

THE SAVE OUR SEAS FOUNDATION MAGAZINE

save our seas



SAWFISH | DEVILS | HAMMERS | FISHERS | RAPA NUI



TRISTAN GUTTRIDGE

Originally from the United Kingdom, Tristan first arrived at the Bimini Biological Field Station 11 years ago to complete his PhD on the social organisation and behaviour of Bimini's lemon sharks. He returned to the 'Shark Lab' a few years later to take up the post of its director and senior scientist. Tristan continues to be fascinated by the social dynamics of sharks and the role of learning in their behaviour. He has recently published important papers on sawfishes and hammerheads at Bimini.



LAUREN DE VOS

Based in Cape Town, South Africa, Lauren has been funded by the Save Our Seas Foundation since 2012. She is currently completing the final year of her PhD on the ecology of False Bay at the University of Cape Town. An accomplished writer and film-maker, Lauren is one of the country's top young science communicators and has used footage from her BRUVS study to generate significant public interest in Cape Town's marine realm.



ANA SOBRAL

In 2011 Ana started her Master's degree, studying the biology, ecology and conservation of mobulids at the Portuguese archipelago of the Azores. For the past three years, under the University of the Azores' Department of Oceanography and Fisheries' Institute of Marine Research, she has been investigating the islands' migrant population of Chilean devil rays, with the help of citizen science and remote underwater video systems. Most recently, Ana was involved with the Manta Trust's campaign to ensure that 'mini mantas' are protected by CITES.



MAREIKE DORNHEGE

Mareike grew up in Germany and obtained her MSc in biology, conservation and management at the University of Oxford. She is currently completing her PhD in Tokyo at Sophia University's Graduate School of Global Environmental Studies. Mareike speaks fluent Japanese and is also a published journalist and the editor-in-chief of a local magazine.



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Sawfishes have become creatures of myth and fascination, for fishermen and for scientists. Ruth Leeney, who has spent years searching for these legendary beasts along the African coast, shares an experience from a remote corner of northern Madagascar and outlines her mission to save the continent's last remaining sawfishes.

036 THE OLD MEN AND THE SEA

With the demise of bluefin tuna, fishers in Japan have shifted their focus to catching sharks. Baselines have shifted as well, with older fishers reporting more drastic changes than younger ones. Mareike Dornhege explains how she uses 'fishermen's tales' to learn about the Japanese shark fishery.

046 HEARTS AND MINDS – AND STOMACHS

During almost 200,000 years of human history we have never witnessed biodiversity loss at the rate that it is happening now, yet despite centuries of conservation effort we are failing to find solutions that balance the needs of people and nature. Philippa Ehrlich looks at alternative approaches that are getting results.

060 HOME AND AWAY

Three years ago, the Bimini Biological Field Station partnered with an expert free-diver to tag giant hammerheads safely. Tristan Guttridge uses the tagging data to unravel the yearly travel plans of these iconic predators.

074 THE SOCIAL NETWORK

In a sector where competition is rife and publications are currency, scientific collaboration, while critical, can be tricky to navigate. Lauren De Vos discusses the benefits of finding ways to work together.

080 SCIENCE AT THE FAR END OF THE WORLD

For millennia, human beings have pioneered their way into new territories across our planet, yet few places remain as mysterious as Easter Island. Lauren De Vos shares some of Naiti Morales' discoveries from the underwater realm of this fabled island region.

092 BETWEEN DEVILS AND THE DEEP BLUE


Mobulas are following their better-known cousins, the manta rays, into the hearts and minds of ocean lovers around the world – and perhaps nowhere more so than in the Portuguese archipelago of the Azores. Ana Sobral recounts her experiences with the enigmatic Chilean devil ray.

104 UNCOVERING SECRETS IN THE 'ALDABRA OF THE AMIRANTES'

The D'Arros Research Centre has been gathering scientific information about the ecosystems of the Amirantes for almost 15 years. Clare Keating Daly describes its research and why it is so important.

frontiers



A group of four whales swimming in clear blue water. The whales are arranged in a vertical line, with the largest whale at the bottom and three smaller ones above it. The water is a deep, clear blue, and the whales are dark in color, likely humpback whales. The lighting is bright, suggesting a sunny day.

*As long as
there are people
who care, we
can and will make
a difference.*

THE FOUNDER | SAVE OUR SEAS FOUNDATION

FILM





At a time when the natural world is under greater threat than ever before, working in conservation is not always an easy job, although it does offer moments that remind us of how privileged we are to be on this incredible planet. Michael Scholl shares one of these moments with a southern stingray at Honey-moon Harbour in Gun Cay near the islands of Bimini in The Bahamas.

Every now and then, specific moments remind us how much we ought to value life. I get these reminders, in many different forms, every time I visit or am in contact with project leaders from around the world. I hear about the enthralling work they are doing and I get to share their enthusiasm and their passion for the ocean and its inhabitants. There is a dedication seldom touched by the mundane twists of everyday life.

Most of my close friends enjoy lives filled with adventure and exploration in unique and fragile ecosystems, and with wild animals that still hold many mysteries for us. Everything they experience is a constant expression of how amazing, exciting, mysterious and wonderful our planet earth – and all life – really is. And of why our endeavours and commitment are so important, not just for ourselves but for life in general. As Senegalese environmentalist Baba Dioum so eloquently said in a presentation to the IUCN in 1968,

‘In the end,
we will conserve only what we love,
we will love only what we understand,
and we will understand only what we are taught.’

Sometimes, though, an unexpected event will challenge our understanding of the meaning of life. The passing of Rob ‘SharkWater’ Stewart earlier this year was one such event; you try to understand the reason ... but there isn’t one. Rob presented a unique outlook on life – a life dedicated to sharks and our Mother Earth. His talent for communicating a strong message, wrapping it in a compelling story and presenting it with astonishing visuals, was truly unique. He was one of the people who inspired me in the past decades. When I attended the Celebration of Life that his family and friends organised in his memory, I was struck by the number and the diversity of the people he had touched – people who shared his enthusiasm and passion for the cause he believed in. And he had touched them all with an intensity that was alive and omnipresent. I believe that for all the different people who shared his appetite for life, Rob will continue to live and to galvanise in each one of us unremitting dedication to a common cause.

‘A man who dares to waste one hour of time has not discovered the value of life.’
Charles Darwin – *The Life and Letters of Charles Darwin*, 1887

This seventh issue of *Save Our Seas* highlights the importance of collaboration and of alternative approaches to conservation, showcases personal stories from the last frontier of the world, dives with devil rays and traces the migrations of great hammerhead sharks and the current whereabouts of mythical sawfishes in Africa. It also explores the potential for learning from local fishers and encouraging them to take over stewardship of species they used to target.

In memory of

ROB STEWART

28 December 1979 – 31 January 2017

'Here's to the crazy ones.

The misfits. The rebels. The troublemakers.

The round pegs in the square holes. The ones who see things differently.

They're not fond of rules, and they have no respect for the status quo.

You can quote them, disagree with them, glorify or vilify them. About the only thing you can't do is ignore them because they change things.

They push the human race forward. And while some may see them as the crazy ones, we see genius.

Because the people who are crazy enough to think they can change the world, are the ones who do.' ROB SILTANEN





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- Eugenie Clark Award (AES) | Austin, USA
- European Elasmobranch Association (EEA) Conference | Amsterdam, NL
- International Conference on Fish Telemetry (ICFT) | Cairns, AUS
- Oceania Chondrichthyan Society (OCS) Conference
- Southern African Shark and Ray Symposium | Hermanus, ZA
- Wavescape 2017 | Cape Town, ZA



The Save Our Seas Foundation was established in 2003 with a mission to protect our oceans by funding and supporting research, conservation and education projects around the world, focusing primarily on charismatic threatened wildlife and their habitats.

In that time, the foundation has sponsored over 200 projects in more than 50 countries, proudly supporting outstanding researchers, educators and conservationists who have contributed to the continued existence of more than 60 of our planet's precious marine species.

To find out more about our funded projects, visit saveourseas.com/projects



SHARKS MAY HAVE THE EDGE IN HEALING

ocean
view

New research suggests that understanding sharks and their DNA could benefit human medical research. The findings not only add to our scientific interest in these predators, but also increase their conservation importance. Nicholas Marra and scientists from the Nova Southeastern University's Save Our Seas Shark Research Center and Guy Harvey Research Institute (GHRI) and the Cornell University College of Veterinary Medicine found that genes linked to sharks' immune systems have

been modified through evolution. These modifications help to explain how, even though sharks swim in bacteria-laden ocean water, their wounds heal quickly. They may also give sharks higher resistance to cancers.

'The immune system of sharks and rays has been battle-tested and evolved over hundreds of millions of years,' explains Mahmood Shivji in a Nova Southeastern University press release. Shivji is director of the Save Our Seas Shark Research Center and GHRI and a co-author

of the paper. He believes the findings increase the urgency to conserve sharks. 'Now we have another important reason to make sure we don't lose these marvelous and ecologically critical animals to overfishing, as is currently occurring in many parts of the world,' he says. 'We've just scratched the surface in terms of learning what these ancient animals can teach us, as well as possibly provide us in terms of direct biomedical benefits.'

The paper, published this year in *BMC Genomics*, looks at four elasmobranch species (the white, shortfin mako and great hammerhead sharks and the yellow stingray) and three bony fishes (the swordfish, hogfish and ocean surgeonfish). The study assessed genetic differences between sharks and bony fishes, homing in on genes linked to their immune systems (the cells, tissues and organs in the body that defend against infection-causing invaders like bacteria).

Two genes linked to shark immunity, dubbed *legumain* and *Bag1*, have equivalents in human beings. When a gene is expressed, the information coded for in our DNA is converted into instructions to make an end product, such as a protein. Sometimes, genes can be stimulated to overexpression, which is expression at higher than normal levels. The overexpression of *legumain* and *Bag1* in human beings is linked to cancer. That sharks have higher resistance to cancers needs more testing, but the researchers highlight this: the function of the proteins produced by these two genes in sharks has undergone changes that potentially make them more resistant to cancer. They stress that these findings don't show that ingesting shark parts will cure or prevent cancer. Rather, the high mercury content in sharks is a hazard that vastly outweighs any mythologised benefits of consuming shark products.

More than 400 million years of evolution have honed sharks for healing. This study shows that several genes relating to the immune system were found only in sharks and rays. These species also have more genes that are involved overall in the function of antibodies (proteins in the body that fight infection) compared to the bony fishes.

Efficient wound healing and potential resistance to cancer are traits attractive to human beings. This new knowledge heightens the imperative we have to protect sharks not only for their ecological role, but also for the medical discoveries they may unlock for us.

Source
Marra NJ, Richards VP, Early A, Bogdanowicz SM, Bitar PDP, Stanhope MJ and Shivji MS. 2017. Comparative transcriptomics of elasmobranchs and teleosts highlight important processes in adaptive immunity and regional endothelium. *BMC Genomics* 18(1): 87.

SAWFISH BIRTHS A BREAKTHROUGH

The first recorded birth of smalltooth sawfishes *Pristis pectinata* in the wild is a boon for scientists trying to find out where this species breeds and has its nursery sites, and whether populations in The Bahamas mix with those in Florida, USA.

On 7 December 2016, Dr Dean Grubbs, associate director of research at the Florida State University, and his team caught a female smalltooth sawfish to tag. While doing so, they discovered that she was giving birth. The researchers delivered five pups before releasing the 4.2-metre [14-foot] female to continue giving birth unassisted. Blood and DNA samples were extracted from each of the five pups and PIT tags were inserted. The mother was fitted with an acoustic transmitter and a satellite tag. Analysis of the samples and movement updates from the trackers contribute to the team's investigation into the level of interaction between populations in The Bahamas and Florida.

Previously, estuaries from Charlotte Harbor, Florida, to Florida Bay in Everglades National Park were the only areas where female smalltooth sawfishes were known to give birth. The confirmation of two pupping areas (Florida and West Andros) is critical to the species' chances of recovery. The region where the sawfish birth was recorded is part of the Andros West Side National Park, 1.3 million acres [5,260 square kilometres] of protected habitat for smalltooth sawfishes. According to Dr Grubbs, the identification and protection of critical habitats like pupping areas and nurseries is essential to sawfish survival. This knowledge, coupled with more information about genetic exchange between the US and Bahamian populations, can inform adequate conservation management of the species.

