

OCEAN GIANTS



**MARINE
MEGAFUNA
FOUNDATION**

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OF BAZARUTO**

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MALDIVES

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This is not your usual Maldives dive liveboard! It's a true Marine Megafauna trip to the hottest new dive destination on the planet. We'll be exploring the Deep South of the Maldives to search for oceanic manta rays, giant adult whale sharks, and other large sharks.

We'll be exploring in comfort, too – diving from the spacious and contemporary liveboard vessel Serenity, part of the award-winning Emperor Fleet.

Your hosts will be the MMF founders, 'Queen of Mantas' Dr. Andrea Marshall and world-renowned whale shark biologist Dr. Simon Pierce, along with Senior Scientist and manta expert, Dr. Elitza Germanov.

LEARN MORE



marinemegafauna.org/trips

OUR OCEAN. OUR FUTURE.

SAVING OCEAN GIANTS FROM EXTINCTION.

Our mission is to save threatened marine life using pioneering research, education, and sustainable conservation solutions. Our objective is a world where marine life and humans thrive together.



**MARINE
MEGAFUNA
FOUNDATION**



COVER

Janneman Conradie filming tagged bull shark.
Photo by Uli Kunz www.uli-kunz.com

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PHOTOGRAPHY

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WELCOME BACK TO OCEAN GIANTS!

I enjoyed fantastic, detailed, inspirational conversations with five scientists to create the features for this Autumn issue.

I'm grateful for the opportunity to share their thoughts, passion, and stories from their projects, and to delve deeper into what motivates these marine conservationists and researchers.

There was also a lot of great material that I couldn't fit into these articles, so I've added these video interviews to 'The Constellation', our new MMF membership program. We're super excited about that – check it out across the page!

The features in this issue have been greatly enhanced by the contributions of several professional photographers. All of these images required a lot of time, expense, and expertise from the photographers to obtain, and we hugely appreciate being able to use them. We've added a page (overleaf) so that you can learn more about these world-class conservation photographers.

It's been a lot of fun putting this issue together. I really hope you enjoy reading it!

DR. SIMON PIERCE

Co-founder, Principal Scientist

NEW!



BECOME AN MMF MEMBER

HELP SAVE OUR OCEAN GIANTS

The Constellation is our **NEW** MMF member community of ocean lovers, just like you, investing in the recovery of endangered marine wildlife. Includes exclusive members-only content.

LEARN MORE



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If you want to help our oceans, now is the time. Join us in saving Earth's most iconic marine wildlife.

DR. ANDREA MARSHALL

Co-founder, Marine Megafauna Foundation

Conservation



BROOKE PYKE

is a photographer and dive instructor. She worked with Elitza to research and photograph manta rays in Indonesia.



@brookepykephotography



oceanicbrooke.com



HENLEY SPIERS

is an underwater photographer and trip leader. He hosts trips to the Eastern Pacific to seek out hunting striped marlin, as seen in Chris's interview.



@henleyspiersphoto



bio.site/HenleySpiers



JULIA BAHLSEN

is a photographer and filmmaker. She worked in the Eastern Pacific to capture some of the striped marlin photographs used in Chris's interview.



@julesintheblue



juliabahlsten.com

WE ARE HUGEY GRATEFUL TO THESE TALENTED PHOTOGRAPHERS

that have allowed us to use their beautiful images
to showcase the ocean wildlife and work that
we've featured in this issue of Ocean Giants.



SIMONE CAPRODOSSI

is an underwater photographer
and co-owner of Sundive dive center.
He works with David on leopard
sharks in Byron Bay.



@scaprodossi



sundive.com.au



ULI KUNZ

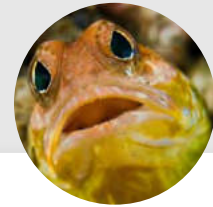
is a scientific diver, photographer and
speaker. He worked with Lukas to
showcase his bull shark work.



@uli_kunz



uli-kunz.com



WARREN BAVERSTOCK

is a marine biologist, conservationist
and underwater photographer. He
worked with David on leopard
sharks in Dubai.



@warrenbaverstock

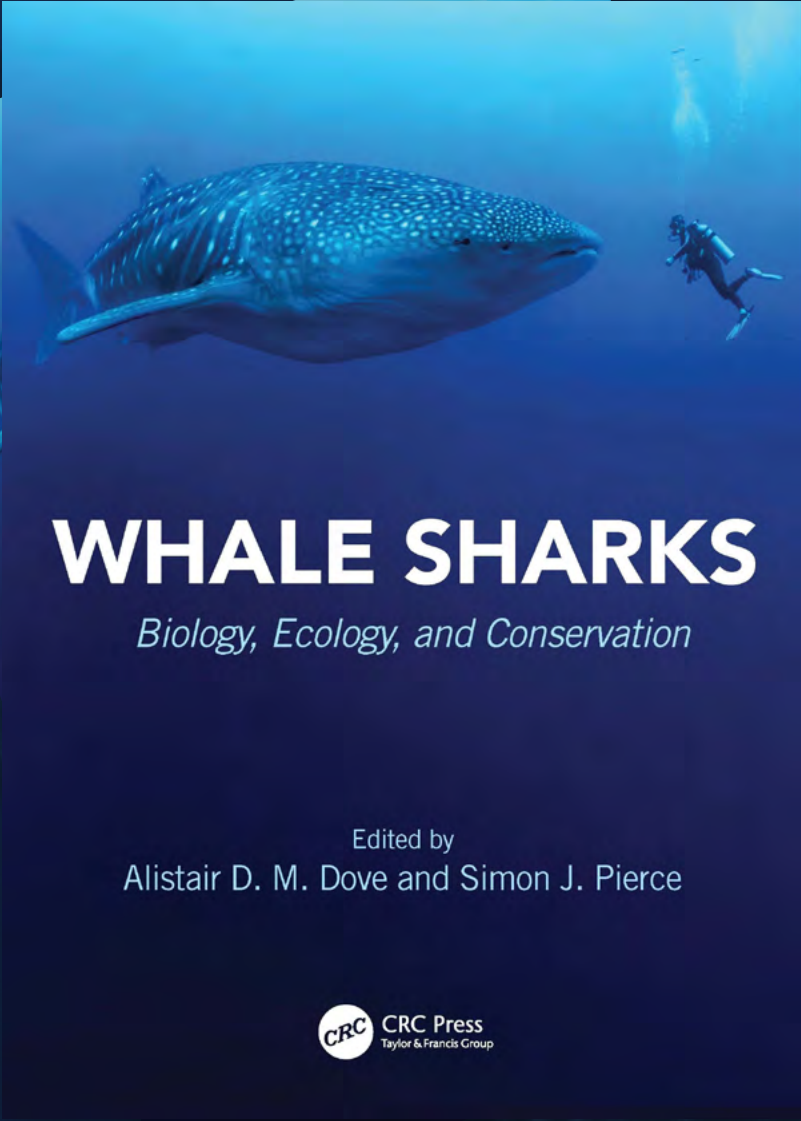


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OUT AUGUST 2021

WHALE SHARKS

Biology



SHARKS

ogy, Ecology, and Conservation

The first scientific textbook on whale sharks, co-edited by MMF Co-founder and Principal Scientist Dr. Simon Pierce, will be published in late August 2021.

Whale sharks, the largest fish that have ever lived, have long captured the interest of scientists and the imagination of the public. This book brings together the world's leading experts on whale sharks to uncover the lives of these awesome ocean wanderers.



[LEARN MORE](#)

UPDATES

Jessica Pate
has been assisting
teachers in Florida
schools with manta
ray lesson plans.



Mozambique is a
global hotspot for
endangered zebra
(leopard) sharks.





The Bazaruto team has launched their new research **"dream machine"**.



FOLLOW OUR CONSERVATION WORK

Emerson Neves was honored as a Disney Conservation Hero for his work in Mozambique.



Marine Megafauna



Marine Megafauna



Marine Megafauna Foundation SE Asia



MMF Americas



SHARKS IN THE PARK

Bulls of Bazaruto



In conversation with
LUKAS MUELLER



“

*in conversation with***LUKAS MUELLER GREW UP
IN A SMALL INLAND COAL-
MINING TOWN IN GERMANY,**

but developed a love of freediving and joined The Watermen Project, where he used his breath-hold skills to work with large predatory sharks. He is now a PhD candidate at Wageningen University in the Netherlands and the project leader of MMF's bull shark research program in Mozambique. Lukas has recently been working in the field, so I talked to him while he was in home self-isolation following his return to Germany.

- Simon Pierce

HOW DID THE PROJECT BEGIN?

I was fortunate to meet Dr. Andrea Marshall in Indonesia while she was doing research. We joined her to work on a virtual reality film about manta rays. We kept in touch afterwards, and in 2018 she asked if I'd like to join in on some bull shark research in Mozambique. I packed my bags and was in Mozambique a couple of weeks later!

