



**MARINE
MEGAFUNA
FOUNDATION**



MOZAMBIQUE RESEARCH REPORT

2022

FOREWORD



Dr. Andrea Marshall
Co-Founder & Principal Scientist

A YEAR OF RENEWED MOMENTUM

2022 was exactly what we needed in so many ways. The pandemic and its effects had left our teams around the world struggling to imagine how we could move forward in many of the places we work. The chaos interrupted our long-term studies, left gaps in our data sets and stalled fieldwork. We lost funding in the economic crisis that ensued and the price of travel to, and operations in, the remote areas we work sky-rocketed. In Mozambique, I worried that lost momentum would compromise our progress and slow conservation projects. Quite unexpectedly, the opposite occurred and government's commitment to the environment seemed to strengthen in 2022. As a result, rather excitingly, international support for marine conservation efforts in Mozambique started to pour in. The renewed hope energized our team and made us believe there was real hope for the Hope Spot we launched with Silvia Earle and Mission Blue in January.

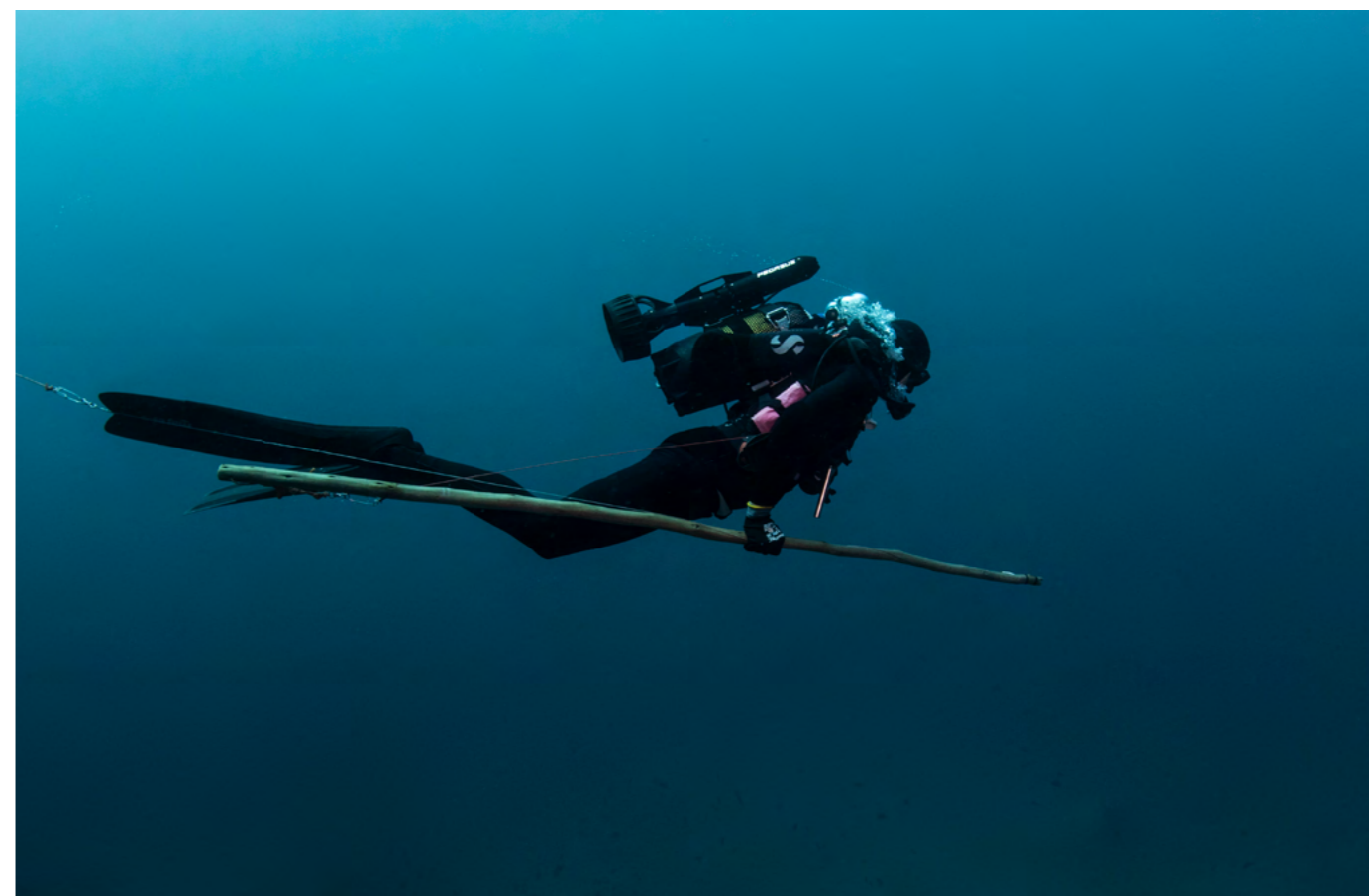
As 2022 comes to a close, I realize how much we took on this year and just how successful of a year it was. We expanded north, opening an office in Inhassoro, as we embark on a three-year pilot study funded by Foundation Segre to research and conserve dugong and wedgefish. We internally tagged bowmouth guitarfish and leopard sharks for the first time, expanded our acoustic array along the coastline, and developed new and exciting, and importantly less intrusive, capture methods for our smaller sharks and rays that left us feeling like underwater ninjas. We collected new eDNA samples to support our elasmobranch census. After years of planning, we expanded our marlin project to Mozambique with the first satellite tags being deployed late this year. After 20 years of research we also began satellite tagging reef mantas for the first time in both Zavora and Bazaruto, reminding me that there is still so much work to be done on this population even after two decades of monitoring.

