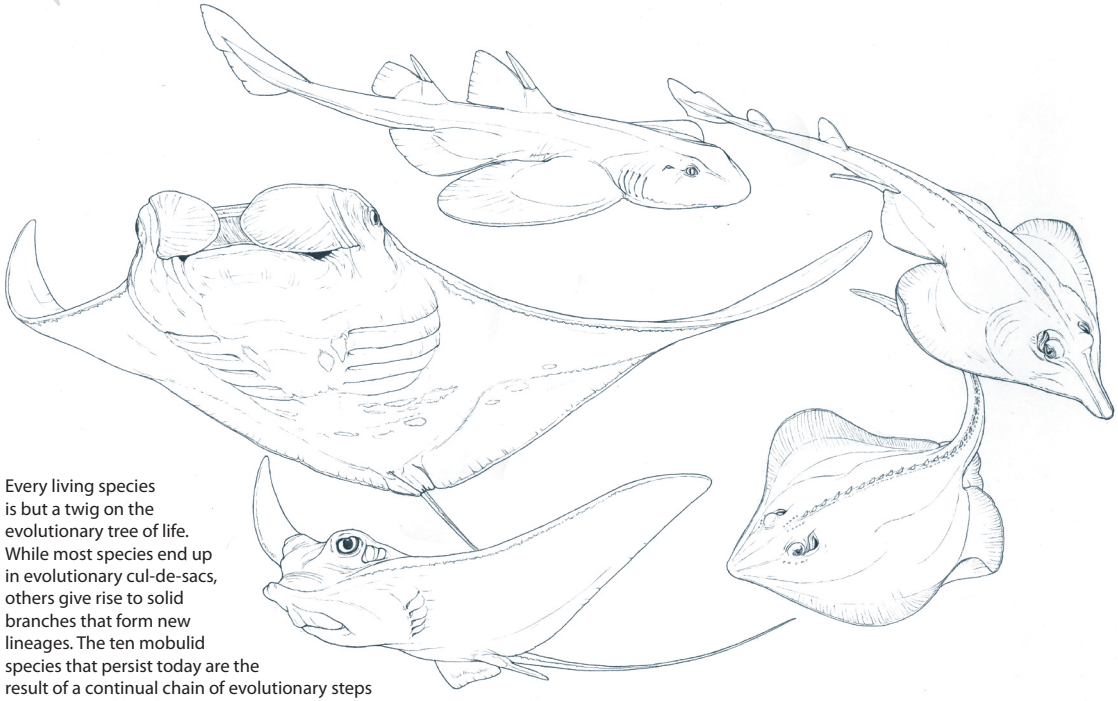
Since its inception, the Manta Trust's global network has positioned itself as the leading authority on mobulids. We are proud of what we and our colleagues have achieved in just a few short years as a global player in marine conservation. Some of our key collaborative achievements to date include: gaining Appendix II listing for all mobulids on the Convention on International Trade in Endangered Species; gaining Appendix I and II listing for all mobulids on the Convention on the Conservation of Migratory Species of Wild Animals; developing, in collaboration with WWF and Project AWARE, the first scientifically advised Best Practice Guidelines for Shark and Ray Tourism; assisting the IUCN Shark Specialist Group in developing a Global Conservation Strategy for Manta and Devil Rays; and publishing *MANTA: Secret Life of Devil Rays*, the world's first book dedicated to manta biology. The Manta Team has also played a key role in gaining national protection for manta rays in the Republic of Maldives, Indonesia and Peru.

INTRODUCTION



Left: a Sicklefin Devil Ray *Mobula tarapacana* cruises around a seamount in the Atlantic Ocean off the coast of the Azores.

An introduction to manta and devil rays



Every living species is but a twig on the evolutionary tree of life. While most species end up in evolutionary cul-de-sacs, others give rise to solid branches that form new lineages. The ten mobulid species that persist today are the result of a continual chain of evolutionary steps that can be traced back through their close ray cousins, all the way back to a common ancestor with the sharks.