That was my first introduction to the Bazaruto Seascape. It's like two worlds intertwined: a huge lagoon-like habitat, crisscrossed by sandbanks, that extends from the coast to the outer islands, and an oceanic ecosystem offshore. Three major islands form the Bazaruto Archipelago, and they act as a barrier to separate this lagoon system from the open ocean. Tidal movement creates a cyclical system of water exchange, pushing ocean water into the lagoon, then pulling the warm water across the offshore reefs on the outgoing tide.

That regular movement of nutrients and animals between the habitats makes the whole area super productive, but the dynamics are complicated. Andrea has been diving around Bazaruto since 2006, so she already had a sighting and photo-identification dataset for bull sharks from her research dives. She and Janneman Conradie know the area really well, so they had a good idea of where and when the bull sharks were most likely to be seen in different conditions. If I'd been working by myself as a PhD student, I'd have had no chance.

(previous) Bull shark tagging
Photo by Uli Kunz

Bazaruto Seascape
Photo by Andrea Marshall

Bull shark in Mozambique
Photo by Andrea Marshall



Dr. Ryan Daly tagging a bull shark
Photo by Uli Kunz





SCIENCE WITH BITE

I'd worked with bull sharks before, in places like the Bahamas, Florida, and Mexico, but the behavior of the sharks in Mozambique is very different to that I'd seen elsewhere. I'm used to them being confident and inquisitive. In Mozambique, they're extremely shy, unless there's action in the water; spearfishing, for instance. In that situation, they might give you a full charge, in bad visibility. I'd been planning to place tags on them while I was freediving, but that situation didn't make 35–40 m dives too inviting.

Free-tagging the sharks was not the only option, though. There are various methods available, such as using a pole to tag the shark near the surface, or catching the shark to implant a tag, or attaching a tag to the fin using a clamp or harness. Working through the options, we realized that catching the sharks would be best, but most of MMFs previous research work has used non-invasive in-water techniques. We decided to ask for help.

Fortunately, there's a whole crew of amazing shark scientists and fishermen working in the south of Mozambique, at Ponta do Ouro, that have experience with bull shark research in similar conditions. That's kicked off a big adventure over the past two years through collaboration with Dr. Ryan Daly and his team. Ryan had tagged over 100 bull sharks already, some of which swam all the way up the coast to Bazaruto, so it was great to be able to combine the tagging experience of the Ponta do Ouro team with Andrea and Janneman's knowledge of the Bazaruto Seascape.

When we tag these animals we think first about the shark's welfare, but we have to consider our own welfare too. These sharks, they're big, they're powerful, they're several hundred kilograms of apex predator. And we're working off an inflatable boat! There's a unique focus when you work with an animal like that. We use a 2 cm-thick protective belt over the pontoons. Once the shark is hooked, we get it to the boat as fast as possible, then we flip it onto its back in the water so it goes into a trance-like state known as tonic immobility. While that's going on, there's a person whose only job is to manage the line coming into the boat, making sure that no feet, toes, hands, or legs get wrapped; otherwise, if the shark decides to make another last run, you're going with it. Once the shark is next to the boat, the shark will try to bite and kick its tail. We've been hit by tails a couple of times now, and the bruises last for weeks. These sharks will absolutely batter you.

Once the shark is secure, we use a sterile surgical kit to make a small incision into the shark's body cavity, then insert one of our acoustic tags. We've set these tags to transmit an ultrasonic ping for the next 10 years. Then, we also attach a small satellite tag in the dorsal fin with some surgical tubing. None of this leads to any long-term harm or consequences for the shark. Over the 100+ sharks that Ryan has tagged, they've never had any mortalities or evidence of damage, and they still regularly see those sharks while diving now, 4–5 years after the start of their project. All of our sharks have been doing well too – we've been receiving lots of pings!

BULL SHARKS IN BAZARUTO

We can detect the tagged sharks by deploying bottle-sized acoustic receivers, we call them 'listening stations', on reefs within and around the Bazaruto Seascape. Andrea pulled up the stations for download while I was stuck in lockdown here in Germany, and it's given us some great insights into what the sharks are up to. These bull sharks are highly resident. Extremely resident in some cases. One shark, tagged over 18 months ago, has been detected at one specific reef almost every day since. The Seascape area is a key habitat for these bull sharks.

'Our' sharks, though, weren't the only ones that we recorded. We also received pings from some of the bull sharks that Ryan had tagged down in Ponta do Ouro. We're continuing to expand our receiver array, so it's going to be really interesting to see how much connectivity there is between the sharks in Bazaruto, Ponta do Ouro, and South Africa. It's becoming evident that the sharks are sometimes traveling thousands of kilometers along this coast.

All of the bull sharks that we've captured in Bazaruto have been adult females but, down in Ponta do Ouro, Ryan sees a 50/50 split between females and males. Further south again, in South Africa, the bull sharks are mostly males. It might be that the females are staying up here, around these protected reefs where they have plenty to eat, while the males are migrating over large distances. Ryan is looking into that using his larger dataset. But it shows that it's often not as simple as 'migratory' and 'resident' animals, as there can be quite complex movement patterns going on within a species.

It's very encouraging for us to see that some of the hotspots for the sharks, especially these adult females, are inside protected areas within the Bazaruto Seascape. They're more exposed when they leave this area, which speaks to the need for a network of protected reef systems and a joint conservation strategy between Mozambique and South Africa. Obviously, it's unrealistic for us to try to protect this whole coastline and, anyway, sustainable fishing is a vital



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One shark, tagged over 18 months ago, has been detected at one specific reef almost every day since. The Seascape area is a key habitat for these bull sharks.





(right) Mozambican reef
Photo by Andrea Marshall



(below) Bull shark with jacks
Photo by Andrea Marshall

source of livelihoods and food. Bull sharks are a critical part of this ecosystem though, they're the apex predator along this coast, and we can ensure that key reefs are well-maintained so that these migratory individuals can stop and replenish on long journeys. It's not just the bull sharks, it's also the manta rays, whale sharks, and a host of other species that are also migrating along this coast, so it's great that the work MMF is doing is helping to create this cohesive plan.

This is an amazing project to be a part of. We've done all this exploration, been bashed up by sharks, and dedicated so much time and funding towards this work; it's really difficult at times. We've all been working so hard to get this information. And then, we download that first acoustic receiver station and see the data, and wow, it's insane. And knowing that we're going to keep getting more data over the next 10 years, a light bulb goes on in my brain because, holy moly, this is a game-changer. If we can tag 20–25 animals like this, the data that we're going to collect is going to tell us so much about the sharks, and how we can best protect this whole ecosystem.

CONSERVATION FLAGSHIPS

Andrea calls this area the 'Marine Serengeti'. That got me thinking, why did we first want to protect these amazing terrestrial ecosystems that are so famous and iconic now? Was it because of the termites and butterflies, which are very cool animals in themselves? No, it was because of the megafauna, it was the lions and the rhinos and all the other animals we read about as kids. And that's where the Marine Megafauna Foundation's strategy really resonates with me.

People are so often drawn towards the ocean by whales, sharks, sea turtles, and other charismatic animals. These big, well-known animals serve as an emotional hook that engages people. By protecting these species, and their habitats, we're also protecting so many other animals; even species we don't even know about yet. That's how I think about it. We see the most conservation success globally by harnessing the public appreciation for these flagship species to unlock broader-scale habitat protection. And that's what I see when I look around the MMF team where, through research and conservation work, we're protecting these endangered species and their habitats. That's why I'm so passionate about the work we're doing.

If you look at a global map of marine protected areas, less than 5% of the ocean is fully protected. And outside these areas, it's often a free-for-all. One experience that really changed me was joining Janneman on an expedition up to the north of Mozambique. It was shocking to see hundreds of kilometers of coastline being fished out, sand mines, and other resource extraction happening, destroying habitats as we watched. But we can protect marine habitats while supporting people, too. I used to do a lot of expeditions where you touched down near the harbor, you got on the research vessel, you went out for two weeks, you did your job, you came back with results, and you left again. In Mozambique, I've been living in the community, and I'm starting to understand the culture better. For people like me, that grew up far from the ocean, there's still this emotional connection that draws us to the coast, often some formative



Janneman filming a tagged bull shark
Photo by Uli Kunz



An aerial photograph of a coastal landscape. On the left, a deep blue ocean meets a sandy beach. The water is a vibrant turquoise color, with white foam from waves visible. To the right of the beach, a winding river or lagoon flows through a sandy area, creating a series of loops and curves. The water in the lagoon is a lighter, more yellowish-green color. The sky is a pale blue with some light clouds.