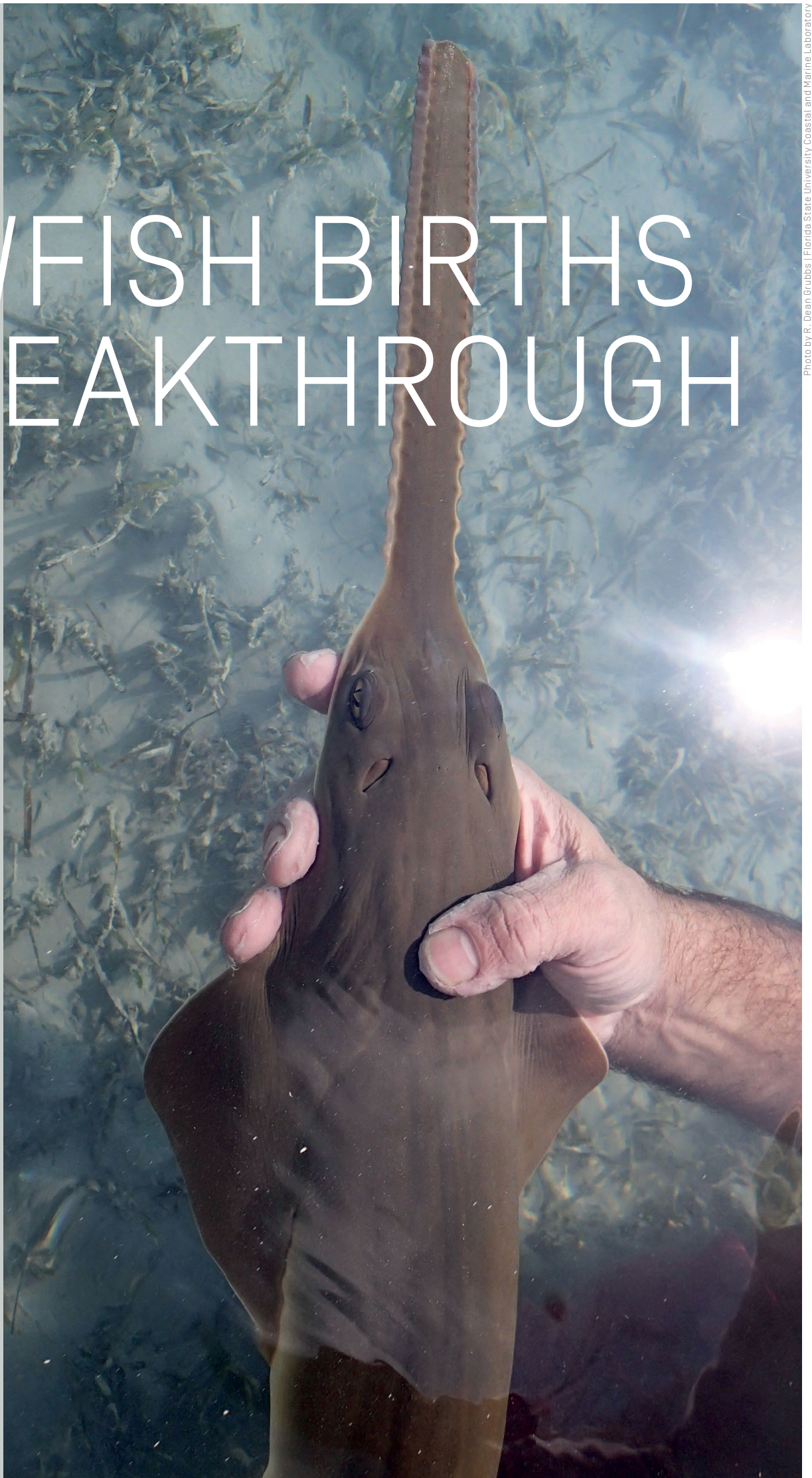
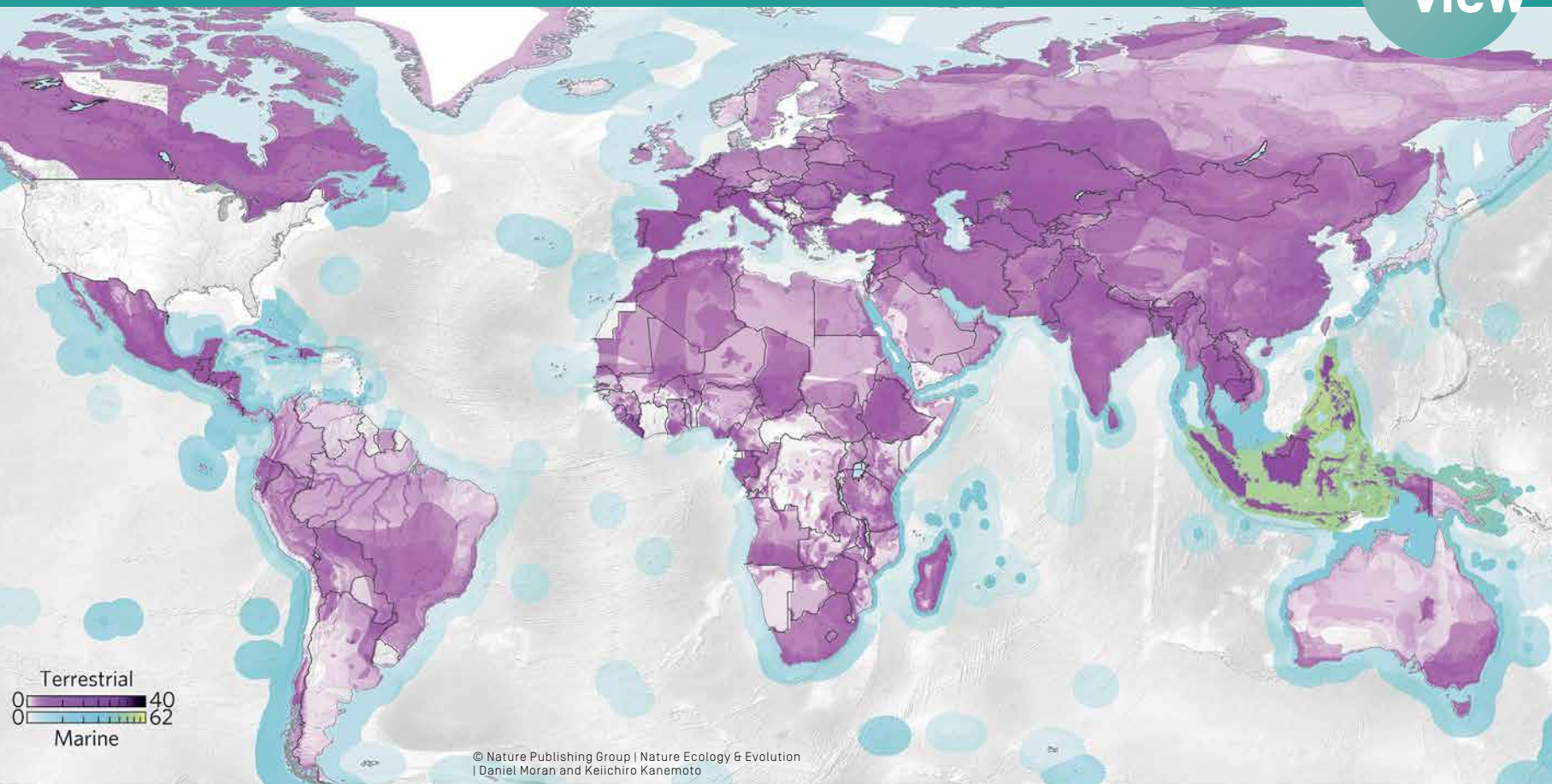


Photo by R. Dean Grubbs | Florida State University Coastal and Marine Laboratory



CONSUMERS WITH CONSERVATION

Do you check the source of your imported Ugandan coffee? And avoid products made with palm oil because you know what that means for orang-utan habitat in Borneo? Tracing the impact of your purchases is tricky, particularly when so many products are integral to our daily lives and the components of most of them are difficult to track. Like that sweater you bought, or an upgraded smartphone you need for work. New maps published this year in the science journal *Nature Ecology & Evolution* trace the products you buy to their impact on threatened species in other countries. The idea is to connect consumers with the actual impact their purchases have on conservation, so that we can take smarter steps to protect biodiversity.

Daniel Moran at the Norwegian University of Science and Technology in Trondheim and Keiichiro Kanemoto at Shinshu University in Matsumoto in Japan analysed 6,803 threatened species worldwide – species listed as Vulnerable,

Endangered or Critically Endangered on the IUCN Red List of Threatened Species. They then looked at the different products whose manufacture or sale places those species at risk. They traced the products to their final consumers in 187 countries. By laying global supply-chain information over the species-threat information, we can visualise the actual effects of trade. The result? Maps that show which countries and which products threaten species in the remaining biodiversity hotspots on earth.

‘Conservation measures must consider not just the point of impact, but also the consumer demand that ultimately drives resource use,’ say the researchers in a key statement from their paper. Simply put: it is no longer sufficient to locate where the impact is felt; we must know whence it is driven. The problem is that we externalise the true cost of the products we consume when we don’t connect them to very real conservation crises thousands of kilometres away. By understanding not only where species

are threatened, but also where demand for species consumption is driven, interventions can be more effectively leveraged.

For marine species, South-East Asia is the major hotspot of threatened biodiversity. This threat is exerted, through overfishing, pollution and aquaculture, by demand for products in the USA and the European Union. Demand in the USA also threatens species in Costa Rica, Nicaragua and at the Orinoco River mouth in Trinidad and Tobago. Species threat hotspots around Réunion, Mauritius and the Seychelles are driven by demand from the European Union. ‘Connecting observations of environmental problems to economic activity, that is the innovation here,’ Moran says in a statement published on Gemini, the research news website for the Norwegian University of Science and Technology. ‘Once you connect the environmental impact to a supply chain, then many people along that chain – not only producers – can participate in cleaning it up.’

Global hotspots of species threat linked to consumption in the United States. Darker areas indicate areas of threat hotspots driven by US consumption, based on the mix of threats exerted in each country and the mix of export goods sent to the United States for final consumption. Terrestrial and marine species colour bars are on log scales showing units of total species-equivalents, which is the sum over all the fraction of species threats allocated to this consumer country.

Sources
Moran D, Kanemoto K. 2017. Identifying species threat hotspots from global supply chains. *Nature Ecology & Evolution* 1: 23.

We know of only three species that enter menopause: short-finned pilot whales, orcas and human beings. Scientists have long been baffled by the phenomenon. After all if, as evolutionary biology suggests, the purpose of life is to pass on your genes, why give up reproducing before the end of your lifespan?

Previous studies suggested that the biological drive behind menopause – at least in orcas – lies in their complex social structure. Research showed that matriarchal killer whales continue to care for their pods long after reaching menopause (they become infertile in their 30s or 40s but can live for more than a century) and that the whole group benefits from their continued survival as ‘repositories of ecological knowledge’. The same is true for humans and has been termed ‘the grandmother effect’. Now, a new study that examined

the same resident orcas in the Pacific Northwest has taken the theory one level deeper – and darker.

The research suggests that it is not just the altruistic nature of grandmothers that drives menopause, but rather the favouritism exhibited by their daughters. The research team, from the University of Exeter in the United Kingdom, examined 43 years of data, during which 525 calves were born. In 161 of these births, older females produced calves at the same time as their daughters did. And in about 31% of these cogeneration births, the calves died, with the mortality of the older females’ calves being 1.7 times higher than that of the younger females’.

‘It’s a tug of war between young and old females, and the young pull harder,’ behavioural ecologist Darren Croft told *Hakai Magazine*.

One of the key dynamics of resident orcas is that a female will stay with the

pod for her entire life, eventually bringing her own offspring into the fold. As the family grows over time, an older female will find that her own gene pool has spread increasingly wide within the pod. While a young mother, with fewer offspring, will fiercely prioritise her own calf, older females are less inclined to show favouritism towards their youngest progeny, choosing rather to ‘spread the love’ among all their relatives. Thus, for these orcas – and perhaps for human beings as well – a rare and sophisticated family structure that leads to both cooperation and breeding competition between generations has made menopause a sensible evolutionary strategy.

ocean
view

PLAYING FAVOURITES



BY THE SKIN OF THEIR TEETH?



ocean
view

Being able to tear and chew food was a revolutionary step in the ability of species to consume energy, and sharks – as some of the earliest animals to have teeth and jaws – hold important clues for understanding the evolution of teeth throughout the natural world. Until recently, it was widely believed that shark teeth evolved from the dermal denticles that cover the animals' bodies, eventually migrating into their mouths. However, a new study suggests that it was taste rather than touch that gave rise to modern teeth.

A research team from the University of Sheffield in the United Kingdom examined the stem cells of a shark embryo during its development and found that both teeth and taste buds develop from the same cells in the embryo's mouth. While some animals, including humans, have taste buds on their tongues, sharks have finger-like buds that line the mouth and pharynx and are concentrated mostly on the soft tissue just behind the teeth. By tracking the development of embryonic stem cells in the shark's mouth, the researchers established not only that these cells are the building blocks of both taste buds and teeth, but also that they hold the secret to a shark's ability to regenerate teeth – and taste buds – throughout their life.

The connection between shark teeth and dermal denticles proved to be far less convincing. Although made of similar materials as teeth and taste buds, denticles are unable to regenerate. At a genetic level, the make-up of denticles and tooth cells are almost identical, except that a gene known as *sox2*, which governs regeneration in many tissues of the body, is expressed in taste buds and teeth but not in dermal denticles.

We already know that in ancient fishes taste buds evolved before oral teeth did because they are present in jawless fishes

like lampreys. So although 'skin teeth' [denticles] may look very similar to oral teeth, it is not surprising that a few pioneering taste-bud cells are the true originators of the modern shark tooth, giving sharks the ability to taste and tear their food simultaneously.



A new proposal by the National Oceanic and Atmospheric Administration (NOAA) could bring about protection for oceanic whitetips in US waters under the Endangered Species Act (ESA). However, discussions currently under way in Congress are making the future of the ESA, and all listed species, uncertain.

In September 2015, wildlife advocates Defenders of Wildlife issued a petition for the protection of the oceanic whitetip. After almost a year of gathering information about the status of the species, NOAA concluded that it is likely to become endangered throughout all, or a significant portion, of its range within the foreseeable future due to its vulnerability to being taken as by-catch in pelagic fisheries. The high value of the oceanic

whitetip's large fins in the international fin trade, despite its protected status under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) was also a consideration. Accordingly, in late December 2016 NOAA released a proposal to add the oceanic whitetip to the ESA as a threatened species.

To assess the whitetip's status, NOAA consulted with numerous experts, including geneticist Cassandra Ruck of the Save Our Seas Foundation's Shark Research Center. Ruck used genetics to investigate the species' global population structure and global trends in its genetic diversity. 'Understanding population structure is critical for defining management units for scientifically based management strategies,' she explained.

'Genetic diversity assessments also enable managers to make priority decisions, as they can reveal particularly vulnerable populations with lower genetic diversity, as well as opportunities to maintain populations with higher genetic diversity.'

The 90-day public comment period on the listing ended on 29 March 2017 and a final decision is expected by 29 December 2017. However, the efforts of Defenders of Wildlife and NOAA may bear little or no fruit for conservation, following a recent Senate hearing to 'modernise' the ESA. Some officials argue that the Act's legislation impacts on their ability to create jobs, particularly in the energy sector.

WHITETIP SHARKS – AND US ENVIRONMENTAL LEGISLATION – UNDER THREAT

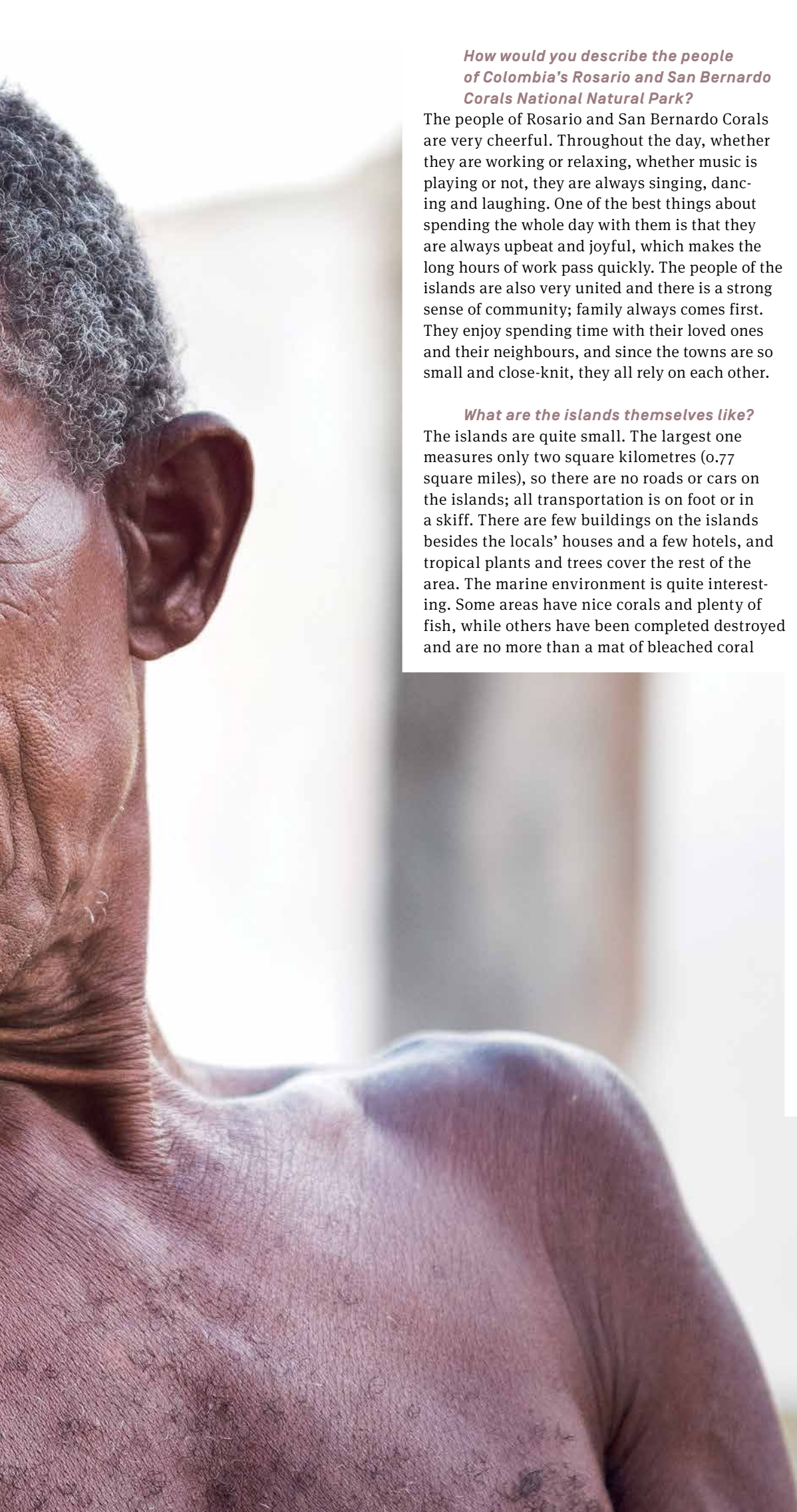


Photo by Brian J. Skerry | National Geographic Creative

Camila spent weeks with communities in Colombia's Rosario and San Bernardo Corals National Park, interviewing artisanal fishers. She met this fisherman at Barú, one of her field sites. Like many of the men Camila spoke to, he held a baby on his lap during the interview. He said that he hoped his grandchild would not become a fisher because it is becoming harder and harder to make a living from the sea.