Manta and devil rays, collectively known as mobulids, like all sharks and rays are classified as elasmobranchs – cartilaginous fishes that belong to one of the two subclasses within the Chondrichthyan fish class (the other subclass is comprised of around 45 species of wonderfully strange looking fishes known as chimaeras). Currently the 1,160 or so species of extant (living) elasmobranchs are divided roughly in half, with about 510 species of sharks and 650 species of rays.

Somewhat resembling modern skates, the first rays appeared in the oceans approximately 150 million years ago, radiating from a common ancestor with the sharks. Their flattened body shape is essentially a squashed version of the archetypal shark, with internal physiology very similar to that of their cousins. There are nine extant orders of sharks, and four extant ray orders: Rajiformes (skates), Rhinopristiformes (guitarfishes and sawfishes), Torpediniformes (electric rays) and Myliobatiformes (stingrays and relatives, including mantas and devil rays).

Mobulids are taxonomically linked to all elasmobranchs by their similar skeletons, comprised of flexible, fibrous and light cartilage, as opposed to the dense bony skeletons of the vast majority of all other fish (approximately 30,000 species) and terrestrial vertebrates. This lightweight skeleton is about half the density of bone, saving valuable energy for the mobulids as they swim through the water. Unlike most free-swimming bony fishes, mobulids and their relatives have not needed to evolve a gas-filled swim bladder to compensate for a denser bony skeleton. Enlarged and extra oily livers compensate for their weight, but overall they are still negatively buoyant and will begin to sink slowly if they stop swimming. For some species, including the manta and devil rays, this leads to a life of perpetual forward motion creating lift.

While some sharks and rays spend their whole life in motion, the vast majority of ray species, and a large proportion of shark species, spend a great deal of time resting on the seabed. They can do this without

asphyxiating by actively pumping water over their gills, much as the majority of bony fishes do. Because nearly all sharks and rays have their mouths on the underside of their heads and not in front, they have evolved small openings called spiracles, just behind the eyes, on either side of their heads. These spiracles allow the animals to draw in clean water without sucking up the sediment beneath them through their mouths. Mobulids still retain these spiracles, although there no longer appears to be any functional use for them in these constantly swimming species. In fact, the spiracles often house hitchhikers – small remoras that use these safe hidey-holes to live and take shelter in. On the manta rays, small flaps of skin cover the spiracles, making it hard to discern their presence just back from their eyes on the top of the ray's head.

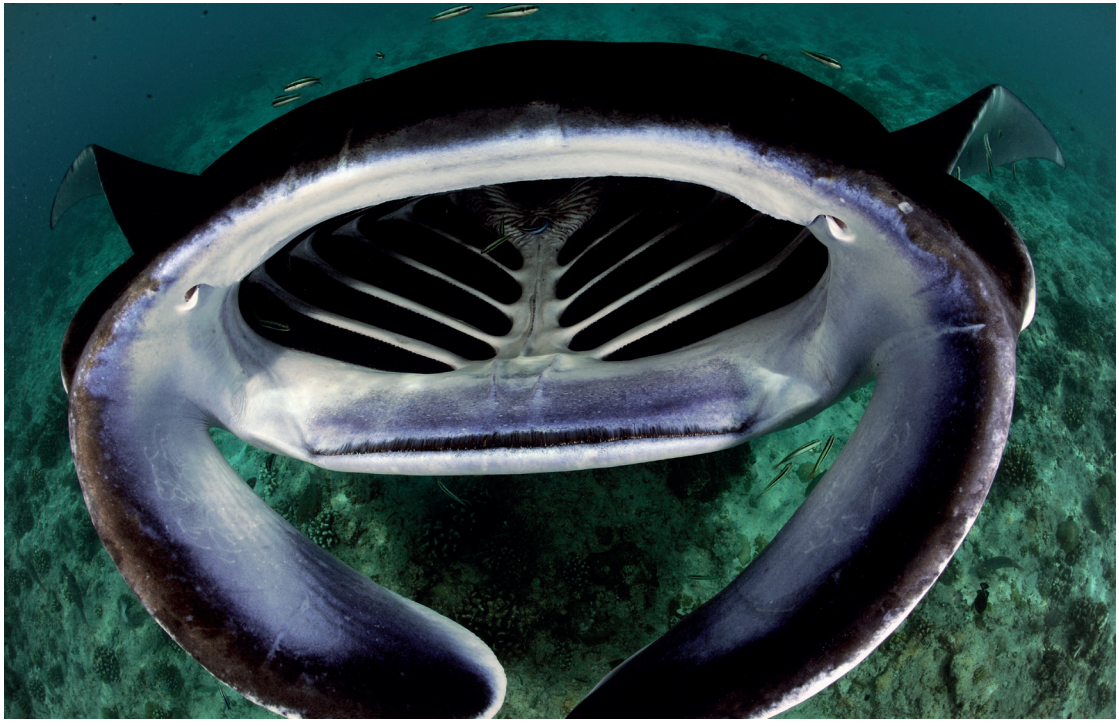
Like all species that live life continually on the move in open water, mobulids have no need to actively pump water over their gills because the animals' constant forward motion pushes all the oxygenated water they need in through their mouths and over their gills. These 'obligate ram ventilators' soon asphyxiate and die if prevented from swimming. This would rarely occur under natural conditions, but is unfortunately often the case when they become entangled in fishing nets or fishing lines.