“

*I've got a chance here, this
once-in-a-lifetime shot to
help protect this amazing,
pristine habitat.*

Pristine Mozambican coastline

Photo by Uli Kunz

experience that connects us to these marine animals. Here in Mozambique, though, if the marine ecosystem is degraded, people are also losing the foundation of their livelihood. The ocean offers a whole range of resources, as well as food, that allows the manufacture of other products. It was all working okay, too, before foreign powers started using Mozambique as a pawn in their geopolitical games, and international fishing fleets from Europe and elsewhere came in to exploit the resources they'd wiped out in their own seas. If the fisheries here disappear or degrade because we've let these ecosystems die, that will have massive ramifications for everyone. It makes sense for everyone to protect some of these habitats so that the broader ecosystem can thrive. Our conservation team at MMF works through these issues with the fishers themselves, and their communities, which is why we have good conservation momentum in Mozambique, despite all the challenges.

As we improve protections, we need to put in place funding mechanisms to support the ecosystem rebuild too. The conservation space is so dramatically underfunded, but what's encouraging to me is the demand I see for doing trips with the MMF team around the world which, of course, is a big part of how we fund these programs. All of us, the people listening to or reading this, we have a special passion for these ocean animals and habitats. And whenever I see people pay for a natural experience, whether it's joining one of our expeditions or visiting a national park, that transaction shows they're taking their money, and they're using it to invest in protecting biodiversity.

And that goes for me too. People ask me, "Why don't you work in the Mediterranean? It's much closer to Germany. It's logistically easier. It's nice weather, you'll get great food." But the Mediterranean is dead. There are some areas where life is

coming back, sure, and it's certainly worth investing in those. But I've got a chance here, this once-in-a-lifetime shot to help protect this amazing, pristine habitat, the Inhambane coastline, the ocean analog to the Serengeti or Kruger National Park. Given the choice between that, or trying to rebuild a dead ecosystem in the Mediterranean, then I'll always choose Mozambique. If we don't prioritize places like this, we're going to lose a lot of critical habitats around the world that we can still save. Here, I can make a big difference right now.



Watch a sneak-peak of the conversation with Lukas!



The full 60 min conversation is available now in the Member's Area.

LEARN MORE



MICROPLASTICS *& Manta Rays*



In conversation with
**DR. ELITZA GERMANOV
& JANIS ARGESWARA**



HOW OCEAN PLASTIC AFFECTS MANTA RAYS



Lacking effective waste management, trash is left near waterways where it's washed away.



Huge amounts of plastic make their way down rivers (blue dots) and into the ocean.



Manta ray distribution (hatched) overlaps the world's highest ocean plastic concentrations (reds).



Plastic in the ocean is ingested by manta rays as they feed.



(previous)
 Mantas in plastic soup
 Photo by Brooke Pyke

How ocean plastic affects manta rays
 Infographic by Madeleine Pierce

“

in conversation with

DR. ELITZA (ELLIE) GERMANOV, A SENIOR SCIENTIST AT MMF, IS A WORLD EXPERT ON MANTA RAYS AND OCEAN POLLUTION.

She started the Microplastics and Megafauna project in Indonesia as part of her PhD work, which studied the impact of the smallest plastics on the largest marine animals.

JANIS ARGESWARA IS LEADING A PROJECT ON THE REPRODUCTIVE ECOLOGY OF MANTA RAYS. She joined MMF as a Research Assistant in 2018. I talked to them from their research base on Nusa Lembongan, off Bali's southeast coast.

- Simon Pierce

HOW DID THE PROJECT BEGIN?

EG: Manta research was developed here by our colleagues, Peter Bassett and Helen Mitchell, who had trained with MMF over in Mozambique. They moved to Lembongan in 2012 and started a great citizen science program focused on the mantas seen at the dive and snorkel sites over at Nusa Penida, a larger nearby island. I was working over in Komodo National Park, and we found that some manta rays were swimming the ~450 km between these two Marine Protected Areas. When I started my PhD on plastic pollution, Helen and Peter suggested that I should come over to Lembongan to work with them. They sent me a couple of horrific photos of mantas feeding amidst plastic off Nusa Penida during the rainy season. I was seeing plastics in Komodo too, but nothing I'd seen was as bad as that.

WHY IS POLLUTION SO BAD AROUND BALI?

EG: Nusa Penida is located in the Lombok Strait, where the Indonesian Throughflow current moves water from the Pacific Ocean to the Indian Ocean. There's a lot of water moving past Nusa Penida, and it brings plastic and other trash right down from China and the Philippines. Manta rays like to feed around Nusa Penida because the island's points create eddies in the flow, which concentrate the zooplankton the mantas feed on into the bays. With so much plastic now being transported, this is being concentrated around the island too, which makes it unavoidable for the mantas. That said, we do see a lot of local plastic as well. Bali has a dense population, and during the Indonesian rainy season we see over 20x more plastic at Nusa Penida than during the mid-year dry season. It's common for villages to just bring their waste close to the riverbank and burn it but, if the river overflows during heavy rain, that flushes the waste right down to the mantas at Nusa Penida.

WHAT SORT OF PLASTICS ARE YOU SEEING?

EG: Most of the identifiable trash, where we can see and read the labels, is Indonesian. We see a mix of consumer products, like plastic packaging for soaps, shampoos, and fast food, along with clear plastic bags that are commonly used in fisheries. Small-scale fishers will take these plastic tubes, fill them with ice, and bring them onboard the boats to keep their fish cold. Those tubes are very recognizable due to their shape. They're widely used in Indonesia, and likely in other countries to the north of us as well, so they could be coming from anywhere.

JA: Some of the recognizable waste is very old too – perhaps from the late 1990s – which illustrates the fundamental problem: plastics last in the environment for a really long time.

EG: Each year's input compounds the issue. The plastic does disappear, eventually, but we're not sure where. Whether it's piling up at the bottom of the ocean or being ingested by marine life, we lose track of it. Hypothetically, it should be breaking down very gradually to its chemical and mineral elements, but that takes a very long time. It can do a lot of damage as it degrades.



Samples collected at manta feeding ground show microplastics mixed with manta food (orange circle, zooplankton).

Plastic collected from a single manta vomit sample.

“

We've estimated how many microplastics the manta rays are ingesting while feeding here at Nusa Penida in the rainy season: about 63 pieces an hour.

WHAT MAKES MANTA RAYS PARTICULARLY VULNERABLE TO POLLUTION?

JA: Manta rays are filter-feeders so, if there's a lot of small plastics in the water among the plankton they're targeting, it's difficult for them to avoid ingesting some of it. Mantas can vomit up plastic, but these small bits can add up and cause damage. Even small plastic pieces can add up to block or inhibit intestine function.

EG: We've estimated how many microplastics the manta rays are ingesting while feeding here at Nusa Penida in the rainy season: about 63 pieces an hour.

HOW IS POLLUTION AFFECTING MANTA RAYS?

JA: Even if the microplastics don't completely block the intestinal tract, like larger plastics can, the chemicals in the plastic can transfer over to the manta rays. Chemicals in the environment will bond to plastic, so if the plastic came from a river to the ocean, and that river was polluted, the plastics will have absorbed those pollutants. Once the plastic is out in the ocean, if it's ingested by marine wildlife, the pollutants in the plastic can leach out into the animal.

EG: We're still in the process of working out whether that's happening to mantas or not. But even if the plastics aren't acting as vectors for environmental pollution, the plastics can be toxic themselves. A lot of them are manufactured with additives, such as flame retardants, that aren't supposed to go into your body. We're hoping to be able to use small

skin samples from wild mantas to detect the accumulation of industrial chemicals in their body.

Reef manta rays, the species we're primarily working with here, are already threatened due to human pressures. Plastic ingestion could cause direct mortalities, but the accumulation of toxic chemicals in their bodies could also have chronic impacts on their reproduction, growth, and maturity. That's part of what Janis' project is looking at.

JA: We're monitoring individual growth rates, how many mantas are pregnant each year, and whether that's changing over time. It's complicated, as there are also broader environmental changes that affect things like food availability, but we can start getting insight into how pollution is affecting manta populations.

Manta rays are likely to be bioaccumulating higher and higher levels of pollutants like PCBs and pesticides that leach out from plastics. We know from other animals, including other sharks and rays, that a process called maternal offloading can be used to move pollutants from the mother to the baby during gestation, potentially as an evolutionary strategy to reduce the burden on the mother. With mantas potentially only giving birth to a couple of pups over their life, it doesn't bode well for this population if that's happening.

THE PROBLEM OF CUMULATIVE THREATS

EG: Plastic ingestion is just one of the stressors on the mantas. Over 10% of the mantas at Nusa Penida have permanent



(left) Manta filter feeding amongst plastic at Nusa Penida

Photo by Brooke Pyke

(right) Elitza & Helen Mitchell trawl for microplastic at manta feeding areas

Photo by MMF



Elitza & Aprilia Trisaka collecting plankton samples

Photo by Lisa Auditore





injuries from entanglement in fishing gear. The problem for mantas is that they can't swim backward, so they can end up with lines wrapped around them, which can cut their fins off or cause severe injuries that affect their ability to swim and feed. We always carry shears with us while we're diving in case we see an entangled manta we can help.