From the field

A short interview with Camila Cáceres



How would you describe the people of Colombia's Rosario and San Bernardo Corals National Natural Park?

The people of Rosario and San Bernardo Corals are very cheerful. Throughout the day, whether they are working or relaxing, whether music is playing or not, they are always singing, dancing and laughing. One of the best things about spending the whole day with them is that they are always upbeat and joyful, which makes the long hours of work pass quickly. The people of the islands are also very united and there is a strong sense of community; family always comes first. They enjoy spending time with their loved ones and their neighbours, and since the towns are so small and close-knit, they all rely on each other.

What are the islands themselves like?

The islands are quite small. The largest one measures only two square kilometres (0.77 square miles), so there are no roads or cars on the islands; all transportation is on foot or in a skiff. There are few buildings on the islands besides the locals' houses and a few hotels, and tropical plants and trees cover the rest of the area. The marine environment is quite interesting. Some areas have nice corals and plenty of fish, while others have been completely destroyed and are no more than a mat of bleached coral

covering the sea floor, with almost no fish. I think this is because some islands rely mostly on tourism and others rely more on their artisanal fisheries for their livelihoods.

What is the first thing you say when interviewing people about local fisheries?

Sometimes fishers are a bit suspicious, even confused, when a young female 'from the city' (not a native islander) wanders around asking questions, so the first thing I tell them is that I am student who wants to learn from them (not about them). I tell them that since I am not able to stay on the island year-round, I want to learn from the people who know the reefs best, who spend many hours a day, day after day, working for their entire lives on the reefs – I want to learn from them. There's no question that I, as an outsider and a sporadic visitor, could ever know as much as the fishers who have grown up along those reefs. I think that recognising this fact really helps the fishers to open up.

How do you spend your time at the islands when you are not working?

While conducting my fisher interviews in Colombia, I was simultaneously deploying BRUVS for Global FinPrint, so for two months straight I did not take a day off. If we had bad weather days, which we had a lot of due to Hurricane Matthew, all the fishers would stay on the island and I would interview them. If the weather and visibility were good, I was out on a boat setting up cameras. Also, since we had limited to no electricity, we could not watch television or read a book when we returned from our day in the field, so we were asleep by nightfall and awake at sunrise.

Do you know any local customs or beliefs that illustrate people's relationship with their environment?

Not really... I mean, a lot of the fishermen believe that ray meat is an aphrodisiac. They all told me that if I gave my husband ray for dinner he would not leave me alone all night. It seems that sharing a meal of ray is considered very romantic and erotic, an important part of any night with a significant other. Besides that, I didn't learn any other local customs.





SAW

Two young men in northern Mozambique show the contrast in size between the small rostrum of a just-born largetooth sawfish and the huge, heavy rostrum of a mature animal of the same species. The latter came from a sawfish caught in 2014 by a fisherman in northern Mozambique – the fisherman’s nephew and son are pictured here.



FISH

THE KING OF THE FISHES
WORDS BY RUTH LEENEY

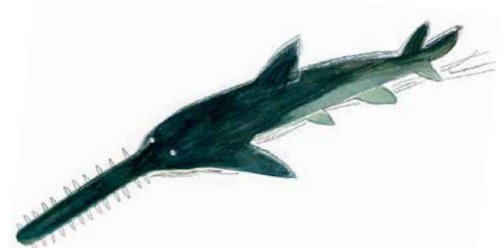
Our knowledge of sawfishes may be limited, but we can be fairly sure that they were once far more abundant than they are today. In a bid to establish just where they occurred, where they no longer occur and where they may be just hanging on, Ruth Leeney is conducting interviews with artisanal fishers – and in Madagascar has found ‘the king’.



Photo by Lynn Johnson | National Geographic Creative



A fisherman at work against a backdrop of silhouetted baobab trees at twilight.



At first I thought nothing of it. Distracted by the task ahead – setting a net 100 metres (330 feet) long, just before midnight – I assumed that the moon was full and busied myself with disentangling the net and checking the floats, grateful for the pale gleam that surrounded us. But the sky was dark; it was the sea glowing all around, green and blue, as if lit from below by a huge spotlight. As the boat picked up speed, the water dancing off its bow looked like sparks of blue fire. Laughing in delight, I dipped my hand in the water and brought up droplets of glittering turquoise. At that moment, we were a tiny bubble of phosphorescence in a sea of darkness.

Mahajamba Bay is a huge, jellyfish-shaped bay on the north-western coast of Madagascar. Its shores are hard to reach: over land, it takes several uncomfortable days in public transport from Majunga, the nearest large town. A sail boat is faster, but more precarious. This relative isolation might, I hoped, have offered the region some protection from overfishing and the exploitation of resources such as mangrove timber. However, in my conversations with local people it became apparent that activities far inland, in parts of this great red island where the local people have never even seen the sea, were having an impact on the communities and ecosystems of Mahajamba Bay.

Two rivers, the Sofia and the Mahajamba, flow into the bay, but local fishermen told me that in recent years the mouth of the Sofia has become too shallow for their boats, preventing them from entering the river to fish. I heard similar stories from fishers along some of Madagascar's other major rivers, too. This siltation – the accretion of sediment at the river mouth – is probably due to erosion occurring far upriver. Erosion is a natural phenomenon, but has been accelerated in recent decades by deforestation and intensive farming practices. International aid and development agencies have described Madagascar's erosion rate as one of the highest in the world. Even far out in the bay, the water around us was the colour of hot chocolate, not

at all the tropical azure I had imagined the Indian Ocean to be.

Tangles of channels edged with lush swathes of mangroves lead away from the bay. The first fishermen I interviewed in this region were a group of subsistence fishers who had a camp – little more than a rickety collection of mangrove-wood planks forming three walls and a partial roof – on a bank of one of the mangrove creeks. They had no running water and certainly no electricity; essentially they had nothing more than their small wooden canoes.

Two of the fishers joined us in our boat to point out the deep pools where, they said, sawfishes can be found. They had seen sawfishes, known locally as *vavana*, a number of times in the local network of mangrove creeks where they fish, and one fisher told me that he had seen one just a month before our interview, but had not caught it. They call the sawfish *le roi des poissons* – the king of the fishes – and said that generally it was considered *fady* (taboo) to catch one. 'Only if God wants you to, then you can catch a sawfish,' they say, 'but we don't try to catch them.'

Sawfishes have a significance in many traditional cultures around the world. In West Africa, they are a symbol of strength and protection; in some places, their rostra are displayed on the roofs of houses or in front of cattle pens to ward off evil spirits. But aside from what the fishers in Mahajamba Bay told me, I heard little to suggest that sawfishes have a special significance in Madagascar. Rather, some fishermen spoke of the guitarfish as a benevolent spirit and recounted a traditional story in which fishermen whose boat had capsized were saved by a giant guitarfish, which lifted them onto its back and carried them to the shore. Because of this story, it was strictly taboo to catch guitarfishes in many Malagasy fishing communities. And now? Unfortunately times have changed, an older fisher explained, and there are those who are willing to ignore their traditional beliefs because they know that the fins of just one guitarfish can fetch a significant sale price. The fins





Much of Ruth's work relies on interviews with fishing communities. She asks them about the significance of sawfishes in their culture and when the animals were last seen. She also looks for physical evidence. In this image, she is discussing how sawfishes use their rostra with local children in northern Mozambique.

of sawfishes are almost as valuable, as most fishermen in Madagascar are only too well aware.

According to a fisherman I spoke with in northern Madagascar, if someone catches a sawfish, the local wisdom advises that they continue to fish in the same area. One or two days later, they would be sure to catch another sawfish. He said this is because sawfishes are reliably found in male-female 'couples'. '*Vavana ... ils sont très amoureux. Si vous attrapez l'un, surement vous attrapez l'autre.*' ('Sawfishes ... they are very loving. If you catch one, you are certain to catch the other.')

Interestingly, I have heard similar stories relating to sawfishes travelling and even feeding in pairs from fishers in Mozambique and even as far away as The Gambia, which suggests that there may be more than just folklore to this belief. This is only one of the many unknown aspects of the lives of these mysterious animals that I hope to learn more about as my work moves from baseline studies – developing a basic understanding of where sawfishes still exist and where research and conservation efforts will be viable – to understanding their ecology and how their fate is intertwined with that of the human communities around them.

Sawfishes were formerly found in coastal waters throughout the tropics and subtropics, but populations globally have declined dramatically in recent decades and in many countries where sawfishes were formerly abundant they are now locally extinct. This precipitous decline probably results from a combination of multiple factors: their vulnerability to being caught accidentally in fishing nets and lines, as well as their targeted capture for the shark-fin industry; the destruction and degradation of their coastal and estuarine habitats; and their low reproductive rate. While it is too late for many sawfish populations, there is some hope that immediate action may prevent others from succumbing to the same fate.



Further into Mahajamba Bay, the phosphorescence had gone and quiet darkness enveloped us as we began to set the net, careful not to entangle our toes in the mesh as, hand over hand, it slipped into the blackness alongside. Such enchanted moments are fleeting; the reality of life in these far-flung corners of rural Madagascar is far from magical. There is limited or no access to schools or health care, and opportunities to improve daily life are few. In many cases, dwindling fish stocks mean that families struggle just to get enough to eat. Communities along Madagascar's coasts and rivers are largely dependent on anything they can catch as a means of survival.

If sawfishes are to be protected effectively in such areas, we must develop conservation approaches that address not only the threats to sawfishes and their habitats, but also the needs of the human communities in and adjacent to those habitats. Education is a critical component of any conservation effort, to help communities understand why it is important to protect their local population of sawfishes and how they will benefit from doing so.

I have developed an educational book that explains how balanced ecosystems – those that include sawfishes, other top predators and mangroves – are healthy ecosystems that protect and provide for the human communities dependent on them. Such communities often have little or no access to educational resources and *The King of the Fishes*, inspired by the name given to the sawfish by fishers in Mahajamba Bay, has been developed with them in mind. The book has been published by the Save Our Seas Foundation and will be distributed in fishing communities in Madagascar later in 2017, as part of a longer-term strategy to encourage a sense of stewardship for sawfishes and their habitats. ●



A fisherman and his wife rest in their pirogue after setting their nets among the mangroves in northern Madagascar. Engaging with fishing communities is critical if we are to protect Africa's remaining sawfishes.



To conduct her field work, Ruth travelled to very isolated fishing communities throughout Africa. This rusty ferry took her from Madagascar's second largest city, Mahajanga, across Bombetoka Bay and into the remote and wild north-western corner of the country.



Sawfish rostra often appear on the stalls of some tourist markets in Madagascar. These vendors kindly allowed Ruth to photograph and measure the rostra they had for sale.



Collecting measurement data from sawfish rostra will help us to understand whether largetooth sawfishes in the Western Indian Ocean have the same morphology as populations of this species elsewhere in the world.



Working in collaboration with local conservation NGOs, we provide sawfish posters to fishing communities. Through focus groups and community meetings, we also ask fishers to report any sawfish catches to the NGO representatives in their area.





Liberia

My study in Liberia focused on only one small section of the coastline, Lake Piso, where anecdotal reports had suggested that sawfishes may be present. However, many of the fishers I interviewed had never encountered one, indicating that sawfishes are not common there, at least in recent years.



Guinea-Bissau

Sawfish imagery features in the traditional ceremonies of the people of the Bijagos Archipelago, off the coast of Guinea-Bissau. Until recently, this region was thought to be the last stronghold for sawfishes in West Africa. However, interviews both on the mainland and in the archipelago revealed that there have been few recent catches of sawfishes, suggesting they are now rare. Fishing pressure, from industrial vessels operating illegally in coastal waters and from the vast numbers of migratory artisanal fishers who travel the length of West Africa's coast searching for new fishing grounds to exploit, may have contributed to the decline of sawfishes.



The Gambia

Recently unearthed research from the 1970s documented the importance of the Gambia River as a habitat for juvenile largetooth sawfishes. Forty years later, I interviewed fishermen along the river and coast and found little evidence to suggest that sawfishes are still encountered. This population now appears to be locally extinct.



Ruth Leeney with a sawfish rostrum. Some fishermen keep sawfish rostra for decorative purposes.



Madagascar

I have found more sawfish rostra in Madagascar than anywhere else I have worked. It seems highly likely that sawfishes are present in this country, possibly in three or more distinct habitats. In 2017 I hope to conduct sampling by means of gill nets to verify the presence of sawfishes. If successful, I also intend to encourage Madagascar's Ministry of Fisheries to develop a national sawfish conservation strategy.



Sawfishes: where they are – or were

Since 2012, I have conducted research to learn more about sawfish populations in eight countries in Africa, Asia and South America. The main aims of such a wide-reaching undertaking were to better understand in which areas future research and management efforts should focus and to document where sawfishes may already be extinct. With this knowledge, it will be possible to make a much smarter allocation of limited financial resources, to the areas where they are most needed. Here are some of the key findings from this work:

Mozambique

Interviews with fishers in Mozambique leave no doubt in my mind that sawfishes are still caught along the northern part of the coast. The logistics of working in this part of the country are complex, however, and recent political unrest and violence in the region have made it challenging to learn more.