I could not be more proud of our hard-working field teams along the coast or have more gratitude and appreciation to our donors, partners and collaborators who have supported us every step of the way and helped us achieve some pretty ambitious goals. With renewed strength and commitment, we could not be more excited for the start of the 2023 season!



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DEVIL RAY RESEARCH PROGRESS



PROJECT OVERVIEW

Southern Mozambique is a global centre of abundance for manta rays, the largest of the devil rays species. Over the last 20 years we have documented the largest identified populations of both giant and reef manta rays in Africa. Both species spatially aggregate in the south of the country, with the highest sightings recorded along the coast of the Inhambane Province. This stretch of coastline appears to provide important breeding, feeding and cleaning areas for these threatened rays and for *Mobula kuhlii*, a smaller endangered species of devil ray. With the sharp increase of indiscriminate fishing practices used by coastal fishing communities, such as gill nets, unsustainable numbers of devil rays are now being caught in their core habitat in the country. Over the last decade, our researchers have recorded up to a 98% decline in observational sighting records of devil ray species, highlighting the urgency for conservation planning and the development of targeted management strategies for local populations. With demand for devil

ray products increasing and a valuable marine ecotourism industry developing in the region, it is imperative to gain a greater understanding of their critical habitats, home range, and movement patterns, including the environmental drivers that influence their behaviour and the anthropogenic threats that put them at risk along this coast.

PREVIOUS PROGRESS

MMF scientists have authored over 30 peer-reviewed scientific papers on manta and devil rays, including 19 which incorporated data from Mozambique. Findings from our studies have been used to aid in regional management efforts and we have contributed to current management plans for marine protected areas, such as the Bazaruto Archipelago National Park (BANP). Our team continues to identify critical habitats for *Mobula* species, particularly in Africa, where targeted conservation activities are necessary and management is likely to be viable and effective.

In Mozambique, we currently collaborate with scientists, conservation bodies, protected area

managers, dive operators, tourism authorities and other government agencies to help create broad-scale protection for manta and devil rays, giving special attention to their critical habitats along the Mozambican coastline.

In a bid to capture a more comprehensive understanding of their status in the region, MMF has expanded our research efforts. Our project now aims to evaluate the health of populations on a broader scale, tracking the abundance and distribution of manta and devil rays along the entire Inhambane coast through increased aerial and boat-based surveys. Intensive monitoring will not only allow us to better understand this dynamic coastal system and the critical habitats these species rely on, but will help us to identify particular areas where significant human pressures threaten to destabilize remaining populations. Our locally based research team continues to update and evaluate trend data, examine the home range, residency times, seasonality and movement patterns of devil ray species in the region and study aspects of their biology and behaviour. We have tailored our project to obtain the information necessary for the development of comprehensive science-based management strategies and to identify priority areas for grassroots conservation initiatives in coastal communities.

ACHIEVEMENTS IN 2022

- We recorded sightings of **394** reef manta rays, **12** giant oceanic manta rays and **324** mobula rays during survey dives across our main study sites in the Inhambane Province
- We successfully deployed **2 SPOT tags** on manta rays for the first time in Mozambique, one of which was successfully recovered
- We deployed **14 acoustic tags** (12 in north-eastern South Africa and 2 in Mozambique)
- We secured **9 miniPAT satellite tags** on reef mantas rays in the Bazaruto Seascape and Zavora
- We collected **3 tissue samples**

FINDINGS

This year we spent time looking for new aggregation sites for manta rays along to the north of the BANP and off Morrungulo. We also continued to survey our normal sites to maintain our long-running datasets. The focus of our research in 2022 was definitely telemetry. We began tagging in Zavora and South Africa placing on many tags in support of Nakia Cullain's PhD project. We placed several new acoustic and satellite tags on reef mantas in the Bazaruto Seascape as well. Perhaps most significantly, our team deployed two SPOT tags on reef manta rays in 2022 providing the first high resolution movement data for this species in Mozambique. Interestingly, location data showed northern movements from the BANP, with some data indicating a potentially important feeding ground immediately outside the park's boundary. Few giant oceanic manta rays were spotted this year preventing us from moving forward with our tagging work on this species.

GOALS FOR 2023

- We will continue collecting identification photos for our long-term photo-ID catalogues
- We plan to deploy **5 miniPAT tags** on reef manta rays in Bazaruto and Zavora
- We plan to deploy **5 miniPAT tags** on giant manta rays in Bazaruto
- We plan to deploy an additional **12-15 external acoustic tags** on reef and giant manta rays across the Province
- We plan to deploy another **3 acoustic tags** in South Africa on reef manta rays as well
- We will continue **RUV deployments** in all of our study locations
- We plan to test and deploy **CATS cameras** on reef manta rays in the Bazaruto Seascape
- Funding dependant, we plan to deploy additional **SPOT tags** on reef manta rays in the Bazaruto Seascape
- Publish a **new paper** on the first long-distance international movements of reef manta rays in Africa using photo-ID

WHALE SHARK RESEARCH PROGRESS



PROJECT OVERVIEW

Whale sharks (*Rhincodon typus*), the world's largest fish, are in sharp decline in many western Indian Ocean countries. They effectively disappeared from the Seychelles, significant declines have been noted in Djibouti and South Africa, and MMF researchers are now analysing a projected 87% decline in abundance between 2005 and 2019 off Praia do Tofo.