Fishing is an obvious threat, but we're also seeing climate change and the changes in larger-scale oceanographic processes that come with it, and other activities like tourism can be a problem if it disrupts their feeding or cleaning. That's where these additive problems like plastic are nasty – if it's slowly reducing the number of baby mantas being born, and then the survival of those babies, all these things will combine to cause population decline. We don't know where the breaking point will be.

WHAT ARE THE SOLUTIONS?

EG: This is the problem with studying plastics: it's depressing. One thing that I grab on to is the huge increase in awareness over the past few years. I'm seeing more people here be considerate and bring their own bags, more restaurants not using plastic straws, and the government has banned the use of plastic shopping bags. All the takeaway containers here now are made from cardboard. That's all happened in the last five years. Waste management is still a struggle, but at least there's less new plastic going into the system.

Corporates have been trying hard to shift the responsibility for pollution onto consumers, but we need them to clean up the mess they've created. There are some encouraging signs. Aqua, a company that makes water bottles here, now sells

a bottle that's completely recycled. The next step would be to have water refill stations everywhere, as they have in the Philippines, since the water from the tap isn't potable.

When we find waste from specific companies we're always tagging them in our photos; it's like, hey, here's your Kinder Surprise out in the ocean choking manta rays. There are various projects focusing on cleaning up the environment, which is excellent, but we need to focus on not creating this waste in the first place.



Watch a sneak-peak of the conversation with Elitza & Janis!



The full 40 min conversation is available now in the Member's Area.

LEARN MORE



MANTAHARI OCEAN CARE



FOLLOW

ON FACEBOOK & INSTAGRAM
TO HELP THEM GROW



Mantahari Oceancare



@mantahari

The Munich fashion start-up "Mantahari Oceancare" was founded in 2018 as a non-profit organization by Tim Noack. During his time as a diving guide in Komodo/Indonesia, one topic touched him above all: the pollution of the oceans by plastic waste. Thus a good portion of their profits is donated to MMF's marine conservation projects in Indonesia. These projects focus on the protection of manta rays and other marine life and public education, scientific capacity building and government engagement through research and science to enable long-term environmental protection.

The startup's product range includes apparel made from recycled PET bottles.

To closely engage with the projects on the ground Mantahari regularly adopts individual manta rays (over 150 and counting) and has contributed > USD 30K in project funding.

WWW.MANTAHARI.COM





MARNE MEGAFUNA FOUNDATION
SAVING OCEAN GIANTS FROM EXTINCTION



OCEAN *SPEEDSTERS*

*Tracking Marlin
in the Indian Ocean*

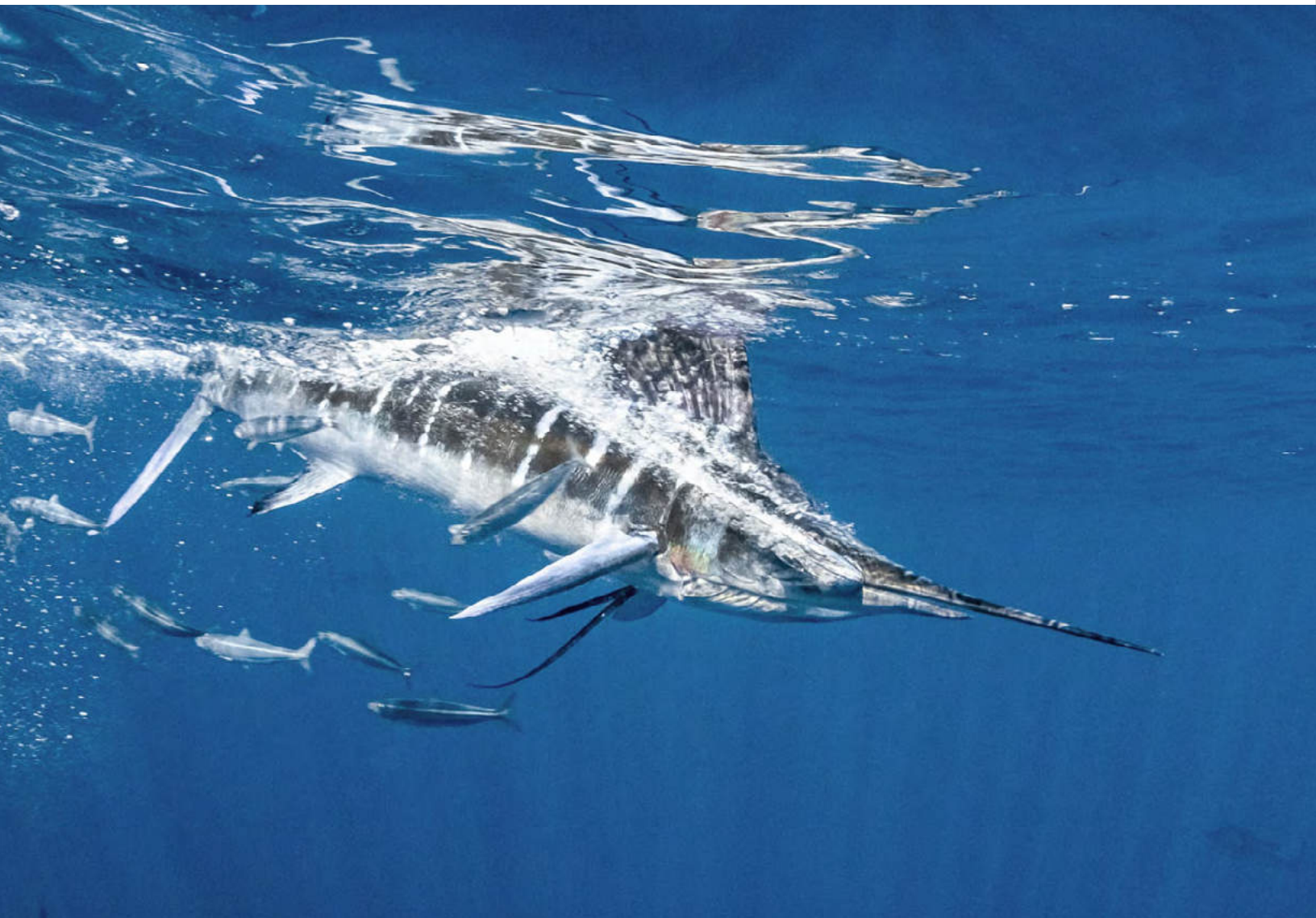


In conversation with
DR. CHRIS ROHNER



(previous, right)
Striped marlin
Photo by Julia Bahlsen

(below) Striped marlin
Photo by Henley Spiers



“

in conversation with

**MMF PRINCIPAL SCIENTIST
DR. CHRIS ROHNER HAS BEEN
WORKING ON TRACKING
MARLIN RECENTLY.**

This was the first time that MMF researchers have worked on these amazing, highly-migratory oceanic predators. Chris has now published two of the first scientific papers on black and striped marlin movements in the Indian Ocean, so I chatted with him to discuss the results.

- Simon Pierce

FISHING FOR INFORMATION

A few years ago now, we were approached by sport fishers for marlin in Kenya who were concerned that little was known about these fishes. Sport fishing for marlin is typically catch-and-release and, following capture, they were able to deploy satellite-linked tags on the fish to track their movements. Analyzing the data is quite technical though, so they asked us for scientific support.

The sport fishers focused on tagging two species, black and striped marlin. The black marlin is one of the biggest of all bony fishes, with a trophy fish being a 'grander' weighing over 1000 lb. Striped marlin are oceanic speedsters whose stripes light up when they're hunting. They're both amazing fish.

It's ended up being the first satellite-tagging project for marlin in the Indian Ocean, and one of the largest studies conducted on these species so far. It's been great to work with the incoming data and help the fishers get the information they were hoping for.

SWIMMING FAR AND FAST

It's hard to keep a tag on a marlin – they're among the fastest of all fish, and they jump too – but, generally, the longer the tag stayed on, the further that individual marlin dispersed from Kenyan waters. We found a lot of similarities between the species; they both swim far and fast, covering 40–50 km per day. Most moved northwards from Kenya towards Somalia and Oman, but there was plenty of individual variation too. One of the striped marlin swam all the way over to the Maldives, and a black marlin swam south into the Mozambique Channel. The longest track was 11,944 km over 167 days.