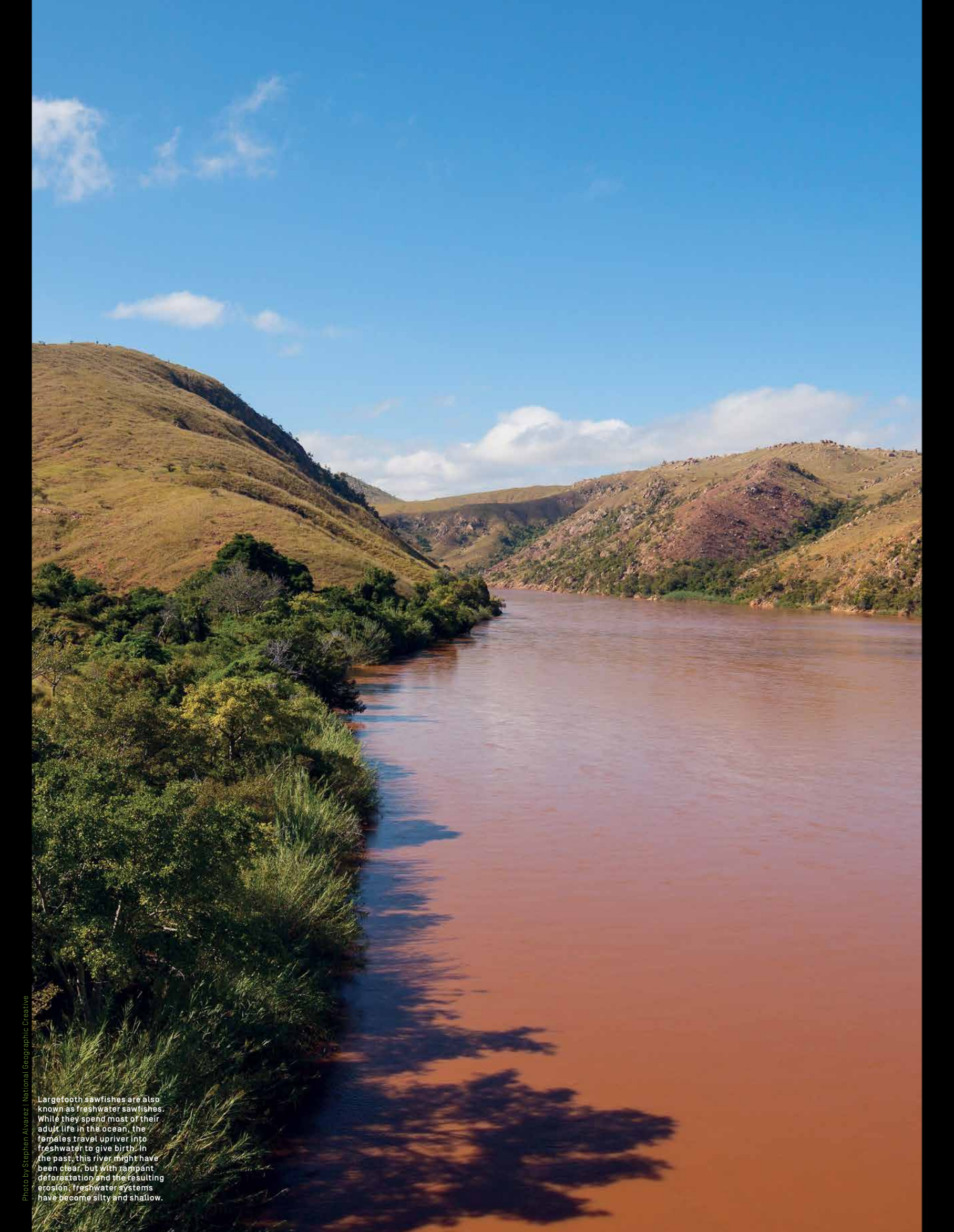


Peru and Ecuador

Sawfishes were previously thought to occur only occasionally in Peruvian waters, but interviews suggest that largetooth sawfishes were encountered quite often by fishermen in the north. There have been some very recent catches of sawfishes in this region, including an adult sawfish caught off northern Peru in February 2015, which was released alive thanks to the education activities of a local NGO. In some South American countries where cockfighting is a popular pastime, the teeth from sawfish rostra have been used as the *espuelas*, or spurs, that are attached to the legs of roosters to injure their opponent.

The Philippines

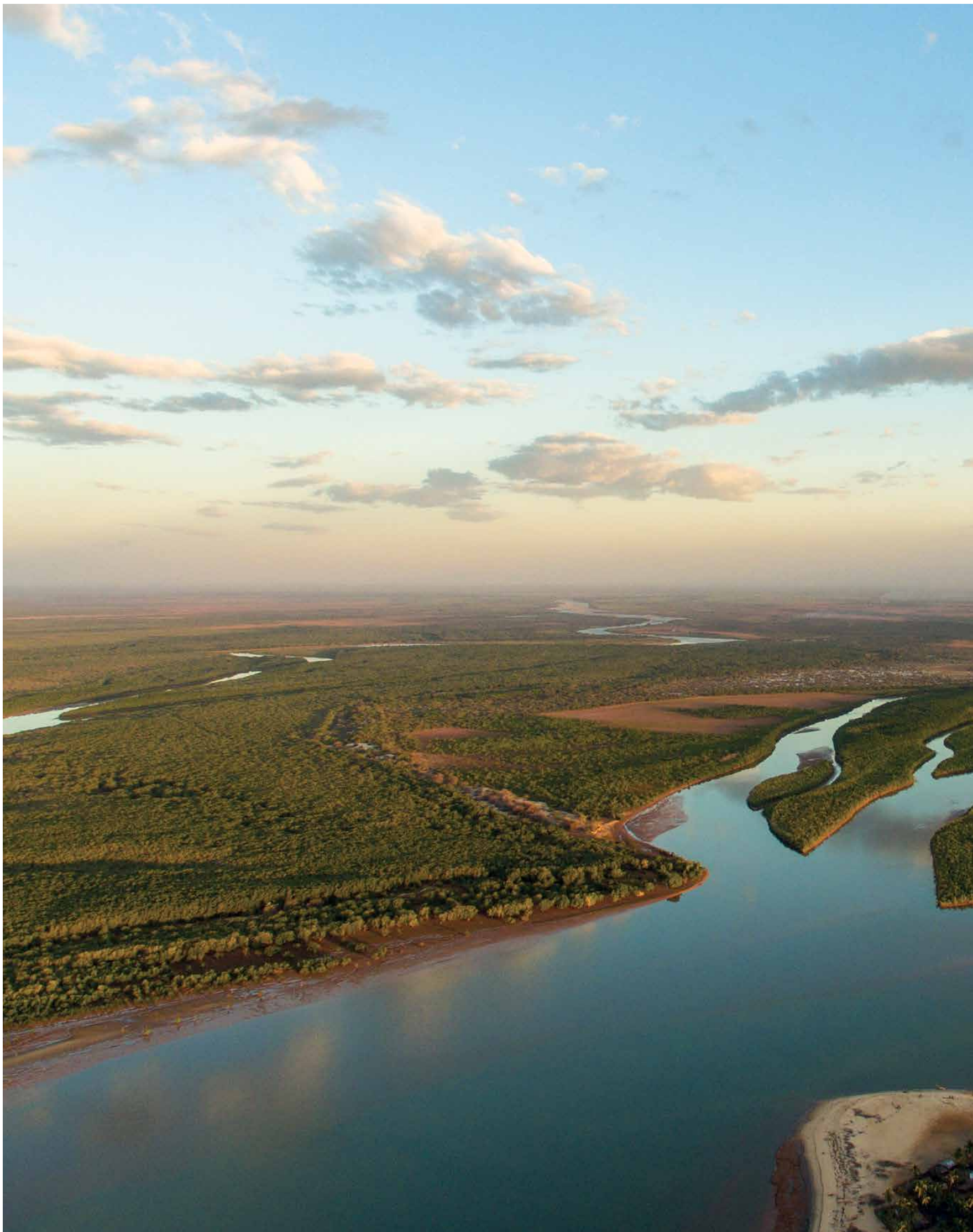
The fish stocks and coastal and riverine habitats of the Philippines are highly degraded and under considerable pressure from a growing human population. Older fishermen around some of the country's large rivers recalled having seen sawfishes in their youth, but no one spoke of catching any in recent decades. A largetooth sawfish was landed in Mindanao in 2014, but overall it seems likely that sawfishes are locally extinct around the Philippines.



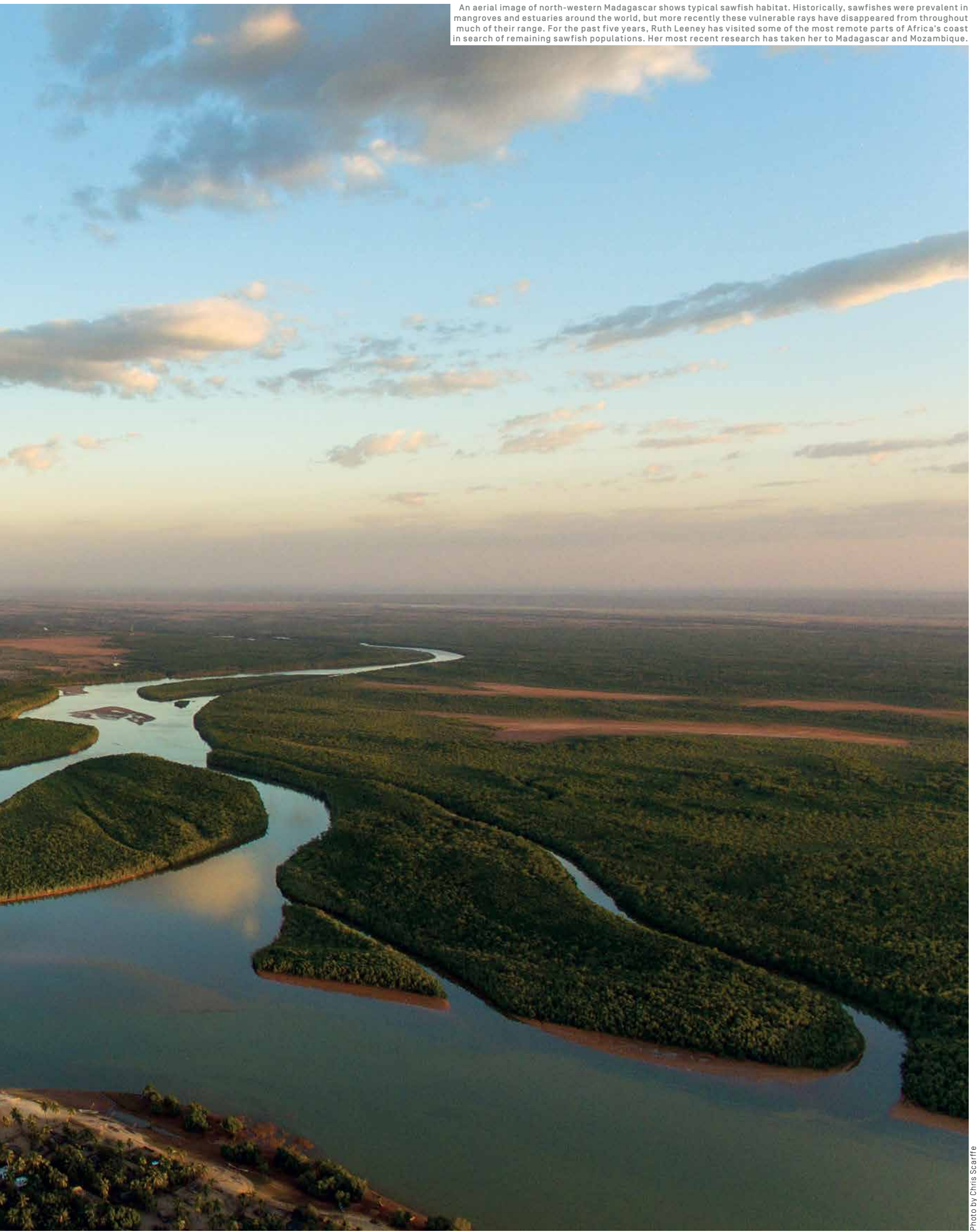
Large-tooth sawfishes are also known as freshwater sawfishes. While they spend most of their adult life in the ocean, the females travel upriver into freshwater to give birth. In the past, this river might have been clear, but with rampant deforestation and the resulting erosion, freshwater systems have become silty and shallow.



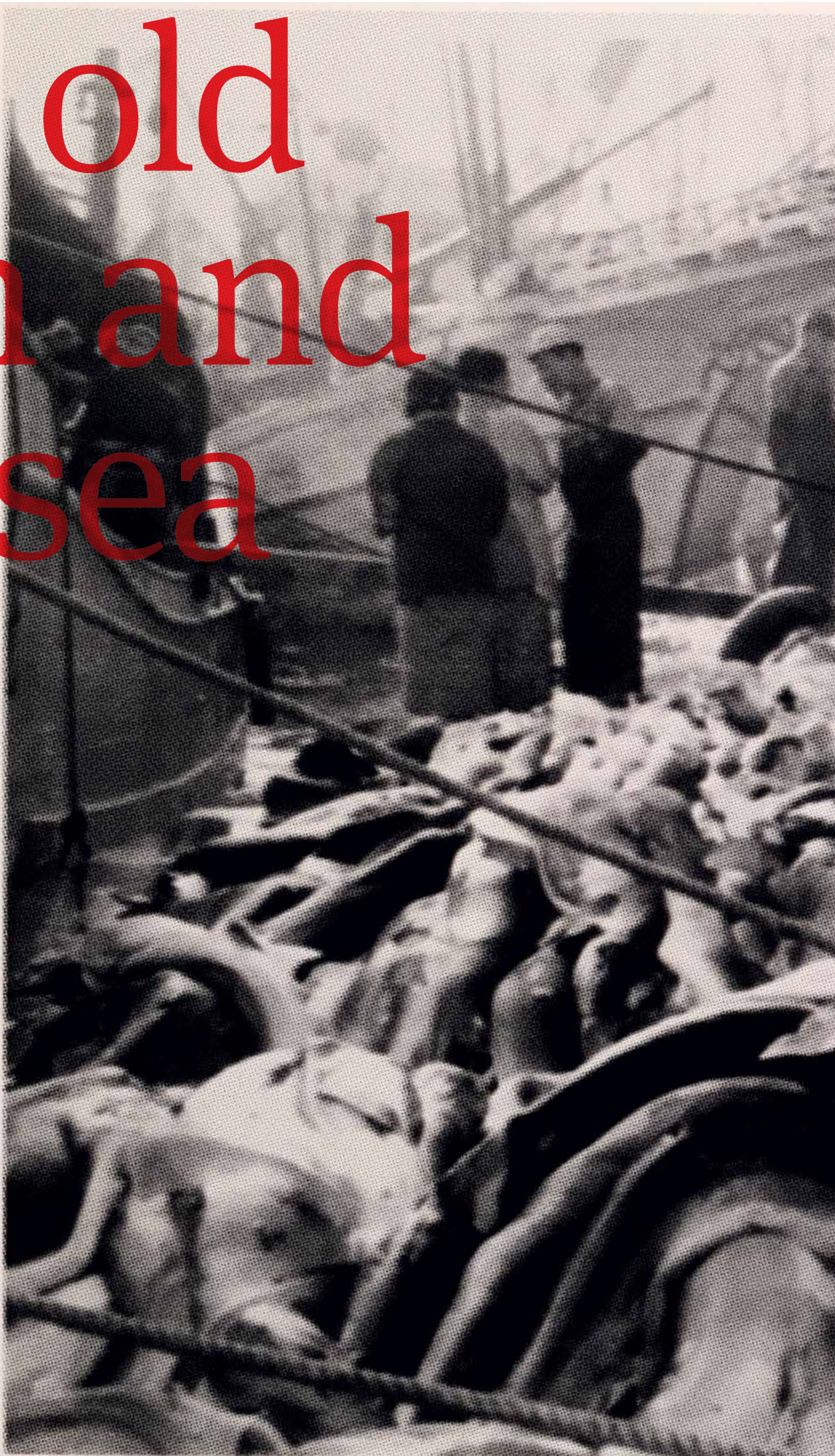
A largetooth sawfish can grow to a length of seven metres (23 feet) and its rostrum may be 25% of its total length. This rostrum, kept by a fisherman after he caught an adult sawfish in 2014, is more than 1.14 metres (almost four feet) long.



An aerial image of north-western Madagascar shows typical sawfish habitat. Historically, sawfishes were prevalent in mangroves and estuaries around the world, but more recently these vulnerable rays have disappeared from throughout much of their range. For the past five years, Ruth Leeney has visited some of the most remote parts of Africa's coast in search of remaining sawfish populations. Her most recent research has taken her to Madagascar and Mozambique.