While mortality from by-catch by artisanal fishers and tuna purse seiners is likely to have significantly contributed to these declines, it is also possible that the sharks have shifted their habitat in response to changing oceanographic conditions and food availability. Establishing the primary cause of this decline, and identifying and mitigating ongoing threats, is the primary goal for our ongoing work in the Inhambane Province. We seek to link these data to our work throughout the Indian Ocean to create regional strategies for their protection.

PREVIOUS PROGRESS

MMF's research team have been studying whale sharks in Mozambique since 2005. Our work in Mozambique has clearly established that the country is a global hotspot for the species, with 784 identified individuals. Our satellite tagging and photo-identification work on Mozambican whale sharks has shown that sharks move freely along the coast from the Bazaruto Archipelago National Park (BANP) in the north to KwaZulu-Natal in South Africa in the south, and three sharks have been re-sighted in Tanzania. We have published 24 peer-reviewed papers on Mozambican whale sharks that detail aspects of their biology, ecology, and conservation.

MMF researchers are now extending our population ecology dataset to monitor the longer-term health of this population, both in terms of abundance trends and maintenance of genetic diversity. We are actively working with coastal communities to minimize threats

to the species, and working with tourism operators and managers to continue sustainable development, based on world-class ecotourism.

ACHIEVEMENTS IN 2022

- MMF researchers recorded **84 whale shark sightings** during surveys throughout our main study sites in the Inhambane Province
- Added **27 new individuals** to the database in Mozambique
- Published **3 new scientific papers** using our Mozambican whale shark database to contribute to global conservation of this endangered species, including a major new study on the risk of ship strikes

GOALS FOR 2023

- Publish an updated analysis of long-term population trend using our 15-year dataset

- In partnership with the Wildlife Conservation Society, we will begin a new project which investigates the impact of ocean noise on marine megafauna in the Mozambique Channel, including whale sharks
- In partnership with Conservation International and other collaborators, we will begin a new project which investigates how the movement and population trends of whale sharks and other marine megafauna are affected by ocean fronts in the Mozambique Channel
- Bilardo Nharreluga, MMF's research manager in Mozambique, will begin a PhD on the potential impacts of climate change on whale sharks
- In partnership with MSc candidates at University of Plymouth and the Ocean Giants Program, we will categorize and analyse the scarring on whale sharks as a conservation tool to assess boat strikes and fishing impacts



BULL SHARK RESEARCH PROGRESS



PROJECT OVERVIEW

The bull shark (*Carcharhinus leucas*) is one of the most important predators in Mozambican coastal ecosystems. Physiological adaptations allow this species to live in marine, brackish and freshwater environments. As a large-bodied and mobile top predator, the bull shark plays a vital role in the functioning of the different aquatic ecosystems through which it moves. Estuaries, mangroves and rivers represent critical nursery habitats for bull sharks and females have shown strong philopatric behaviour, returning to their natal sites.

Recent studies in southern Mozambique have shown that bull sharks remain resident to marine reef systems, but can perform long distance return migrations of several hundred kilometres. Meanwhile, fisheries assessments have revealed that shark landings in Mozambique have increased by up to 220% in recent years. One of the most commonly landed species is the bull shark, comprising up to 17.3% of total shark catches in some areas. Motivated by the lack of knowledge surrounding bull shark movements and

habitat use in Mozambican waters, MMF began focused studies on this species in 2019, with a view to providing information for the adequate management and protection of this apex predator.

PREVIOUS PROGRESS

In 2019 Lukas Mueller supported by senior MMF researchers and a team of international collaborators officially launched MMF's bull shark research project, primarily focusing on movements in the Bazaruto Seascape and surrounding areas. The aim was to provide key stakeholders with actionable insights into fine-scale habitat use and residency patterns of the species, as well as identification of critical habitats and provide further insight into broad-scale population dynamics, transboundary migrations and potential linkage between Marine Protected Areas along the east African coast.

Telemetry (tagging) methods are the primary tool we are using to investigate bull shark movements in southern Mozambique and beyond. In 2019, we began the installation of an acoustic array

across the Bazaruto Seascape, which has grown each year. These receivers record the signal from tagged bull sharks, as well as other species tagged by collaborators along the southern African coast. We successfully deployed tags, both satellite and acoustic in 2019, 2020 and 2021.