Marlin hunt oceanic fish and squid. We don't know the distribution of these prey in real-time, but we can retrospectively compare the marlin tracks to oceanographic features, like fronts. Fronts are where different water masses meet, and we can monitor their location through remote sensing satellites. Fronts concentrate plankton at a high density, so planktivorous fish and everything else congregate

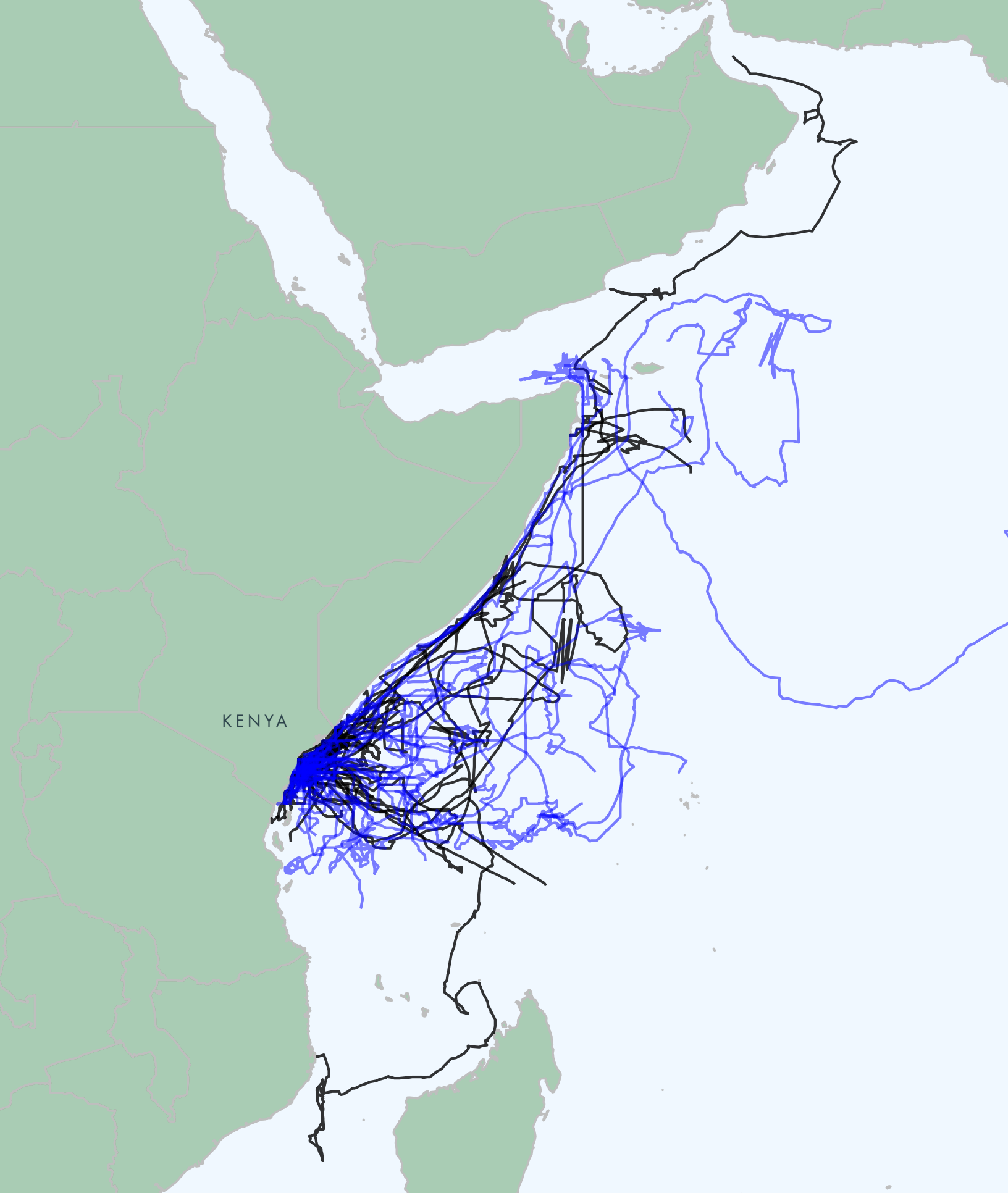


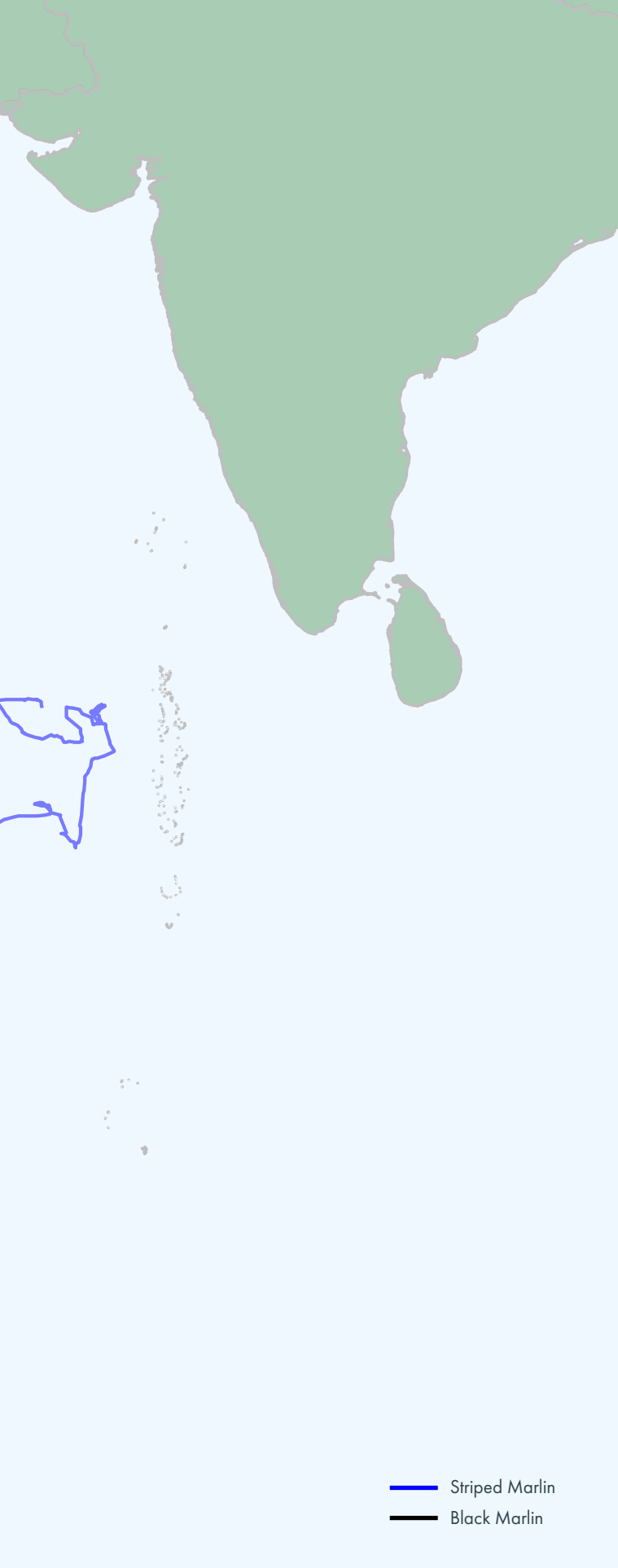
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It's ended up being the first satellite-tagging project for marlin in the Indian Ocean, and one of the largest studies conducted on these species so far.

Tagged black marlin
Photo by Roy Bealey







in these areas, including top predators like marlin. That's not all we can see with the satellite data: we can look at ocean temperature and chlorophyll (phytoplankton) density as well, which is helpful too.

Striped marlin followed ocean productivity through the year, with high productivity off Kenya during the Dec-Mar period when they were caught, before moving north towards the Horn of Africa around the island of Socotra. There was lots of cool-water upwelling there, which means productive surface waters and probably dense prey. We looked at four years of satellite data for that area and there's a consistent front present that is clearly very attractive for oceanic predators.

Black marlin were similar during the first half of the year, moving north to the same general area, but they moved back down the coast to Kenya in the second half of the year. That return movement is difficult to explain because there's no particular front, upwelling, or obvious productivity we could detect through those months.

Generally, though, both species are going to be moving around to find food, so there's probably a prey source present that we can't identify remotely.

There's also the possibility of spawning activity, which we haven't gotten to the bottom of yet. Striped marlin larvae have been found up north, off Oman. No Indian Ocean spawning areas for black marlin have been identified. We think they might be spawning off Mozambique, so we'll be looking into that for the next phase of the project.

MODEL MARLIN

We had some helpful external reviewer comments for the black marlin paper that encouraged us to explore advanced modeling work to understand marlin habitat preferences. With the help of some mathematician friends at The University of Queensland, we randomized the real marlin tracks, then set computer-generated 'model marlin' to (digitally) swim across the ocean. By comparing random model fish movements to where the real fish went, and the





oceanographic conditions both swam through, we could test whether the real fish were actively choosing particular areas and conditions.