The old men and the sea



A 1959 archive image from the Rias Ark Museum in Kesenuma shows the shark catch at the city's dock, one of the most important landing sites in Japan.

Photo by Tadakazu Nakajima | Rias Ark Museum of Art



サメの水揚げ

昭和三四年

撮影—中嶋忠一







Words by Mareike Dornhege

A frequent visitor to the docks of Kesenuma, Japan's busiest landing port for sharks, Mareike Dornhege recognises the value of learning from Japanese fishermen, the veterans of the Pacific shark fishery.

I am hopping from one leg to the other, rubbing my palms in a futile attempt to warm them. It is 4 am on a cold January morning on the Pacific coast of northern Japan and I am standing on the dock at Kesennuma. Japan is currently the globe's 10th biggest shark-fishing nation and Kesennuma is responsible for about 80% of the landings. I am watching a 30-ton drift-net vessel unload its catch of dozens of salmon sharks. Crows and seagulls circle overhead as port workers lay out the sharks' bodies in neat rows on the brightly lit dock. At the far end, longfin mako, shortfin mako, hammerhead and a few thresher sharks are on display for potential buyers, next to large piles of hundreds of blue sharks. It is this species that makes up about 80% of the landings.

It is a noisy and busy place and the port worker at my side is concerned that I might slip on one of the puddles of frozen water and blood, or perhaps collide with one of the many forklifts scooting quickly back and forth behind me. I smile at the captain of a salmon shark vessel who is cleaning up on deck and remark on how neat his wooden-decked boat looks. Eagerly he begins to tell me of his four-day fishing trip to the northern tip of the main island of Japan in search of salmon sharks. The trip was clearly successful, as I watch his small crew unloading more large adult salmon sharks from the hold, lifting them by the tail fin one by one with a rope and crane, careful not to sever their still-whole bodies.

'How do you know where to find them?' I ask. In the thick accent of northern Japan, he explains to me that sharks 'ride the currents' and he has learnt to follow their seasonal migration over the years.

For a moment I forget about the noise, the cold and the wind as I absorb first-hand knowledge about the behavioural ecology of salmon sharks. I am fascinated by his detailed understanding of their movement patterns and sexual and age disparity. Contemplating that visits such as this might prove even more interesting than I have envisaged, I follow a member of the port staff to see the operations of the dock's central office.

Gladly I accept a hot coffee from a young dock worker as we take our places for a run-down into the workings of a fishing dock that on most weekdays handles several tons of fish, including tuna, bonito, billfish, sharks and Pacific saury, not to mention catches of coastal delicacies such as seaweeds and even sea squirts. Many of the other staff members eye me suspiciously. Few women work here and those that do are definitely not foreigners. I realise that I will have to break down a few barriers. This is my third visit already and only now am I finally allowed to conduct interviews.

'We've had bad experiences,' explains one of them with a shrug. Western journalists came, took photographs of their shark catch and sold them to newspapers for sensational stories telling how Kesennuma fishermen ruthlessly hunt sharks to extinction. Although media coverage about the dire need to conserve sharks is vitally important to inform the wider public of our work, such reports that include no scientific background or statements from the local community can do more harm than good. In the worst-case scenario, they harden the front between fishermen and scientists or NGO workers, hampering progress on sustainable fisheries management.

The fisheries cooperatives in a few ports arrange for me to meet some retired long-line fishermen. Most are in their 80s and, having started fishing in the 1960s, they have decades of experience. A few active fishermen in their 40s join us. The fishermen explain their gear and methods in great



Photo by Jeremy Sutton-Hibbert



Photo by Keita Iijima | The Yomiuri Shimbun | AP Images





← Finning at sea is prohibited for Kesennuma fleets and is done on the dock.

↓ Dried fins are exported mainly to Hong Kong and mainland China.

↓↓ Besides shark fin soup, a variety of shark meat products are consumed in Japan.



Photo by Jeremy Sutton-Hibbert



detail and one even goes to fetch some equipment to show me.

I am testing the strength of their monofilament leaders and comparing J-hooks and circle hooks when a retired captain in his late 70s explains how the latter can be easily removed from the mouth of a sea turtle taken as by-catch. My own jaw drops as they all nod in agreement when he tells me that turtles are viewed as gods and must be released back into the water – but only after they have been blessed with salt and sake, both of which are used for various sacred purposes in Shinto, Japan’s national religion. Circle hooks also snare sharks, though not as deeply as the much straighter J-hooks do. A shark caught on a circle hook has a greater chance of survival if it is subsequently released.

The fishermen tell me of all the shark species they can no longer land since 2014. More forbidden species followed in 2016, shrinking the pool of shark species they are allowed to catch to only seven. It seems that their fishery has undergone a lot of change in the past decade.

‘It’s true,’ they confirm, telling me that for decades they had only one goal: to catch bluefin tuna. An individual tuna could sell for thousands of dollars, depending on its size and the fattiness of the flesh. Sharks were merely by-catch. But as tuna stocks dwindled, the fishermen’s targets changed to billfish and sharks, even though they fetched a fraction of the price for tuna.

When I ask about the changing state of stocks, several reasons are given. Overfishing seems to be an important one and all Pacific fleets appear to be culprits, including illegal vessels that these fishermen regularly report to the coastguard. The effects of climate change are also mentioned. The oldest of the fishermen is concerned that their target species are not finding enough food; another says that they are catching more hammerheads further north than ever.

I notice a gap in their perceptions. Most of the fishermen in their 70s and 80s report that there used to be up to three times as many fish in the ocean as there are now. Bluefin tuna has almost completely disappeared; there is less change in catches of blue sharks, more in catches of carcharinid species. But the younger fishermen, with one or two decades of experience, paint a different picture. They have seen few changes in shark stocks – and fish stocks in general – although some say the fish are smaller.

This phenomenon, also known as the ‘shifting baseline syndrome’, is reported for more and more marine ecosystems around the world. There are often no detailed scientific records for fishing activities more than 30 years ago. Interviews with fishermen of different age groups can fill in this gap. Their accounts, authenticated by old records, literature and photographs, can give a comprehensive and robust image of the oceans of the past.

To get a better understanding of historical fish stocks and fisheries I go on a scavenger hunt, collecting more pieces to complete the puzzle of what I have heard. This leads me first to the local museum in Kesennuma, which has a collection of old fishing gear, fishermen’s kimonos painted with sharks (showing that the relationship between fishermen and sharks is not new) and, most interestingly, photos showing shark landings in the 1960s. They comprised mainly of blue sharks and, to my great surprise, the quantity is comparable to the landings of today.

Next, the national library provides me with records of shark meat being used as a staple food for more than 500 years all over Japan. However, my interest is piqued by the changing species that are mentioned in landings, in recipes and in general. As we enter the 20th century, there is a clear trend away from coastal species and towards pelagic ones.

My final visits take me to the processors of shark fins and meat in Japan. Most of the companies are family-run businesses in their second or third generation. I am usually greeted by the son or daughter, often appointed managing director, who is frequently about my age. In the best interviews, two generations attend together. Once again the older generation reports a shift, this time in the species processed. At the beginning of the 20th century it was mainly coastal spiny dogfish, but this population is reported to have crashed in the early part of the century and by the mid-1900s large landings of blue shark were being processed at Kesennuma.

All the interviewees agree that their businesses are family concerns and they want to pass them down to the next generation. They also know they can only do so by following sustainable fishing and processing practices, which they want to achieve together with fisheries managers, scientists and consultants.

On a sweltering summer day, I make a return visit to the landing docks of northern Japan. After two years, it has finally happened: I am allowed to attend an annual meeting of the long-line captains. It turns out to be one of the most memorable days of my project, when I witness a new dimension in shark fisheries.

For years, the longline fishing fleets have been shrinking; big catches of tuna have turned into a far-away dream of yesteryear. Instead, the fishermen are trying to survive on billfish and shark landings, which only rake in a fraction of the money the men used to earn. The fisheries cooperatives, the Japanese government and the Western Central Pacific Fisheries Commission (WCPFC), the regional fisheries management organisation, are tightening the rules year by year: more shark species that can no longer be landed, stricter regulations on gear. In this meeting even quotas on shark landings are now being discussed. The Japanese are known for their polite manners, but here I see a bulky, broad-shouldered captain in his 50s lose his temper. How is he to survive under these regulations? If the trend continues, his vessel will be the next to leave the fleet.

Silence follows his outburst. The other fishermen, the government officials, the fisheries scientists – no-one has a solution to his dilemma. For the first time I see the fishermen’s despair and realise just how charged this topic is.

As much as fishermen are part of the overfishing problem – the main threat to shark species worldwide – they can also be part of the solution. I have learnt so much from these men over the past two years as they shared decades of observations on the high seas. Their knowledge can serve as a starting point for scientists to investigate sexual and age separation and mating and pupping grounds in oceanic shark species, which so far remain uncharted territory to us. Fishermen can give detailed accounts of patterns of behavioural ecology that they have observed repeatedly.

If we are to successfully apply policies and management measures aimed at sustainability, we will need to involve the fishermen. And it is possible that a mutual understanding would not only make these policies and measures work more smoothly, but also help scientists to gain a deeper knowledge of shark ecology – and that in turn can help us to devise better policies. ●



Salmon sharks are a target species of the driftnet fishery in northern Japan.





Fishing is an ageing profession in Japan and unpopular with the younger generation. The average age of fishermen is now above 50 years old.



Photo by Takumi Harada | AP, Yomiuri Shimbun | Keystone

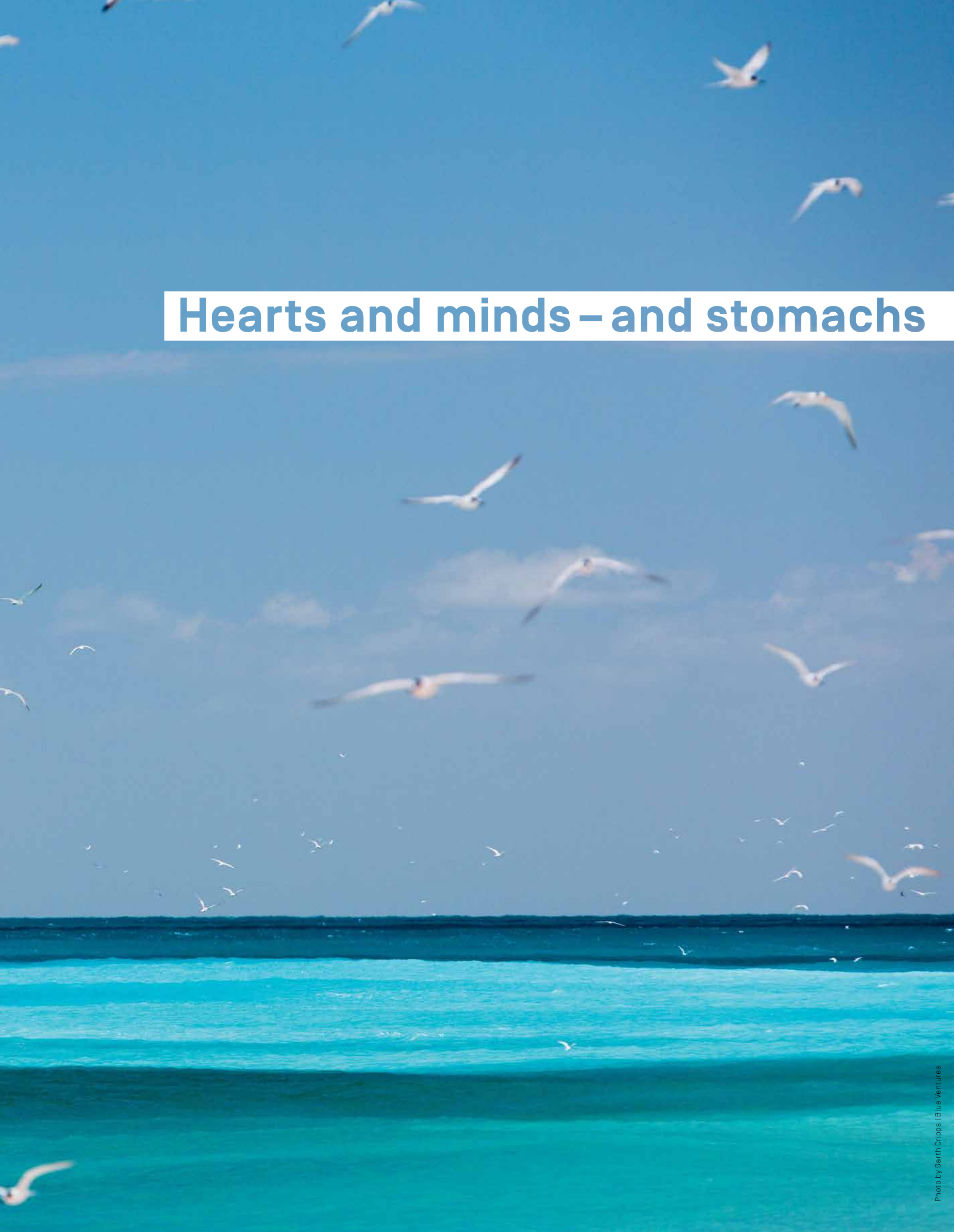
Conservation came late to the Western world, it seems, starting only in the 17th century. Elsewhere people had been living within – and respectful of – their environment for hundreds, even thousands, of years. Philippa Ehrlich talks to modern researchers and conservationists who have learnt to empathise with communities whose survival depends on living in harmony with the world around them.