ACHIEVEMENTS IN 2022

- We recorded **62** bull shark sightings at our major study sites in the Bazaruto Seascape
- Collected **1 tissue sample** for genetic analysis
- Recovered, downloaded and re-deployed all acoustic receiver stations throughout the province in May and October to support our ongoing acoustic telemetry studies
- Deployed **3 additional acoustic receivers** in the Inhambane Province, from the Bazaruto Archipelago to Zavora expanding our array
- We acoustically tagged **1** bull shark with a **V16 long-term acoustic tag** in the Vilanculos Coastal Wildlife Sanctuary, taking our total number of tagged bull sharks to **17**

FINDINGS

Since 2019, **17** internal acoustic tags have been deployed on bull sharks in the Bazaruto Archipelago and San Sebastian region. Interestingly, all but one of the tagged individuals to date were female, indicating that this region may be an important aggregation site for female sharks, possibility linked to reproduction. Data logged on our acoustic receivers shows a high residency index for these female sharks.

GOALS FOR 2023

- We will tag an additional **3** bull sharks with **acoustic tags** for ongoing studies
- We will deploy an additional **21 acoustic receivers** to expand our array throughout the Inhambane Province
- We will sequence our growing environmental DNA (**eDNA**) library for bull shark DNA to investigate distribution
- We intend to submit our first scientific paper to a peer-reviewed scientific journal



WEDGEFISH RESEARCH PROGRESS



PROJECT OVERVIEW

Rhino rays, which include the guitar and wedgefishes, were recently identified as the world's most threatened marine fishes, with populations experiencing declines on a global scale. Low reproductive rates hinder population recovery and exacerbate their extinction risk, whilst the high value of their fins and meat drives excessive, unregulated fishing throughout their range. To make matters worse, a paucity of focused research or general scientific knowledge hinders the development of effective conservation strategies for these animals.

The listing of 15 rhino ray species as Critically Endangered by the IUCN in 2019 sparked a global call for rapidly acquired research to better understand this lesser-studied group, specifically to inform effective conservation strategies and prevent further decline. Biological and ecological knowledge of these rays is currently lacking and consequently few management plans exist to protect declining populations worldwide.

The Inhambane Province is a critically important habitat for rhino rays in Africa, with at least three

species of identified wedgefish, including the bowmouth guitarfish – *Rhina ancylostoma*; the bottlenose wedgefish - *Rhynchobatus australiae*; the white-spotted wedgefish – *R. djiddensis*. Other documented, but undescribed, wedgefish species and one species of guitarfish (grey-spotted guitarfish - *Acroteriobatus leucospilus*) inhabit coastal waters as well. Fishing pressure in the form of gill netting, long lining and targeted poaching has increased substantially in the past decade, presenting a major threat to these already vulnerable species. To date, there has been almost no direct research conducted on this group in southern Mozambique, thus their distribution, habitat preference, movements and baseline numbers remain unknown.

Additional information is urgently required to build the necessary knowledge base that will guide the effective conservation of these vulnerable rays. MMF's rhino ray program has been designed to rapidly collect high-priority information on guitarfish and wedgefish in southern Mozambique and develop a science-based conservation strategy for them in a region fraught with anthropogenic threats.

PREVIOUS PROGRESS

MMF has built on long-term sightings data and photographic records of wedgefish from diver surveys over the past decade, and kick-started a wedgefish research program in 2020. Through exploratory diving and the use of remote cameras, we have identified a number of wedgefish aggregation sites spanning from the Bazaruto Seascape to Zavora, including potential nursery areas.

Our researchers have been documenting the diversity and abundance of wedgefish and taking identification photos to try and validate the use of photo-ID techniques on these species. Detailed photographic work will assist our researchers as they help to clarify the complex taxonomy of this group. To support this work, our researchers have also been opportunistically collecting tissue samples to build a sample library for future taxonomic work and genetics studies. The early phases of this program have produced promising results and our team has recently secured funding for acoustic and satellite tagging studies to better understand the movements and habitat use of these enigmatic rays.

ACHIEVEMENTS IN 2022

- Recorded sightings of **57** wedgefish on survey dives throughout the province
- Added **21 photographic ID records** into a photo ID catalogue for *R. australiae* bringing the total number of identified individuals to **85 individuals**
- We collected **11** tissue samples adding them to our library for genetics studies, focusing on taxonomy and population genetics
- We tagged **2** bottlenose wedgefish with **internal acoustic tags** and **1** bowmouth guitarfish
- We compiled new records of historical landings and observational sightings
- Secured funding** from Shark Conservation Fund for a 3-year project on wedgefish in the Vilanculos Coastal Wildlife Sanctuary