Real marlin preferred more productive waters than the digital marlin, which makes sense of course: they want to be in places where they can find prey. Even though it's a simple result, it was tough to calculate. For each real track we generated 100 model tracks, then sampled the environmental conditions along all of them, so there were about half a million data points to extract for each variable that we were interested in. That would have taken weeks of solid processing on my trusty computer, so we borrowed some time on a big supercomputer. Even that took a couple of days. It was worth it in the end though, the results were pretty cool.

HOLDING THEIR BREATH?

Squid are an important part of the diet for both species, so they dive a lot. One individual striped marlin moved almost 15 km vertically over a single day. There are a couple of factors that come into play on deeper dives. The first one is temperature. It gets colder when they dive past the surface mixed layer, and both marlin species dived down to 450–500 m on occasion, with the coolest temperature around 10°C. Marlin are cold-blooded, or ectothermic, so the water temperature dictates their body temperature. However, they have a special blood circulation adaptation to route warm blood from their swimming muscles to move past their eyes and brain, so their sensory system maintains a more constant temperature and remains fully functional for hunting at depth. It's very clever. Still, they will want to come up into warmer surface water to heat up their body after a long period at depth.

Their other consideration is oxygen. Because billfish swim so fast to catch their prey, they have a high metabolic demand. That means the oxygen content in water can actually be a limiting factor for them. There are areas with low oxygen close to the surface in the northern Indian Ocean area, where these marlin migrated to, forcing the marlin to dive into what we

call the oxygen minimum zone (OMZ). That will limit their movements after a short time exposed to those low oxygen conditions, as the muscles can't get enough oxygen to function properly. That's another reason why they'd have to swim up and down; to reoxygenate their gills near the surface before swimming down again.

With the changing climate, the OMZ is becoming shallower over time in some areas. In the Atlantic, the OMZ has expanded so dramatically that marlin habitat has shrunk. They have less vertical space to hunt in, because they have to spend most of their time in this increasingly narrow band where they can get enough oxygen.

One of the other areas where deoxygenated water is likely to be a problem for marlin is up around Oman, where some of our marlin swam. In some areas up there, the OMZ is only about 20 m deep. It's harder for them to hunt in such a narrow range, and it also affects their vulnerability to fisheries – there's no depth refuge from longlines and nets. Some of the gillnets up there are 30 km or more in length, and there are many thousands of fishing boats. Marlin need more help from people if we're going to improve their outlook for the future.

OPEN-OCEAN CONSERVATION

When we started this project I was surprised at how little was known about marlin, considering how popular they are with sport fishers. What we quickly learned was that there are real conservation concerns around marlin. Commercial catches of marlin have increased quite dramatically, tenfold since just the 1990s for some species in the Indian Ocean. These are big fish that can clearly swim long distances, so nobody is sure how many are actually out there. Fisheries observers often struggle to identify the species; there's a shortage of even the most basic information. That makes it difficult to manage these fisheries, obviously, because so little is known about their biology and ecology. At the moment there aren't any legal limits on how many can be caught.

There are two areas of high commercial catches for striped marlin in the region: up north of the Horn of Africa, and off





(right) Striped marlin
Photo by Julia Bahlsen

(below) Striped marlin
Photo by Henley Spiers



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The open ocean is the new frontier for marine conservation.

Kenya. Those were the areas our tagged marlin used too. Prior to this work, we didn't know that it was the same fish moving between both. Now we have shown that this whole region needs to be considered as a single management unit. The entire Indian Ocean might, in practice, be a single population for both species – our tags were set to pop-off the marlin after six months, so they're only capturing a snapshot of their movements, and one swam over to the Maldives in that time alone.

People tend to think of the open ocean as a fairly homogenous environment, but there are definitely some areas that are in much higher use by open ocean predators like marlin, tuna, and sharks. Commercial fishers know that too, and they use the same remote sensing data we analyzed here to identify where the best catches will be. The challenge for conservation in this open ocean habitat, which covers a good portion of the planet, is that it is international waters where no particular government has jurisdiction. That means there needs to be international cooperation to do obvious things, like institute more protection for critical habitats of overfished species, but these habitats like frontal zones aren't necessarily at the same location throughout the year. And then, these areas are far offshore and it is hard to enforce any protections that are put in place.

There are broader social considerations to this too. Marlin swim from coastal areas to the open ocean and back. At the coast, they're a target for artisanal fishers and an important source of protein. In some areas, including Kenya, there's a

big economic benefit from sportfishing for marlin too. It's all linked. When open ocean commercial fisheries deplete the stock, coastal communities suffer the consequences. At least our new results allow us to inform these conversations with management authorities. The open ocean is the new frontier for marine conservation.



Watch a sneak-peak of the conversation with Chris!



The full 25 min conversation is available now in the Member's Area.

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Queen of the Mantas

Andrea Marshall is marine biologist and National Geographic Emerging Explorer. She and leads research on globally threatened manta rays, as well as having discovered

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e founded the Marine Megafauna Foundation
d two new species.



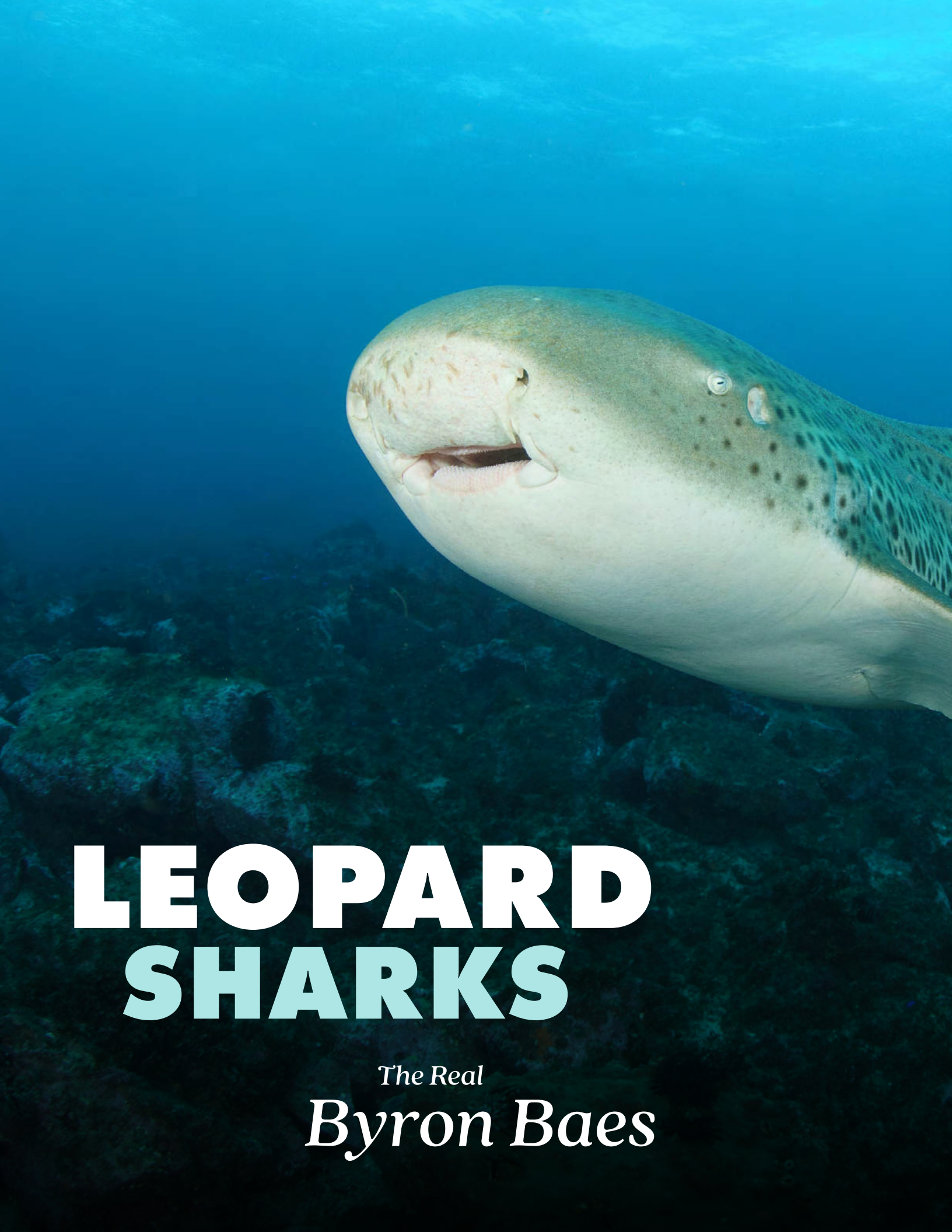
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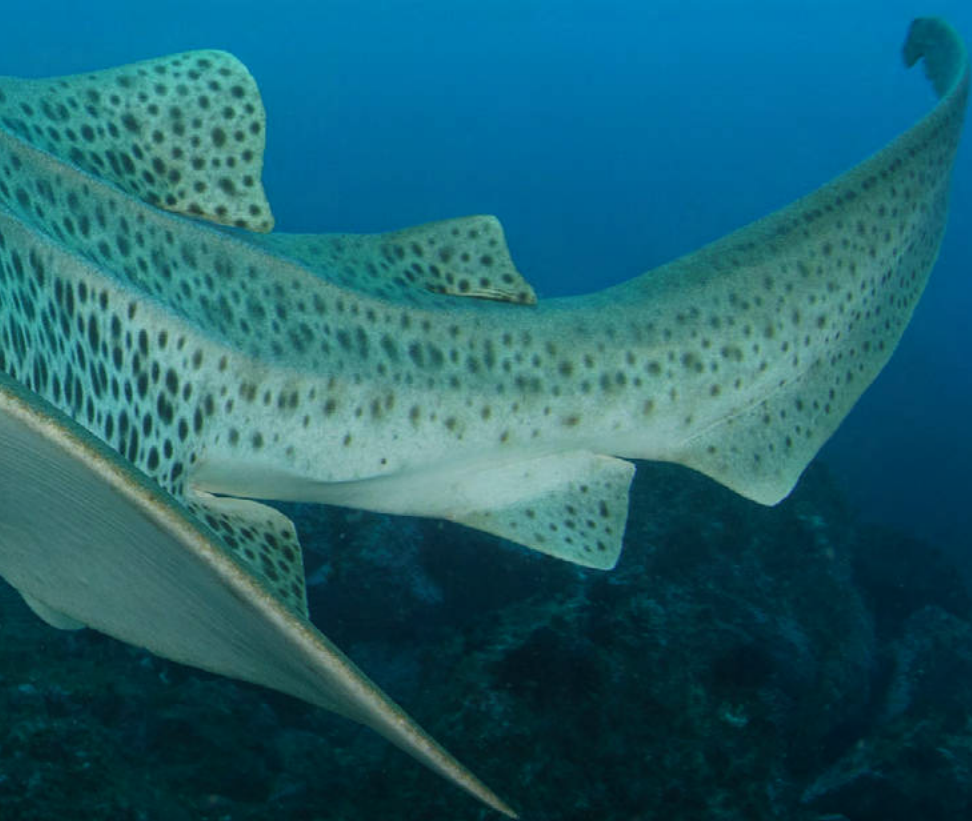