Words by Philippa Ehrlich

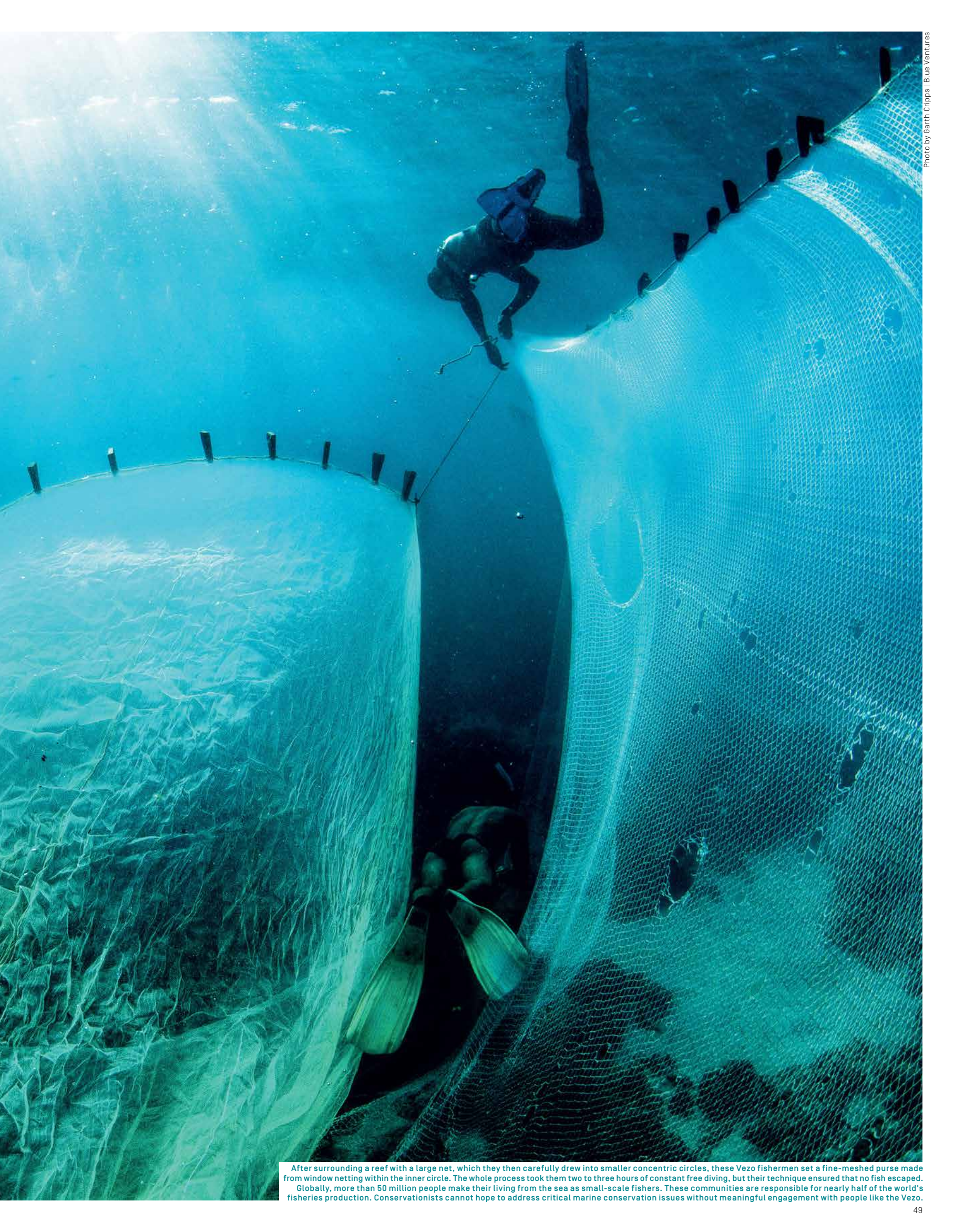


The Vezo people of Madagascar are seasonal nomads of the Western Indian Ocean. Their intimate knowledge of the winds, currents and animals of western Madagascar has made them masters of their environment. They lived in harmony with the sea for hundreds of years, but over the past three decades the demand from external seafood markets and the introduction of more modern fishing gear have driven fishing to unsustainable levels.

Hearts and minds – and stomachs







After surrounding a reef with a large net, which they then carefully drew into smaller concentric circles, these Vezo fishermen set a fine-meshed purse made from window netting within the inner circle. The whole process took them two to three hours of constant free diving, but their technique ensured that no fish escaped. Globally, more than 50 million people make their living from the sea as small-scale fishers. These communities are responsible for nearly half of the world's fisheries production. Conservationists cannot hope to address critical marine conservation issues without meaningful engagement with people like the Vezo.



For the islanders of Colombia's Rosario and San Bernardo Park, fishing is a way of life. According to researcher Camila Cáceres (see page 16), these communities are also committed to taking care of one another and they share their extra catch with their neighbours.

In a world where public officials in the USA are no longer allowed to speak about climate change and where terms like 'the anthropocene era' and the 'sixth great extinction' have become commonplace in global media, the outlook seems increasingly bleak for conservation. Despite the efforts of thousands of passionate individuals, centuries of dedicated work and billions of dollars spent, we are losing the battle to conserve our planet. This may be due, in part, to the sheer magnitude of the task. But as human beings we have successfully solved an endless parade of problems that might once have been seen as insurmountable. To change the apparently hopeless narrative around conservation, we need to take a very honest look at how we approach our work and measure its impact across the board, and to pay special attention to examples of conservation success.

A quick Wikipedia search reveals that Western literature points to conservation as a practice starting in 1662 with the publication of John Evelyn's paper *Sylva*, which advocated for the protection of England's forests in the face of rapidly dwindling timber resources. The more modern conservation movement, also dedicated to the protection of forests, can be said to have arisen in India in 1842. This may be the prevailing narrative recounted in the West, but there are numerous examples of conservation practices being carried out by indigenous people going back for thousands of years.

In 1981 Dr Robert (Bob) Johannes, a tropical marine ecologist, published *Words of the Lagoon*, in which he chronicled his work to discover and test the traditional ecological knowledge of fishing communities in Palau. What he found was an enormous encyclopaedia of critical and accurate knowledge about marine species and their life cycles and behaviours. Perhaps more surprisingly, he discovered how Palauans used this knowledge to fish not only successfully, but

sustainably too. Traces of practices like theirs continue to exist on the fringes of modern society, where traditional communities are struggling to honour both their cultural way of life and their need to survive in the face of increasing competition for natural resources.

Small-scale fishing communities that rely directly on our oceans' resources for survival are by far the biggest constituency of fishers globally. According to the Food and Agriculture Organization (FAO), more than 50 million of the world's 51 million fishers are employed in small-scale fishing and are responsible for nearly half of the fisheries' production worldwide. According to Dr Alasdair Harris, the executive director of Blue Ventures, 'the only thing small about small-scale fishers is the size of their canoes'. Alasdair founded the UK-based marine conservation organisation in 2003 and in the past 14 years its work has given rise to some of the most successful conservation initiatives in the marine sphere. In western Madagascar, where Blue Ventures has been working the longest, the results have been startling. Today about 13% of Madagascar's seabed is enclosed in 65 locally managed marine areas (LMMAs), following models that were pioneered by Blue Ventures and its partners just a decade ago.

In recent years, marine protected areas (MPAs) have been endorsed by international conservation organisations as the 'silver bullet' for sustaining marine ecosystems. In a growing trend, governments have been declaring mega-MPAs such as Chagos in the Indian Ocean and Pitcairn in the Pacific. Their aspirations are bold, yet few data exist to show how effective such immense, predominantly open-ocean MPAs really are, and many questions about critical issues such as enforcement remain. 'Sadly, the prevailing paradigm in conservation today is that our industry is still largely dominated by science and it often pays no more than lip service to recognising the

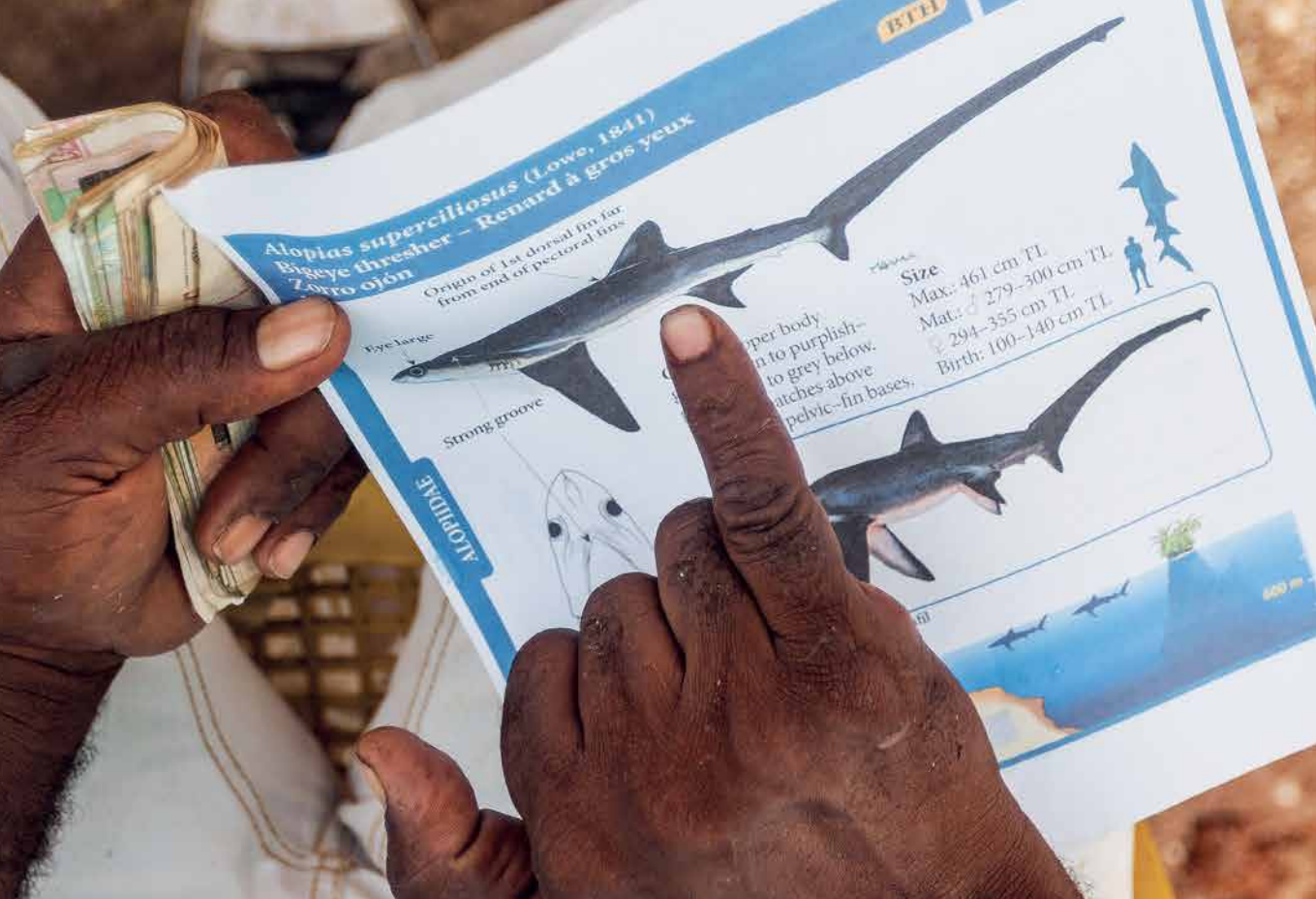
importance of engaging with the people who depend on the sea,' explains Alasdair. 'The fact that the vast majority of the world's marine protected areas are failing is a sobering reminder of their poor design and their failure to understand or address local needs.'

In the case of Blue Ventures' work in western Madagascar, the LMMMA model is very different. Here protected areas have been designated with the support of local people, who are managing them autonomously in cooperation with neighbouring communities and with the support of Blue Ventures and its NGO partners. After years of monitoring and evaluation, the data are looking positive. 'Key ecological indicators are demonstrating compelling evidence of improvements in locally managed marine areas in Madagascar,' reports Alasdair. 'Inside reserves established by communities 10 years ago, fish biomass has started to increase compared to areas outside the reserves. That's the holy grail result that we're after with marine protection.'

An abundance of conservation programmes is scattered throughout the developing world, and while they appear to be generating significant funding, the majority have not been successful in terms of delivering real-world conservation results. So what is it about the Blue Ventures model that works? It seems that its approach in Madagascar has benefited from what Bob Johannes had learnt in the Pacific. At the time, many biologists thought that he had deviated too far from the conservation norm and become a scientific drop-out, yet his effectiveness was evident and hinged on one critical factor: his attitude to the people who lived in the places where he worked. Many researchers had visited these places before him, but Bob became known to the Palauans as 'the first one who ever asked us about our knowledge; the others only told us about theirs'.

Camila Cáceres spent time in fishing communities in Rosario and San Bernardo Park, interviewing fishers to better understand local conservation challenges and to glean their knowledge about local shark populations.

Photos by Julián Andrés Rodríguez Agudelo



Acknowledging the value of indigenous knowledge and tradition has been a critical tool for Blue Ventures, whose most successful social marketing and behaviour change campaigns have focused on celebrating the traditional cultural identities of the communities in which its teams work. In Madagascar, for example, they have worked with the Vezo people to celebrate their masterful seafaring traditions – a people who are intimately aware of the winds, the tides and the ecosystem with which they are interacting. The Blue Ventures message has been to encourage a sense of pride in traditional Vezo identity: 'Vezo don't need to use destructive fishing because they are Vezo.'

When Alasdair is asked how he determined his approach during the organisation's first few months in Madagascar, his answer is very straightforward: 'We didn't have an approach. We didn't need one. We were there to listen and learn, with no predefined project agenda or arbitrary cut-off date. We monitored ecosystems and we started to understand the broader economic system. Our approach is to live with and within communities. We're able to work in this way because we are a social enterprise and our bottom line depends on us staying in these communities. Our expeditions, which rely on this model, provide much of our funding. We see ourselves more as an R&D laboratory within which we are developing models that can go to scale through our partners.'

Having the freedom to spend time learning from the communities that they support meant that after those early years of research, the Blue Ventures teams could devise a conservation programme that was built around local needs and interests. They recognised very early on that a marine protected area would not be viable in the context of their first site in remote south-western Madagascar. The people there weren't willing to close off the reef because they

needed to fish so badly and demands on the resources were so extreme. The Blue Ventures team needed a shorter-term catalyst to show communities what they could gain from protecting their ecosystem. That gave rise to the temporary fishery closures that became the model for Madagascar's growing network of LMMAs.

The first step was to convince fishers to close off small areas of octopus habitat for a short time, giving the octopus population a chance to recover between harvesting periods. Once the locals saw that resource management programmes worked, they were open to broader conservation practices. 'Reef octopus happened to be the biggest export-driven small-scale fishery in the country,' explains Alasdair. 'It's a species that grows phenomenally quickly, produces the vast majority of fisheries-derived income, and – in the case of southern Madagascar – is targeted predominantly by women. So we saw this huge lever that could demonstrate the economic benefits of conservation. And it became a powerful means of engaging communities in marine management.'