Mobulids are relatively large, slow-growing, migratory animals that form small, highly dispersed populations. They are among the least fecund of all sharks and rays, giving birth to a single pup every two to seven years after a gestation period of about one year. Such life history characteristics make them among the least productive species in the ocean and therefore very susceptible to anthropogenic pressures. Their aggregatory nature and schooling behaviour can make them vulnerable to even artisanal fisheries.

Growing global demand for the dried gill plates of mobulids in Asian medicine has exacerbated this issue and led to an increase in target fishing, along with higher retention in bycatch fisheries. This unsustainable demand has resulted in severe population declines across their range which, combined with their limited ability to recover from a state of depletion, greatly threatens their survival.

A Feathertail Stingray *Pastinachus sephen* digs for crustaceans and molluscs in the sandy seabed of a shallow lagoon in the Maldives, using large spiracle openings behind each eye to breathe in clear water while its mouth is buried in the sand. Although the stingray's manta and devil ray cousins still retain these spiracles, a life of constant motion in the open water column means these breathing holes are greatly reduced in size and function.

Taxonomy and evolution



A giant mouth opens wide as a Reef Manta Ray *Mobula alfredi* hovers above a cleaning station in the Maldives. Like all mobulids, manta rays are filter feeders, using five pairs of modified gill plates which encircle their mouth and paddle-like cephalic fins (head fins) to strain zooplankton and small fishes from the water.

Manta and devil rays (collectively known as mobulids) belong to a group of rays called the Myliobatiformes, which contains 12 families and about 370 species. Mobulids (Mobulidae) are most closely related to the eagle rays (Myliobatidae and Aetobatidae) and cownose rays (Rhinopteridae). All are characterised by diamond-shaped bodies and wing-like pectoral fins which they use to propel themselves through open water. Eagle rays and cownose rays all feed on the seabed, using their mouths to dig among the substrate in search of buried molluscs and crustaceans. The manta and devil rays, however, have taken to a completely pelagic way of life, never resting on the seabed.

Taxonomically within the Mobulidae family there is just one genus: *Mobula*, which contains ten species – two (possibly three) manta species and eight devil ray species. All are filter feeders, using their mouths and modified gill plates to strain plankton and small fishes from the water. In general, devil rays are much smaller than the manta rays and can be distinguished by morphological differences in their mouths and cephalic fins (head fins). Devil rays have a bottom jaw that is undercut so that the edge of the lower jaw rests much further back than the upper when their mouths are closed, whereas manta rays' jaws are aligned evenly.

The other differentiating anatomical feature is the shape of the cephalic fins, which when rolled up look like horns projecting off their heads – hence the name 'devil rays'. The primary function of these fins is to help funnel planktonic food into the gaping mouths of the rays when they are feeding. Unfurled, the devil ray's cephalic fins are a little smaller than the manta's, which unravel to form large, paddle-like structures that touch in the centre, creating a complete funnel around the manta's mouth.