MMF collaborator, Stella Diamant, wearing
Waterlust's Whale Shark Warrior Leggings.
Madagascar



LEOPARD SHARKS

The Real
Byron Baes



In conversation with
DR. DAVID ROBINSON





(left) Julian Rocks

Photo by T Park Photography

(previous, below) Leopard sharks
at Julian Rocks

Photos by Simon Pierce



“

*in conversation with***DR. DAVID P. ROBINSON, NOW
THE CO-OWNER OF SUNDIVE
DIVE CENTRE IN BYRON BAY**

on the eastern coast of Australia, has been working with MMF for years on whale sharks and sea turtles. I wanted to talk to him about his new project, focused on leopard sharks, sometimes known as zebra sharks in North America* because they're wonderful.

- *Simon Pierce*

*Largely to avoid confusion with an unrelated shark, also called a leopard shark, that lives in California. I'm just leaning into the confusion here... sorry.

THE CAPE BYRON LEOPARD SHARK PROJECT

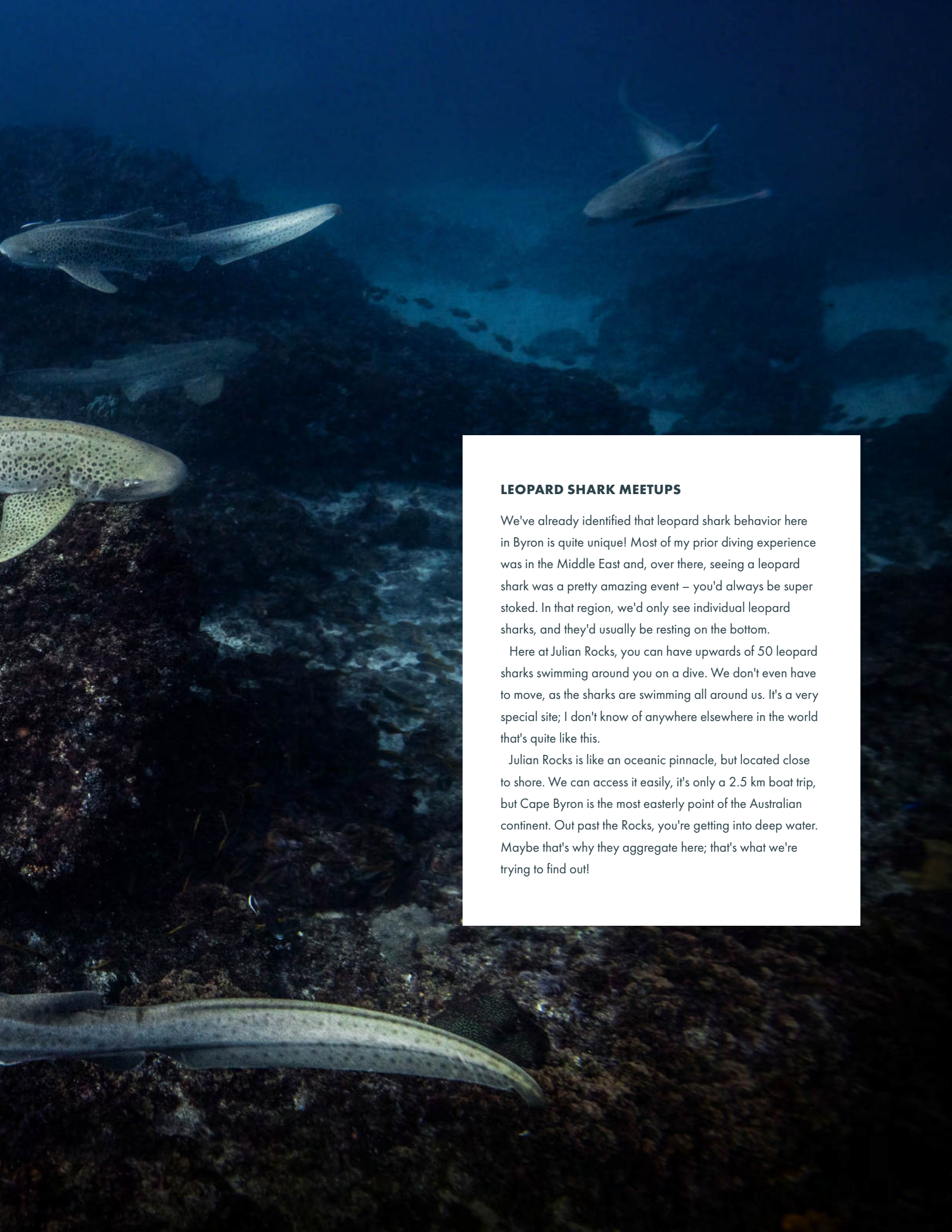
We moved to Byron Bay Australia from the Middle East in 2018. I love diving, and I wanted to help the marine environment as well, so we bought ourselves a dive center: Sundive. That's given us the chance to introduce lots of people to ocean life, and to start some new scientific projects as well.

I'd lived in Dubai since 2006, where I was working as the Assistant Curator for the Burj Al Arab aquarium. We had a lot of sharks within the exhibit there, including leopard sharks, so I was very familiar with the species.

I knew there was an aggregation of leopard sharks here at Julian Rocks, the main dive site off Byron Bay, but I wasn't really prepared for just how many sharks there are, and how special this place is. It was a no-brainer, really, to start a project looking at their ecology in the region.

I contacted the Cape Byron Marine Park. They thought it was a great idea and came on board, along with MMF of course. Together, we've formed the Cape Byron Leopard Shark Project to investigate all aspects of the species' life in this area.





LEOPARD SHARK MEETUPS

We've already identified that leopard shark behavior here in Byron is quite unique! Most of my prior diving experience was in the Middle East and, over there, seeing a leopard shark was a pretty amazing event – you'd always be super stoked. In that region, we'd only see individual leopard sharks, and they'd usually be resting on the bottom.

Here at Julian Rocks, you can have upwards of 50 leopard sharks swimming around you on a dive. We don't even have to move, as the sharks are swimming all around us. It's a very special site; I don't know of anywhere elsewhere in the world that's quite like this.

Julian Rocks is like an oceanic pinnacle, but located close to shore. We can access it easily, it's only a 2.5 km boat trip, but Cape Byron is the most easterly point of the Australian continent. Out past the Rocks, you're getting into deep water. Maybe that's why they aggregate here; that's what we're trying to find out!

(previous) Free-swimming leopard shark aggregation at Julian Rocks
Photo by Simone Caprodossi

Adult and baby leopard shark color patterns.
Photos by David Robinson (main) & Warren Baverstock (inset)

COLOR-CHANGING SHARKS

Leopard sharks change color as they grow up. We used to breed them in the aquarium and, when they're first born, they have vivid alternating dark and light stripes, which is where their other common name of 'zebra shark' comes from.