Despite his own organisation's success, Alasdair remains concerned about the apparent ineffectiveness of conservation efforts in general when it comes to protecting nature and marine systems on a global scale. 'We're living in a time when we are doing pretty well in meeting almost every global target across the social sector, whether it's literacy, education, malaria or HIV. Yet in biodiversity conservation all indicators seem to be collapsing. Of course, we don't have enough resources. But what we do have could be spent so much more effectively,' he says. 'As a sector, we think too rarely in terms of delivering lasting impact or behavioural change, and even less about how we measure our results. And we're just not seeing enough interventions that are designed so that they can be replicated. Scalability is fundamental to a sector

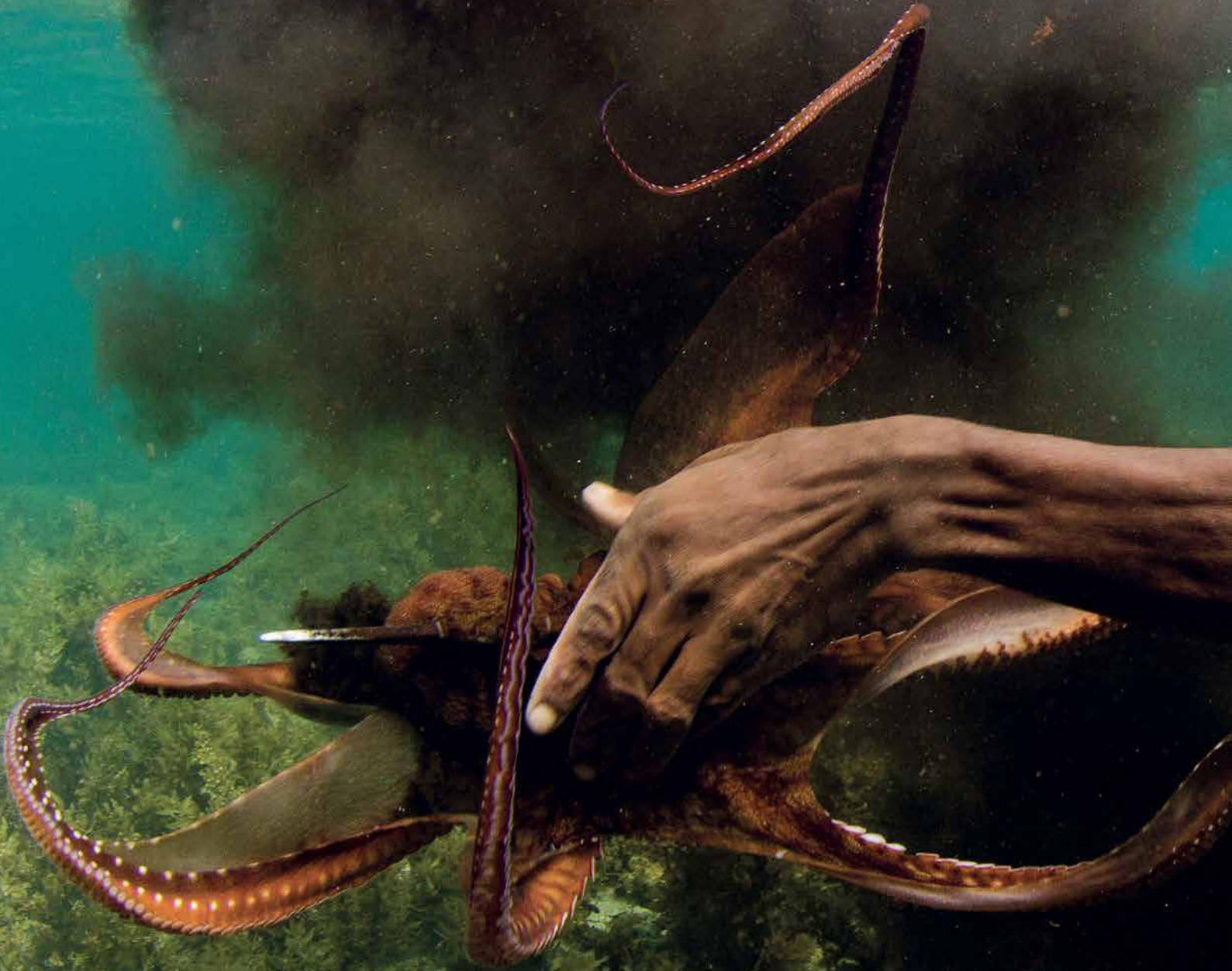
whose resources are dwarfed by the scale of the problems we're trying to tackle. Yet too often we're still looking through a myopic site-based lens: silo-like, donor-dependent interventions that are highly insecure and, in the context of marine conservation, often simply not delivering impact.'

Perhaps the social sector has found success because, by definition, social development is designed to serve the needs of people. More than a century of conventional conservation practice has shown that trying to protect nature while ignoring the people who live closest to it has done little to mitigate the 'sixth great extinction'. It seems that if we are going to tackle the mounting crisis of global biodiversity loss, we will need to shift towards a more holistic, multidisciplinary approach to conservation and conservation science. And the tide does appear to be shifting, with a number of younger researchers becoming braver about trying to understand the people as well as the animals that function within the ecosystems that they hope to serve.

With funding from the Save Our Seas Foundation, Peter Musembi has initiated an elasmobranch conservation programme at Watamu National Park in Kenya. This is one of the oldest MPAs in Africa and very few conservationists are looking into the abundant population of sharks and rays in the region. The local fin trade is growing, blacktip reef sharks are being poached in shallow waters and elasmobranchs are consistently being found at local fish landing sites.

Peter is employed by A Rocha Kenya, a faith-based conservation organisation. His intention is to integrate science, conservation and cultural and spiritual beliefs into an environmental education programme. There are about 300,000 people living around the national park and more than 70% of them depend directly on natural

In Madagascar, Blue Ventures convinced the Vezo people to temporarily close a small section of reef in order to allow octopus numbers to recover. The community was so impressed at the reserve's success that other villages followed suit and these short-term octopus reserves became the catalyst that opened the door for marine conservation in the region. Now, about 13% of Madagascar's coastline is protected by locally managed marine protected areas.





Rather than starting up as a non-profit, Blue Ventures is a social enterprise. It sees itself as a research and development laboratory for scalable conservation interventions. The organisation continues to work in Madagascar, and now also has projects in Belize, Timor-Leste, Comoros and, most recently, Mozambique and Indonesia.



Photo by Steve Roccliffe | Blue Ventures

resources through either tourism or fishing. As in many developing communities, there is a lot of mistrust and suspicion from the community in Watamu when it comes to resource management and Peter has a daunting task ahead of him, but as a Kenyan national he has a major advantage. He has also been working in the area for two years already, which has given him the time he needed to build relationships with local stakeholders and they are becoming more open to conversations about protecting sharks.

Echoing Bob Johannes, Peter is very aware of the significance of spiritual belief systems, especially among the more traditional members of the community. The Bajuni people, for example, moved to Watamu from further north in Kenya. They are historically linked to the ocean and Peter expects they may have some cultural beliefs that centre on sharks. 'I have talked to a few of these people already. Sometimes they go into the ocean and before they start fishing, they will see which animals are in the water and if they see a bad omen, they will go back. We are expecting to hear more stories like this that might explain what motivates them to target some species more than others,' he explains.

Although some families have lived at Watamu for centuries, the area is a melting pot of people from all over Kenya, many of whom have come to the park to earn money from tourism. Despite living just 50 metres (160 feet) from the beach, very few of these people have a connection with the ocean and the prevailing attitude towards sharks is one of terror. 'Most people think sharks are bad,' says Peter. 'They tell their children "Don't go into the ocean. You will be attacked by sharks." They think if they see a shark, that shark will definitely attack them. There are people who have been selling curios on the beach for 30 years, but they have not gone into the water, they have not snorkelled, they have not swum.'

The programme may still be in its infancy, but Peter has already seen some positive shifts,

especially among the children for whom he runs intertidal and snorkelling excursions. Recounting a recent conversation with a boy who was just entering high school, he says the youngster told him, 'I didn't know such things existed. I thought that this was just blue water. I didn't know that there was so much life beneath the waves. There are hills and mountains in the water just like on the land.' Peter continues, 'I think if you can change a kid in just a few years, then this is a worthy cause. I hope that eventually change in attitude will grow into change in behaviour.'

Understanding the motivations behind conservation attitudes and behaviours is something that intrigues another young scientist, Danielle Nilsson, a conservation psychologist who recently completed her PhD at the University of Queensland. Looking into the psychology behind shifts in conservation behaviour, Danielle recognises that the conventional approach by Western conservationists is to incentivise developing 'impoverished' communities with monetary rewards and external benefits. As a psychologist, however, she believes that shifting people's behaviour is more complex. 'That thinking is really challenging because in psychology we know that this is not really how people operate. Economics can be one motivator, but there are often many more. Human behaviour is just not that simple. We know this, but no one has investigated it in the context of community conservation in developing countries,' she explains.

Danielle's study hinged on the distinction between types of motivational factors: heteronomous versus autonomous. The predominant approach to community-based conservation today is to motivate people heteronomously, through extrinsic incentives such as monetary or development rewards or through legislation and threats. For psychologists, these motivators are

regarded as falling outside an individual's core values. Autonomous motivation, on the other hand, is inspired by inherent enjoyment, feelings of empathy or core beliefs around personal identity. These behaviours hinge on freedom of choice rather than positive or negative coercion. 'In psychology we know that if someone is intrinsically motivated, that effect is going to be much more sustainable than if the motivation is extrinsic,' says Danielle.

To explore her hypothesis, she visited communities in northern Sumatra and interviewed hundreds of participants to gain an understanding of their attitude to conservation and behaviour towards orang-utans and their forest habitat. What she discovered was that although external rewards were important, autonomous motivation was also a critical influence on people's attitude to conservation and, more importantly, their behaviour towards orang-utans and the forest.

In Bukit Lawang, the large-scale tourism operation that focuses predominately on semi-wild orang-utans has brought many economic benefits to the village, but there have been negative impacts on the animals. 'Many people's attitudes changed, but their actual behaviour didn't,' recalls Danielle. When people at Bukit Lawang were asked why they protected the animals and their surrounding habitat, they responded with answers such as 'Orang-utans are useful to my job' or 'Because it is forbidden to damage the forest. It is a national park'. This is not a sustainable conservation model, because if the economic benefits from tourism or the enforcement of the national park were to disappear, so would any incentive to protect the orang-utans. Already, unsustainable conservation attitudes and motivations have resulted in unethical practices involving guides and tourists who will touch or feed the orang-utans, despite park rules not to. And on top of that, the community itself has become increasingly disharmonious.

Blue Ventures' success hinges on a multi-faceted approach and the relationships it has built with the communities in which it works. In addition to its environmental work in Madagascar, the organisation has started a community health programme. In Veliondrake, one of the communities it serves, the proportion of women using contraception grew from 10% in 2007 to 55% in 2013.



Photo by Garth Cripps | Blue Ventures

The situation in Tangkahan village, less than an hour away, is very different. In this case, members of the community realised that logging was unsustainable and developed an environmentally sound ecotourism programme with the help of conservation organisations. 'There was a strong core psychological motivation behind this programme,' explains Danielle. 'It was built for the community, by the community. They had a strong sense of ownership of and identity with the programme and their aspirations had been met.' The community members' responses to her questions reflected this: 'Orang-utan is just like us, I feel sympathy for it' and 'I was born in the place, the forest is a part of my nature and environment'. By meeting these deeper psychological requirements, the conservation programme not only protects the animals and serves the material needs of the village, but has strengthened people's relationship with their ecosystem. The village even won a prestigious award from the Indonesian Ministry of Tourism for excellence in pioneering community-based ecotourism.

While orang-utans might be very far away from the shoreline, understanding the benefits of paying more attention to the internal world of human beings has great value in the marine context as well. Camila Cáceres, also a recipient of an SOSF small grant, is gathering baseline data about shark fisheries in Rosario and San Bernardo Corals National Natural Park in the Caribbean Sea just off the coast of Colombia. She is using Baited Remote Underwater Video Systems in her research, but much of it also relies on speaking to the people who live on the islands. Her interviews support the theory that although the islanders have very little material wealth or comfort, financial gain is not the most powerful motivator for them.

'I was really surprised by the sense of community,' says Camila. 'If the fishermen go out and

fish and they don't come back with anything, they are not worried because as long as one fisherman catches something, their friend or neighbour will always have their back. There is no electricity, so if they catch a bunch of fish, it's almost pointless to keep it for themselves. They would rather just cook the same three fish that they share every day among their family and give the rest to their community,' she explains. And while it seems logical to attribute this generosity to the lack of electricity, Camila is convinced that it goes much deeper than that. 'They say that the islands are the most beautiful place on earth and they are more interested in day-to-day living. Money works, but it's not number one. Community is number one for sure and they care most about spending time with their families.'

It has become clear to Camila that the major conservation challenge in Rosario and San Bernardo Park is not that communities want to be allowed to exploit natural resources unsustainably; rather, it is the poor relationship that has developed between local people and the park authorities. She recalls, 'When I was interviewing the islanders, the first thing they would ask was "Are you working for the national park?"' It seems that rather than viewing the MPA as protection from industrial fishing, the islanders mistrust the national park staff, whom they regard as outsiders. In that social climate, enforcement has become very difficult. Camila asserts that the first step for any conservation programme at Rosario and San Bernardo Park would be to hire park rangers from the local community.

Peter, Danielle and Camila are just beginning their journeys in community conservation. It is commendable that they have recognised that while a solid scientific foundation of ecological understanding will always be critical, conservation can no longer belong solely to the school of natural scientists who attempt to 'save wildlife'

by studying animals and ecosystems as if they function outside of human interference. However, it remains to be seen whether the knowledge gleaned by these young scientists will be transformed into real-world conservation stories.

In the meantime, 14 years since Blue Ventures first set foot in Madagascar, the organisation's unconventional approach has made it a powerhouse in the world of marine conservation. Blue Ventures has received a number of international awards, employs more than 150 people around the world and is continuing to expand, with projects in Belize, Timor-Leste, Comoros and, most recently, Mozambique and Indonesia.

When asked about his formula for successful conservation in small-scale fishing communities, Alasdair points to a few key ingredients. 'In many ways, conservation works best where there is still that local ecological connection that comes from living in proximity to nature,' he says. 'These are the areas we look for – where conservation benefits can be seen and understood, and where our very limited resources will get the traction they need to have a hope of enduring.'

Once those communities have been identified, conservation success depends largely on building compassionate, sustainable relationships and an attitude of mutual respect between organisations and communities. And that is what Alasdair is most proud of. 'We have played a small role in changing the conservation narrative in the Indian Ocean to one that promotes empathy for people as well as wildlife. Regardless of what happens to Blue Ventures, we have shifted the needle towards this goal. And today we see everyone, from the World Bank to donor institutions, using language and ideas that we dragged into the Indian Ocean from the South West Pacific 14 years ago. And that's pretty cool.' ●



Photo by Greg Davis | National Geographic Creative

Peter Musembi, a Kenyan conservationist, is working with educational and religious networks at Watamu, one of Africa's oldest marine protected areas, to open conversations about conservation.

act on aid

As part of its holistic approach to conservation, Blue Ventures has established programmes that create alternative livelihoods for the communities in which they work. These include sea cucumber and seaweed aquaculture.



After more than 14 years in Madagascar, Blue Ventures has successfully won the trust and support of Vezo people to the extent that fishers living in some of the most remote communities in western Madagascar have been trained as citizen scientists and are helping the organisation to monitor shark catches using mobile phone technology.





KIO FESOKE

A great hammerhead shark swimming near the ocean's surface. In the winter months, these iconic predators visit the waters off Bimini in The Bahamas.