FINDINGS

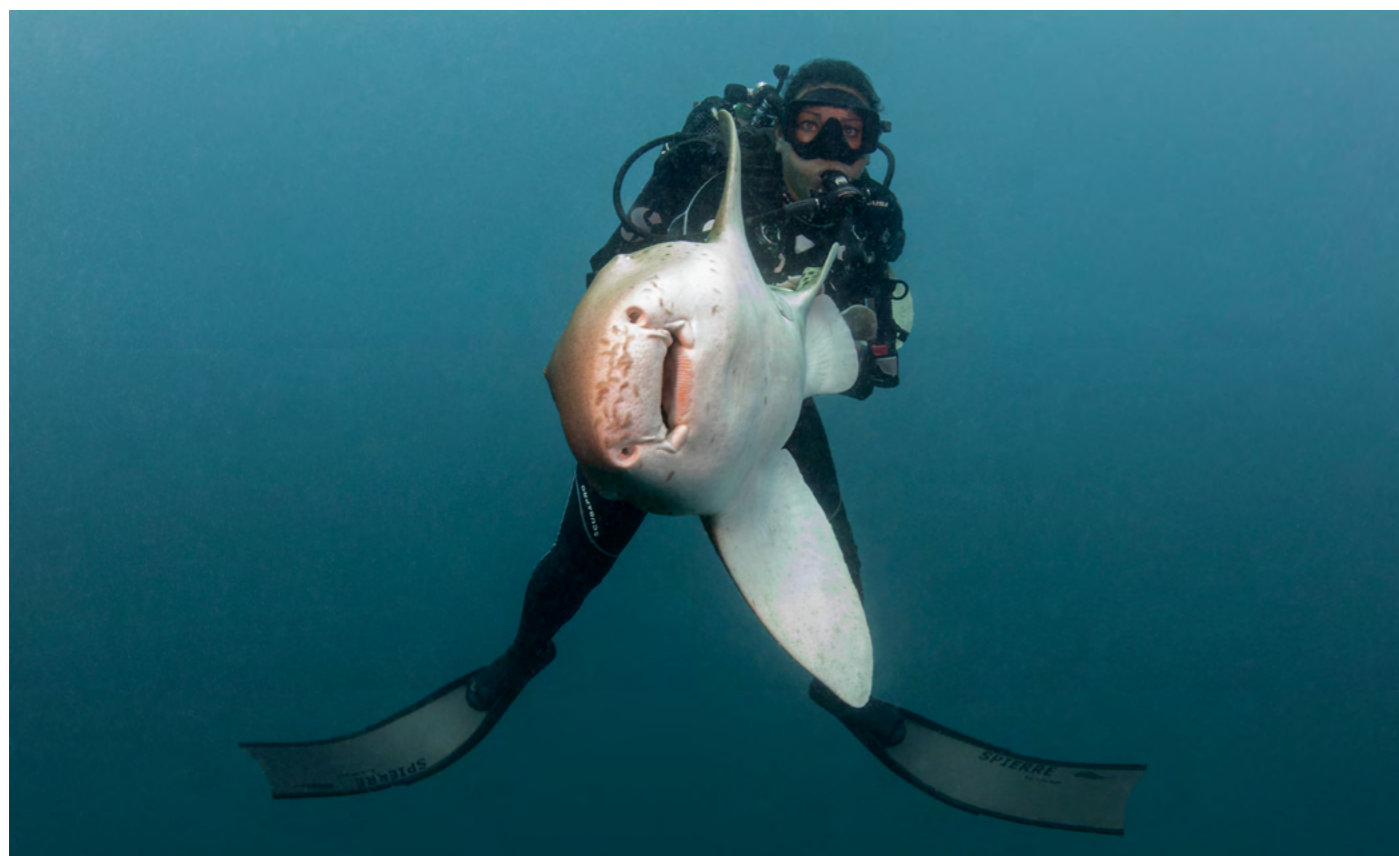
We believe we have now confirmed the presence of four distinct species of wedgefish in the coastal waters of the Inhambane Province. Their distributions vary and will be the focus of an upcoming paper-our first on wedgefish in the country. We continue to make progress on developing a photo ID database for the bottlenose wedgefish, which are the most commonly encountered species in the Bazaruto Seascape. The biggest win for our team this year was tagging a bowmouth guitarfish internally using a new less invasive capture method underwater that enabled us to bring the individual up to the boat for tagging.



GOALS FOR 2023

- We will continue to collect high quality identification photos from sightings for our Mozambican wedgefish photo-ID database
- We aim to acoustically tag an additional **15** wedgefish to investigate movements, habitat use and site fidelity and expand our array along the coast with 15 more acoustic receivers
- Analyse miniPAT data and deploy **2 additional satellite tags**
- We will continue to collect tissue samples to add to our growing genetic library to conduct future taxonomic and population genetics assessments
- Submit our first peer-reviewed scientific paper introducing our work on wedgefish in the region

LEOPARD SHARK RESEARCH PROGRESS



PROJECT OVERVIEW

Leopard sharks (*Stegostoma tigrinum*), also known as zebra sharks, are found in inshore waters of the Indian and western Pacific Oceans. In 2016 the species was listed as Endangered on the IUCN Red List, as they are heavily fished throughout most of their range. Extensive fishing pressure, coupled with low reproductive rates, has led to steep population declines, with the Indian Ocean-Southeast Asian sub-population suspected to have declined by at least 50% over the last 3 generations (51 years). Given their narrow habitat range, potential for limited dispersal and strong site fidelity, targeted and unsustainable fishing methods could lead to the rapid removal of individuals and local population extinctions. So far, studies focusing on leopard sharks have mostly been restricted to Australia and Thailand. The Indian Ocean, in particular the eastern coast of Africa, has been highlighted as a data deficient area. Knowledge of the distribution and population status of leopard sharks in the this region is vital to understanding the scale of

governance required for effective management of remaining populations. Leopard sharks are commonly seen in southern Mozambique with several aggregation sites noted along the Inhambane coastline. Inshore reefs in this region appear to be important habitats for this bottom-dwelling shark but focused research is needed to understand more about local populations and their most significant threats in the area.