Our friend Dr. Christine Dudgeon, who is amazing, worked out that the young leopard sharks are actually mimicking sea snakes (and sea kraits). The sharks' relatively long tails give them a very sinuous movement when they're swimming, emphasizing their snakiness. They even have distinctive eyespots on each of their pectoral fins, so a potential predator looking down will see something big and venomous staring back at them, and presumably thinks "I'm going to leave that thing alone".

MONITORING LEOPARD SHARKS

The 'leopard' spots in older sharks form from these 'zebra' stripes. The distinct stripes gradually change within a year or two to leave the spots behind, then this adult spot pattern seems to stay fixed for the rest of their life. That allows us to identify and monitor individual sharks over time.

We had a fantastic 2020–2021 leopard shark season in Byron, carrying out dedicated surveys every week when the weather allowed. We identified 306 individual sharks that visited between December and May, with the total number of identified sharks from Julian Rocks now up to 387.

We've got a team of regular research divers here at Julian Rocks, but we've also got great support from the broader community along this coast. Anyone with a camera can submit images to the global database photo-identification database for leopard sharks, www.leopardshark.wildbook.

org. We need the left side of the shark for ID: the area behind the gills and along the body. I just received photos from Wolf Rock, which is about six hours drive north of here, and even one from Tonga the other day, which was very cool.

Chris Dudgeon identified hundreds of leopard sharks during the 2000s at North Stradbroke Island, off Brisbane. She's uploading those onto the Wildbook website now. We've already had one match this year. Chris had done some shark tagging at North Stradbroke back in 2005, and I noticed that one of the Byron sharks had an old tag insertion mark below its dorsal fin. That shark was already a mature male when Chris tagged it 16 years ago. We'd been estimating about a 25-yr lifespan for leopard sharks; I think we might be greatly underestimating their true longevity.

ISN'T IT ROMANTIC?

About 74% of our identified sharks at Julian Rocks have been adult females, with smaller numbers of mature males and sub-adults. Their behavior here is unusual. Most of them are swimming around during the day, constantly expending energy, whereas elsewhere, even at North Stradbroke Island, they're normally resting on the bottom through the day.

I'm assuming they're displaying some form of pre-mating behavior. We do see the males following females – and I have seen a photo of a male with engorged claspers – but we haven't observed any actual mating attempts. I'm kind of stumped on that one. Maybe it's occurring at night, and that's why we're not seeing it. We've got some ideas about deploying sensitive night-vision cameras over the upcoming summer to find out what's actually going on. Perhaps mating will happen at night, under the full moon. Very romantic.





Leopard shark at Julian Rocks
Photo by David Robinson

An underwater photograph showing two large, spotted sharks swimming over a rocky, algae-covered seabed. A large school of small fish is visible in the upper left. The water is clear and blue.

“

I wasn't really prepared for just how many sharks there are, and how special this place is.

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We need to identify and protect these critical sites in advance.

MYSTERY OF THE BABIES

We don't see many juveniles in the wild, anywhere in the world. I've seen leopard shark eggs in the Musandam in Oman at about 30 meters' depth, near the limits of recreational diving. I think the sharks must be heading out to deeper waters to drop off their eggs. Recreational diving in eastern Australia is so well-established and widespread that, if the pups were within recreational diving limits, you'd have to expect that people would be seeing them.

"THEY'RE BASICALLY SWIMMING TANKS"

Leopard shark teeth are made for grasping and crushing. They'll feed on things like octopus, fish, crabs, and lobster for instance. They can pretty much decimate these crunchy crustaceans.

I've never seen leopard sharks hunting in the daytime; they're mainly nocturnal predators. I suspect that smell is their most important sense for hunting. I've done some post-mortems on leopard sharks in the aquarium and the olfactory region of their brain is huge. They'll smell something tucked away within the reef, and they'll dig right into the rocks to get it. Their skin is extremely, excessively thick to protect them. They're basically swimming tanks.

PROTECTING LEOPARD SHARKS

We think leopard sharks are doing okay on the east coast of Australia, but they're very much endangered in other parts of the world. They're such an easy target; they're harmless, coastal, and spend a lot of time sitting still on the bottom. They're one of the first sharks to disappear when fishing starts.

I just saw a photo from the Andaman Islands, just north of the Maldives. About 50 sharks had been caught at once. They probably stumbled across an aggregation site, like Julian Rocks, and fished them out in a day. Boom, done. The sharks can't recover from that. We need to identify and protect these critical sites in advance.

That's part of what is so nice about working here in Byron Bay, as Julian Rocks is already a marine protected area. That said, they're only here from around December to May each year. We don't really know where they go after that. We'll try some acoustic tagging later this year and, of course, when divers submit photos it's extremely helpful for tracking the sharks.



Watch a sneak-peak of the conversation with David!

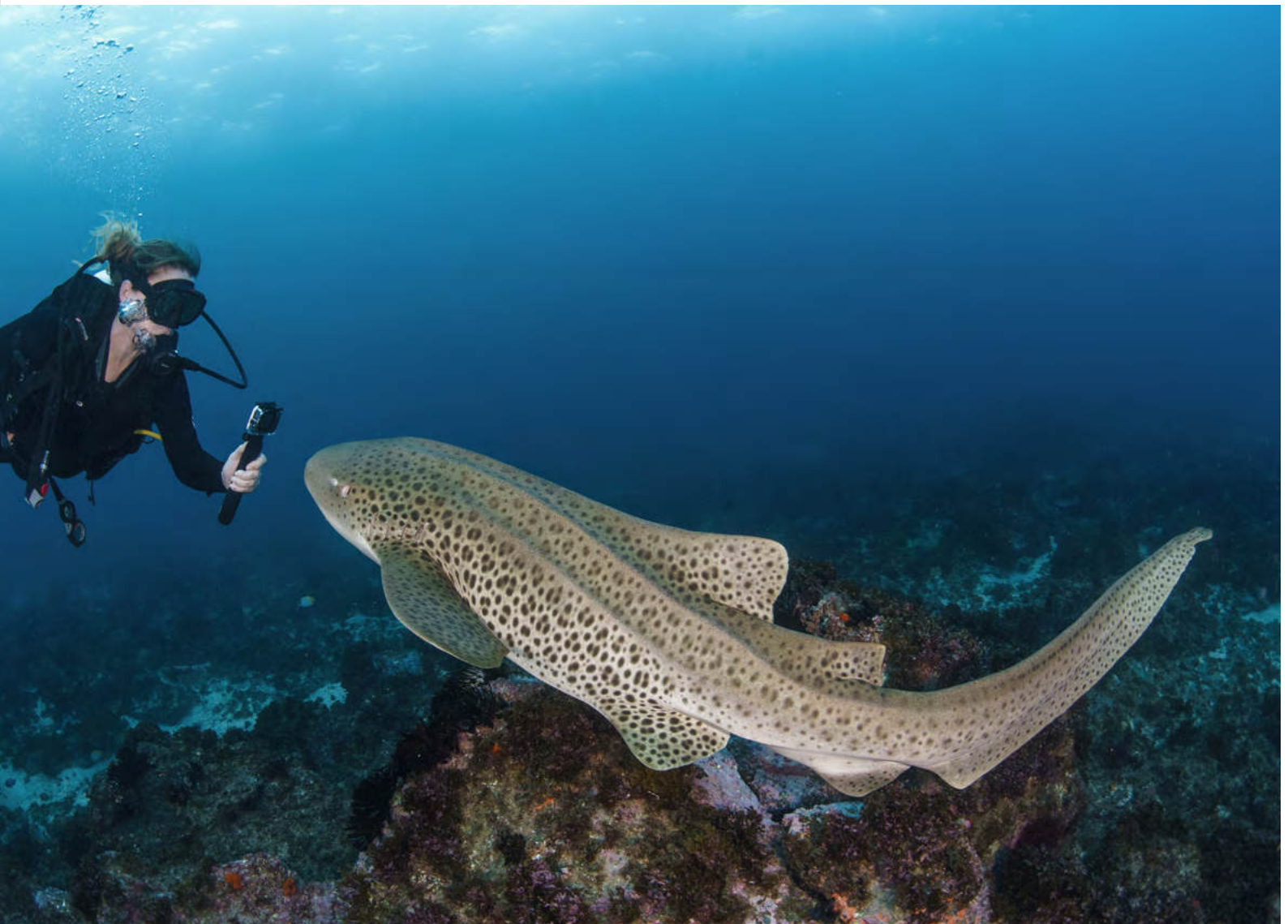


The full 60 min conversation is available now in the Member's Area.

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Divers with friendly leopard sharks at Julian Rocks
Photos by Simon Pierce



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