PREVIOUS PROGRESS

The distinctive spot patterns that give leopard sharks their common name can be used to identify unique individuals and track them over time. MMF researchers have been recording leopard shark sightings and collecting photo-ID data during survey dives since 2010. In 2018, MMF completed the first focused study on leopard sharks in southern Africa, which described population demographics, distribution and site fidelity of leopard sharks in the waters surrounding Tofo.

This research identified the reefs around Tofo as critical habitat for this species, but suggests that this

could be a transient population with a larger home range. Our researchers have recorded leopard sharks at dive sites in each of our major research locations in the Inhambane Province, from Zavora to the BANP, providing an excellent opportunity to expand our studies and build an extensive database covering the entire province. The next step is to further investigate the spatial ecology of leopard sharks using telemetry techniques and evaluate connectivity along the coastline through population genetic/genomics studies.

ACHIEVEMENTS IN 2022

- We recorded **37 leopard shark sightings** during surveys across our major study sites in the Inhambane Province
- We deployed **4 acoustic tags** internally on leopard sharks off San Sebastian and in Morrungulo
- We collected **4 additional tissue samples** for our genetic library
- We developed a new less invasive technique to catch and bring to the surface leopard

sharks from the reef for tagging which will limit injury and stress to animals being worked up by our researchers.

GOALS FOR 2023

- We will continue collecting identification photos for our long-term photo-ID catalogue
- We plan to look for new accessible aggregation sites for leopard sharks in the Bazaruto Archipelago National Park, Pomene and Zavora using diver surveys and remote cameras
- We plan to collect more tissue samples from leopard sharks throughout the province for on-going genetic studies
- We plan to tag an additional **10 leopard sharks with acoustic tags**
- We plan to deploy additional acoustic receivers to support our tagging at leopard shark aggregation sites
- Funding dependant, we may attempt to satellite tag our first leopard sharks



SMALLEYE STINGRAY RESEARCH PROGRESS



PROJECT OVERVIEW

In 2008 MMF researchers made a landmark discovery - a large, seemingly stable population of the elusive small-eye stingray, *Megatrygon microps*, living off the coast of southern Mozambique. The discovery represented a range extension for the species of over 5000 km from the Maldives - its most westerly known location in the Indian Ocean. While initial distribution records suggest this species is wide spread in the Indian Ocean, sightings of this enormous stingray are infrequent, suggesting it is rare and perhaps patchily distributed. Despite being the largest known marine stingray on record, little is known about the biology or ecology of this species and it is currently listed as Data Deficient on the IUCN's Red List of Threatened Species. Regular sightings on inshore reefs in southern Mozambique have confirmed this area is not only a critical habitat for the species but suggests it may be the first reliable area to study this species in the wild. Unfortunately, a marked increase in the use of indiscriminate fishing practices along this coast, such as gill

netting, long-lining and seine netting, now presents a looming threat for the species. Targeted fishing of small-eye stingrays also occurs in the country. To exacerbate the problem, their large size, presumed late age of maturity and production of a single pup per litter, all but guarantees their susceptibility to over-exploitation. Considerable research on this species is warranted to help immediately address the paucity of available data and to address conservation concerns.

PREVIOUS PROGRESS

MMF has launched a focused research project on small-eye stingrays in southern Mozambique. To date we have identified over a dozen reefs in the province that boast high sighting rates of this rare marine stingray. Interestingly, many of these locations are cleaning stations for manta rays and other marine megafauna species like sea turtles. Through sustained monitoring efforts our team has now identified almost 100 individual rays in the region - the largest and most comprehensive database of its kind in the world.

In 2019, we published the first study examining the longevity of dorsal spot patterning and feasibility of using photo identification techniques for long-term monitoring. We recently co-authored another paper showing how these enormous rays, like mantas, can be tracked using automated matching algorithms. Our preliminary data show that these semi-pelagic rays show fidelity to certain reefs and may regularly use these sites to be cleaned or to interact with other individuals. Despite their size and functional tail spine, these rays are easy to approach and we have run feasibility tests for sampling and tagging free-swimming individuals. Our team has also documented several heavily pregnant females in the region, suggesting that small-eyes may give birth along this coastline and that nursery habitats may be accessible.

ACHIEVEMENTS IN 2022

- We recorded **20** small-eye stingray sightings during surveys across our major study sites in the Inhambane Province
- We collected **2** additional tissue samples from individuals as we begin building our genetic library for the species

- We began analysing the initial tracks from our tagged rays after successfully recovering some tags
- In total we tagged **7** individuals with external acoustic tags
- **1** of these was 'double tagged' with miniPAT satellite tag

GOALS FOR 2023

- We aim to externally tag **4** additional small-eye stingrays with acoustic tags
- We aim to tag **2** additional individuals with miniPAT satellite tags
- We will work with WildMe to add small-eye stingrays to the Wildbook for rays, so that we can upload and manage our photo-ID dataset through this online platform and encourage citizen science submissions
- We will continue to collect tissue samples from individuals for genetic analysis
- We will expand our reach in the province to include the Morrungulo area, where we will increase survey effort in 2023



MARLIN RESEARCH PROGRESS



PROJECT OVERVIEW

Billfishes are heavily exploited in the western Indian Ocean. The Indian Ocean Tuna Commission flagged in 2017 that both black and striped marlin are seriously overfished, with management action required. Knowledge of regional population structure and movements of billfishes are currently lacking, hindering the development of effective management and conservation plans.

MMF work in Kenya on a project that has focused on satellite-tagging black marlin (*Istiompax indica*) and striped marlin (*Kajikia audax*). While these eastern African billfishes move large distances in just a few months (exceeding >9,000 km), they typically move north- and eastward from East Africa. Only one of our 98 deployed satellite tags has popped up south of Kenya, in Mozambican waters. This suggests a degree of isolation between these two regions.

The Bazaruto Seascape in the Inhambane Province is one of the few areas in the world where large adult (>450 kg) black marlin are

caught. There is a high probability that this region is a spawning area. If so, it would represent the only one identified thus far in the Indian Ocean.

PROPOSED WORK IN MOZAMBIQUE

Given the potential importance of the Bazaruto Seascape as a spawning area for black marlin, unsustainable exploitation in commercial fisheries, and a poor understanding of regional stock structure, we view work in this region of southern Mozambique as a critical expansion of our current studies in East Africa and our collaborative work in the Indian Ocean basin.

The broad goals of this project are to clarify the population structure of billfish species in the Bazaruto region, investigate the biology of black marlin, in particular, and to determine the connectivity and stock structure of all marlin species within the Indian Ocean.

As a response to emerging evidence of unsustainable exploitation, coupled with a lack of data on the ecology of these species, we propose to continue a collaborative approach

to the study of billfish using the expertise of the game fishing community in East Africa.

OUR APPROACH

The best approach for investigating regional connectivity of marlin populations is to combine detailed short-term studies, using pop-up archival satellite tags, with medium-term biochemical and ecological studies (stable isotope and fatty acid analyses) and long-term work through genetic, and potentially genomic research.

Immediately we hope to clarify if and how marlin populations are connected along the eastern coast of Africa, identify important spawning habitats, and evaluate areas of overlap with fisheries to guide the management response to the present state of overfishing in this region.

ACHIEVEMENTS IN 2022

- We officially **launched our Marlin Project** in the Bazaruto Seascape this October
- We collected **21 tissue samples** from

individuals as we begin building our genetic library for the species in Mozambique

- We successfully tagged the first marlin in the Bazaruto Seascape in November with **2 miniPAT satellite tags** placed on 400 and 500 lb black marlin

GOALS FOR 2023

- Secure funding for additional **3 miniPAT tags**
- Deploy an additional **9 miniPAT tags** in partnership with FLOPPED international billfish tagging programme
- Collect additional genetics samples for global analysis to determine connectivity between stocks
- Begin running **larval tows** to help confirm spawning grounds in the Bazaruto Seascape region of Inhambane
- Carry out gonad assessments when possible to help confirm spawning grounds in the Bazaruto Seascape



ELASMOBRANCH CENSUS RESEARCH PROGRESS



PROJECT OVERVIEW

Globally, one third of all shark and ray species are considered threatened with extinction as a result of overfishing. Moreover, a recent worldwide study, which MMF scientists contributed to, surveyed 371 reefs across 58 countries to assess shark abundance. Sharks were not observed on almost 20% of surveyed reefs, indicating a widespread decline that has gone undocumented on this scale until now. The Inhambane Province is recognised as an area of outstanding shark and ray diversity, supporting numerous species of ecologically important elasmobranchs, largely due to MMF's long-running research programs in the region. At this stage, however, basic census information, including abundance, diversity and seasonality, are lacking. Unfortunately, many of these species are caught in artisanal and commercial fisheries throughout the province, particularly as by-catch in non-selective fishing methods such as gill-nets. This poses a primary threat to elasmobranch populations in southern Mozambique, but also to the overall health of marine ecosystems. Effective

management and protection requires baseline data informing species diversity and abundance and identifying areas of critical habitat and aggregation sites. However, for mobile, rare or elusive species this information can be difficult and time consuming to collect through diver surveys alone. Therefore, MMF researchers are integrating emerging and innovative research techniques into their regime to rapidly gather much-needed census information for sharks and rays throughout the Inhambane Province. This includes the use of baited remote underwater video (BRUV) systems, remote cameras and environmental DNA (eDNA) in addition to in-water and aerial surveys.

PREVIOUS PROGRESS

MMF scientists have collected over a decade of elasmobranch sightings data during survey dives (up to 20 years in some regions). These data have enabled estimates of abundance and trends over time, and identified a number of key aggregation sites and important habitats for our main focal species (manta rays and

whale sharks). At the same time, our researchers collected abundance data on other shark and ray species encountered on survey dives. In 2016, MMF scientists successfully conducted over 200 BRUV deployments, which contributed to the global shark census known as Global Finprint. Our research team have also been refining the use of remote (unbaited) camera traps to collect video data in the absence of divers and have begun the collection of seawater samples in the Bazaruto Seascape to be used in eDNA analysis.

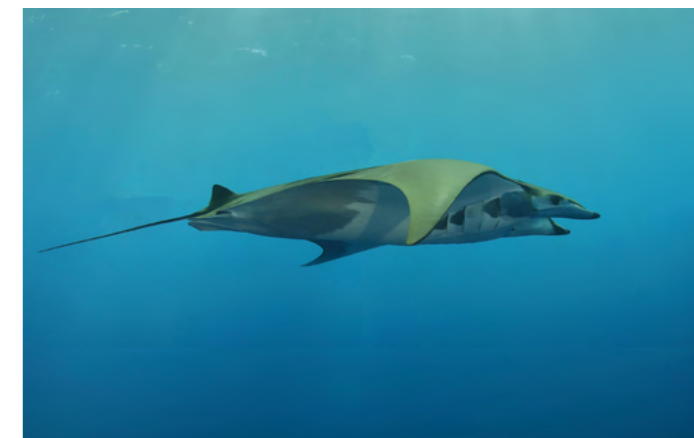
ACHIEVEMENTS IN 2022

- We conducted **611** observational in-water surveys (SCUBA and freediving) throughout the province, recording sightings of **31** different shark and ray species
- We collected **32** eDNA samples from **13 sites** around the Bazaruto Seascape
- We deployed over **10** unbaited camera traps at sites in the Bazaruto Seascape and **26** additional baited cameras (BRUVs) on in Tofo, Barra, Praia de Rocha, Morrungulo and Zavora
- We conducted opportunistic surveys at fisheries landing sites to document species landed in fisheries and collect specimens for genetic and taxonomic studies
- We collected **33 tissue samples** from **10 different species** of free-swimming sharks and rays to add to our elasmobranch genetic sample collection
- We documented **4** new elasmobranchs, not currently in our records, along the coastline of Inhambane
- After registering two rare sightings of an ornate eagle ray in the Bazaruto Seascape, we published a peer-reviewed note to record the first encounters of this species in the country.

GOALS FOR 2023

- We will deploy BRUVs and un-baited remote cameras at key study sites throughout the Inhambane Province

- Collect another **~50** eDNA samples throughout the Bazaruto Seascape
- Deploy remote cameras to observe the cleaning of sharks and rays at major aggregation sites
- We aim to continue opportunistic fisheries surveys and the collection of tissue samples to



CAPACITY BUILDING, ENGAGEMENT & PRESENTATIONS



A crucial part of MMF's research program is to build capacity by training Mozambican scientists in fieldwork skills, data collection and management, scientific writing and communication. We especially aim to provide opportunities to early career researchers to gain practical field experience, including boat-based and in-water data collection. We also strive to get them ready to present work at scientific conferences and publish findings in peer-review scientific journals.

We also engage with protected area managers, stakeholders, local and national government authorities to communicate our research findings and work with authorities to translate these findings into effective conservation management strategies.

ACHIEVEMENTS IN 2022

- We **matriculated 1 MMF research fellow** and welcomed a new fellow into our program
- We **trained 3 Mozambican MMF scientists to SCUBA dive**, then mentored

them in underwater research methods including underwater photography and reef surveys

- We **trained 1 scientist** from the Mozambican Institute of Oceanography (InOM, formally IIP) **to SCUBA dive**
- **2** MMF staff members attended the Western Indian Ocean Marine Science Association (**WIOMSA**) **conference** in South Africa in October and Nakia Cullain presented at the Sharks International conference in Spain
- MMF **co-hosted the Dugong Special Session symposium** at the WIOMSA conference and Mozambican project coordinator **Abdul Mugabe presented** about our dugong and seagrass work in Inhassoro
- We trained **14** Ocean Ambassadors in Barra in catch monitoring and **78** CCP members and fishers

- **6** members of our research team, including 4 Mozambican staff members, **presented on 20 years of MMF research** to government representatives from Institute of Oceanography, the Department of Tourism, and the Department of Science and Technology in Maputo in November
- Our research coordinator, Bilardo Nharreluga and team, **attended 29 additional meetings** with government and civil society organizations, **2** of which were hosted by MMF

GOALS FOR 2023

- **Train 3 additional MMF scientists** to SCUBA dive and mentor them in research
- **Train 3 MMF Mozambican scientists** on internal tagging methodology
- **Train 2 MMF staff** to be 'Ocean Safari' data collectors
- **Train 1 new InOM scientist** to dive
- Start a new collaboration with **Eduardo Mondlane University**, and develop a field trip program for their students



2022 SCIENTIFIC PUBLICATIONS

Improving sightings-derived residency estimation for whale shark aggregations: A novel metric applied to a global data set. Araujo G, Agustines A, Bach SS, et al. *Frontiers in Marine Science*.

Global collision-risk hotspots of marine traffic and the world's largest fish, the whale shark. Womersley FC, Humphries NE, Queiroz N, et al. *Proceedings of the National Academy of Sciences*.

Evidence of Závora Bay as a critical site for reef manta rays, *Mobula alfredi*, in southern Mozambique. Carpenter M, Cullain N, Venables SK, Tibiriçá Y, Griffiths C, Marshall AD. *Journal of Fish Biology*.

First records of the ornate eagle ray *Aetomylaeus vespertilio* from the Inhambane Province, Mozambique. Venables SK, Conradie J, Marshall AD. *Journal of the Marine Biological Association of the United Kingdom*

Fatty acid profiles of more than 470 marine species from the Southern Hemisphere. Nichols PD, Pethybridge HR, Zhang B, et al. *Ecology*.



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