Home and

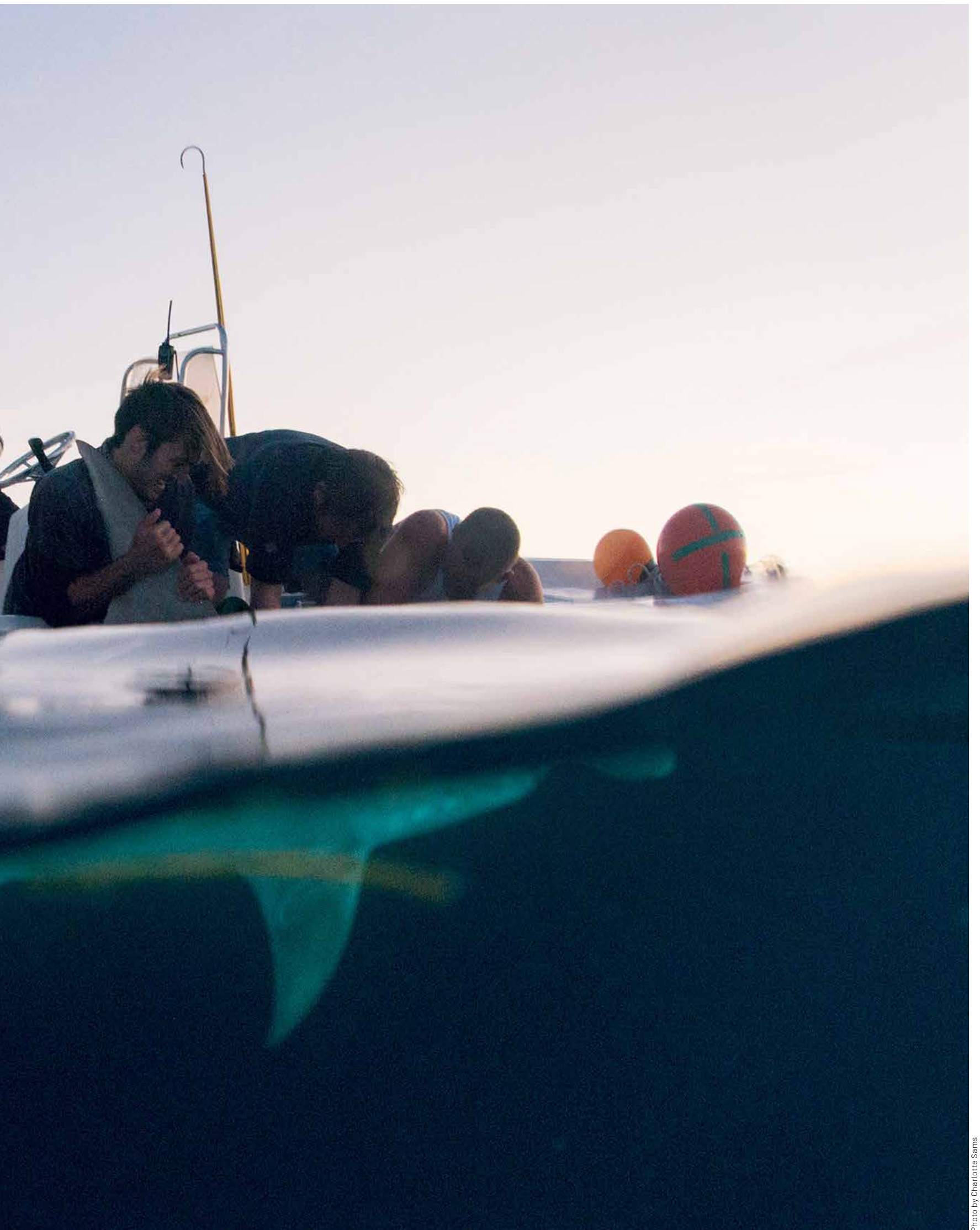


away

Words by Tristan L. Guttridge

Tristan Guttridge and the Bimini Biological Field Station team work up a great hammerhead at dusk. These sharks are extremely sensitive, so the team needs to work fast to ensure that the animal recovers.





One of the oceans' most imposing predators, the great hammerhead shark is shrouded in mystery, its feeding and breeding grounds still largely unknown. It seems to have taken a liking to Bimini in The Bahamas, though, and researchers there are making breakthrough discoveries about where these enigmatic sharks go in summer.

Extraordinary, elusive and emphatic – the great hammerhead shark *Sphyrna mokarran* is without doubt one of the most recognizable and charismatic large predators on earth. Not only is it a shark, but it's a shark with a head in the shape of a monster-sized hammer. This remarkably graceful hunter reaches an intimidating size of six metres [20 feet], is known to migrate long distances and uses its sophisticated, highly evolved head-weaponry to locate, manipulate and then pin down its prey, a stingray perhaps, before consuming it. Yet despite its prominence as one of the ocean's greatest predators, we still know little about its biology and behaviour. For example, we have no reliable estimates of its population size or natural abundance and little, if any, information about its preferred habitats or nursery grounds.

Such basic gaps in our knowledge are particularly worrying when we consider that substantial population declines are thought to have occurred throughout the species' range as a result of overfishing. In 2006 the hammerhead family was the second-most abundant species group in the international shark-fin trade. Great hammerheads were highly sought after because of their large fins, which were particularly prized in Hong Kong and could fetch up to US\$100 per pound. This popularity has not diminished and in 2016 the maximum value calculated for a single great hammerhead was US\$6,429. Like other sharks and rays, great hammerheads have conservative life-history traits and their populations are likely to take decades to recover from even modest overfishing. Moreover, their transboundary migratory habits, or refusal to acknowledge national boundaries, puts them at greater risk from fishing pressure than possibly any other group of marine animals.

Sadly, even when hammerheads are not targeted, if they are hooked inadvertently they expend so much energy that many die before they can be released. In fact, between 1994 and 2005 more than 90% of great hammerheads caught in the commercial bottom-longline fishery in the north-western Atlantic and the Gulf of Mexico were dead by the time they were brought to the side of the vessel. And even if they are released promptly, many subsequently die because the stress of capture is too great for them to survive.

The challenges to improving the conservation and management of great hammerheads are significant, yet progress has been made and there are some positive signs that we are acquiring a better understanding of the species and that this is leading to legislation and ultimately protection. For example, in March 2013 the great hammerhead and two other hammerhead species were listed in the Convention on International Trade in Endangered Species' (CITES) Appendix II, which means that international trade in products from these species is better regulated and managed and that sustainable fishing for these sharks is promoted.

In 2014, two petitions in the United States to list the great hammerhead in the US Endangered Species Act led to a comprehensive review of its global status. The resulting report concluded that the species 'is not currently in danger of extinction throughout its range'. Although this was encouraging news, the assessment was cautionary and, disturbingly, it stated that 'available data [were] severely lacking or flawed, with no consistent inference regarding past or present status'. The assessors emphasised the urgent need for more data.

So how does one learn more about a species that probably has a naturally low abundance, has experienced population declines due to overfishing and is highly sensitive to capture? Enter the Bimini Biological Field Station Foundation, aka the Shark Lab. Established in 1990 by Professor Samuel H. 'Doc' Gruber as a 24/7 shark research facility, the Shark Lab is located on South Bimini in The Bahamas, approximately 85 kilometres [52 miles] east of Miami, Florida. At Bimini, plankton-rich waters from the Gulf Stream flow into its lagoon each day with the tides and generate pristine waters that provide an ideal environment for a diversity of marine animals. None is more magnificent than the great hammerhead shark, which Shark Lab staff have been documenting in the waters around Bimini since the facility's inception in 1990. Indeed, two direct observations of predation events have been reported by our team, one on a southern stingray *Dasyatis americana* and the other on an eagle ray *Aetobatus narinari*.

These extraordinary sightings aside, encounters with great hammerheads were infrequent. They usually occurred during the winter months, but no-one could predict exactly when or where.

Then about a decade ago, Shark Lab staffers began to see these mysterious sharks more often. Again and again they lured the great hammerheads with food to research skiffs anchored in the clear, shallow waters on the west side of Bimini. Now and again, they used free-diving techniques to tag the sharks with external National Marine Fishery Service (NMFS) darts, which they attached using a pole-spear. These early encounters were important as they demonstrated that it was possible to get close enough to a great hammerhead to tag it and record fundamental characteristics such as sex and size. Repeated sightings of the same tagged shark over a week or a month suggested that it might be displaying some level of residency in Bimini.

In 2014, partnering with the Save Our Seas Foundation and free-diving world-record holder William Winram, we placed the first acoustic tracking devices on great hammerheads at Bimini. These tags 'talked' to stationary receivers that were deployed in various habitats in the surrounding waters: shallow and deep reefs, wrecks, mangrove fringes and sand and sea-grass flats. As a tagged hammerhead swam within range [about 350 metres, or 1,150 feet] of a receiver, the time, date and the shark's ID number were recorded and stored. From these data we could identify when the hammerhead arrived at Bimini, how long it stayed, what habitats it used and when it left. In addition, by participating in a data-sharing network [the Atlantic Cooperative Telemetry; ACT] we substantially increased the potential for detecting our tagged hammerheads outside our acoustic array, as 762 other receiver stations spanned mainland USA [Florida, Georgia and South Carolina] and The Bahamas [Andros, Cape Eleuthera and Grand Bahama].

Also in 2014 and in 2015, and again using the free-diving technique, our team deployed 23 acoustic devices on adult great hammerhead sharks. In addition, to explore cross-border movements we implanted 10-year acoustic tags in great hammerheads off Jupiter, Florida, which lies about 100 kilometres [62 miles] west of Bimini. Strong currents and murkier waters here meant that we had to adopt a different tagging technique. Known as poly-ball fishing, it involves rigs consisting of free-floating individual lines and baited circle hooks that are set to drift within two to three metres [6.5 to 10 feet] of the substrate.



Laser photogrammetry

It's difficult to measure a shark unless you capture it. After all, you can't exactly swim up to it with a measuring tape! So we use laser photogrammetry, a method that has proved to be effective for estimating the length of large marine animals such as whales, sharks and rays. Measuring great hammerheads in this way is important as it helps us to understand the demographics of the population at Bimini. Two green lasers are positioned 20 centimetres [eight inches] apart on a mount with a camera secured between them. When the shark and the photographer are parallel, the lasers are projected onto the shark's flank. A photograph is simultaneously taken and the two laser points can be used as a scale bar to estimate the total length of the shark.

Using this capture method, our team successfully processed and tagged nine great hammerheads, each within minutes of the bait being struck. With efficient team work – not unlike that at a motor-racing pit stop – hook-up to release was a rapid 16 minutes or less. This technique was specifically adapted to overcome the fragility of the great hammerhead and enabled us to obtain important biological material for molecular and dietary studies without killing the shark, as is done in standard fishery research. To further reveal the migratory paths and summer destinations of Bimini's great hammerheads, we deployed pop-off satellite archival transmitting (PSAT) devices. These tags archive depth, temperature and light data at intervals of five to 15 minutes and fall off the sharks after a certain time, which could be between one and nine months.

The results of our tagging efforts have provided the first evidence of philopatric behaviour in the highly mobile great hammerhead shark. This means that great hammerheads tend to stay in, or regularly return to, particular areas as part of their usual movement or migration patterns. Great hammerheads tagged in Bimini, The Bahamas, and Jupiter, Florida, were recorded making return migrations from as far north as Virginia (a return trip of about 3,000 kilometres, or 1,864 miles), as well as movements to and from Florida (Jupiter and Key Largo) and the Bahamian islands of Andros, Bimini and Grand Bahama. These movements were usually made towards the end of the winter season, suggesting they are for the purposes of feeding or breeding (pupping or mating).

Great hammerheads at both our study sites displayed long-term site fidelity, with some individuals, of both sexes, observed or detected in five consecutive winter seasons. In addition, many of these sharks were resident during the winter months, having been detected on receivers placed along the Florida coastline as far north as Cape Canaveral, observed regularly at the dive site or picked up by our acoustic array at Bimini.

The movements of two individuals in particular are worth highlighting. Great hammerhead 'Gaia', a large female estimated to have a total length of 3.3 metres (nearly 11 feet), was first identified by our team in 2013. We tagged her with an external NMFS dart for identification, but after repeated encounters and lots of photos, some

features appeared easy to recognise and were persistent through time. For example, on her left side a patch similar to a birthmark and about three square centimetres (0.5 square inches) in size could be clearly seen behind the pectoral fin. Since the first sighting, we have identified her annually until 2017 – that's five consecutive years! In addition, through our laser photogrammetry technique [see panel] we now have an accurate length measurement for her: an impressive 3.45 metres (11.3 feet).

More importantly, on 15 February 2015 Gaia was tagged with an external acoustic tracker. This has proven to be one of our most informative tags, as since then Gaia has completed two consecutive return migrations of 1,600 kilometres (1,000 miles) to South Carolina in 2015 and 2016, having been recorded on receivers off the coast there over the summer months. As of February 2017, she is holidaying in Bimini's waters and is observed regularly at our dive site.

Great hammerhead 'Nemesis', another female, was also first identified in 2013. She was estimated to be three metres (almost 10 feet) long and has distinctive notches on her first and second dorsal fins that enable us to identify her again easily. In early 2014 Nemesis received an external acoustic tag and was monitored at Bimini until March, when her tag was lost. For the next two years we photographed her on dives between February and April, and in 2016 we caught her by our poly-ball method and fitted her with a 10-year internal acoustic tag and an external nine-month PSAT device. Nemesis returned safely 'home' to Bimini in February 2017 after completing a 1,600-kilometre return migration to South Carolina. Amazingly, her satellite tag stayed on for the whole nine months and our partner Microwave Telemetry was able to retrieve it. The tag will prove crucial for revealing the migratory path that she took.

This philopatric behaviour we are seeing in Bimini's great hammerheads is turning out to be a common phenomenon in many shark species and has important implications for management. For example, the sharks' predictable, seasonal and repeated use of specific locations, areas or migratory routes makes them more vulnerable to targeted fishing. Locally in the western North Atlantic, these findings are important as they can be used to help delineate essential habitat for great hammerheads, which is defined

as 'those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity'. Indeed, early indications from our acoustic tracking of Gaia and Nemesis suggest that coastal regions off South Carolina and Georgia could be important pupping sites during the summer for the species. Moreover, if female great hammerheads are returning to their birthplace to give birth, as some other species (like lemon shark, turtles and salmon) do, then this could have implications for management. This behaviour, known as natal philopatry, is one of the factors that could reduce gene flow across the Atlantic.

In addition, great hammerheads tracked by our team were found to move regularly across state boundaries, as well as between the exclusive economic zones of the USA and The Bahamas. Their transborder movements highlight the need for cooperation between jurisdictions to ensure that this species receives the necessary protection throughout its migrations. This is particularly important for The Bahamas, given that a recent study estimated that shark diving is worth US\$109-million in direct and value-added expenditure to the country's economy, while great hammerhead tourism at Bimini is calculated to contribute US\$1-million to the local economy. Clearly, multilateral environmental agreements and coordinated action by many nations, international organisations and industry regulators will be required if the populations of migratory species like the great hammerhead are to recover to a healthy level and be safeguarded into the future. ●

Guttridge TL, Van Zinnicq-Bergmann M, Bolte C, Howey-Jordan L, Kessel ST, Brooks J, Bond ME, Winram W, Jordan LK, Cashman R, Tolentino E, Grubbs RD, Gruber SH. 2017. Philopatry and regional connectivity in the great hammerhead shark, *Sphyrna mokarran* in the U.S. and Bahamas. *Frontiers in Marine Science*. doi.org/10.3389/fmars.2017.00003.

A hammerhead cruises in the mid-water just off Bimini.





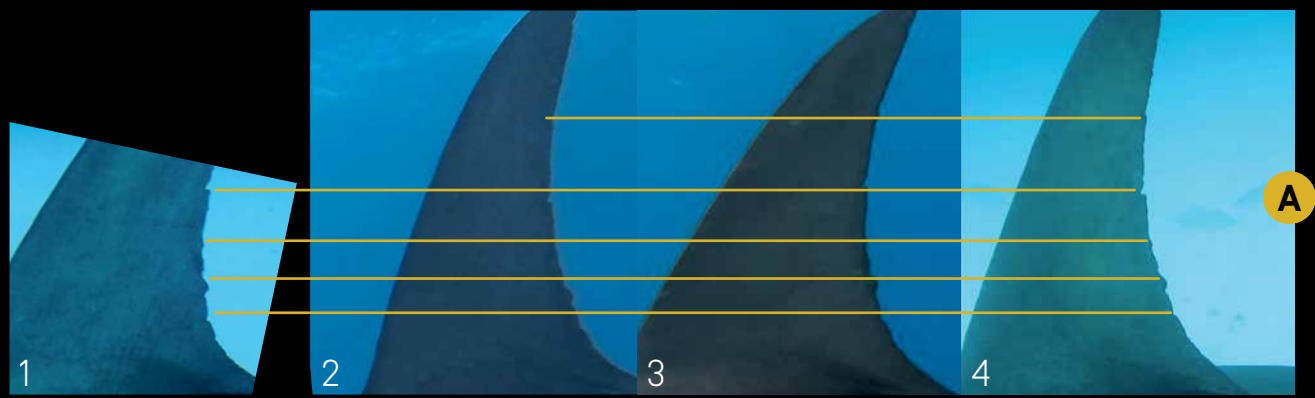
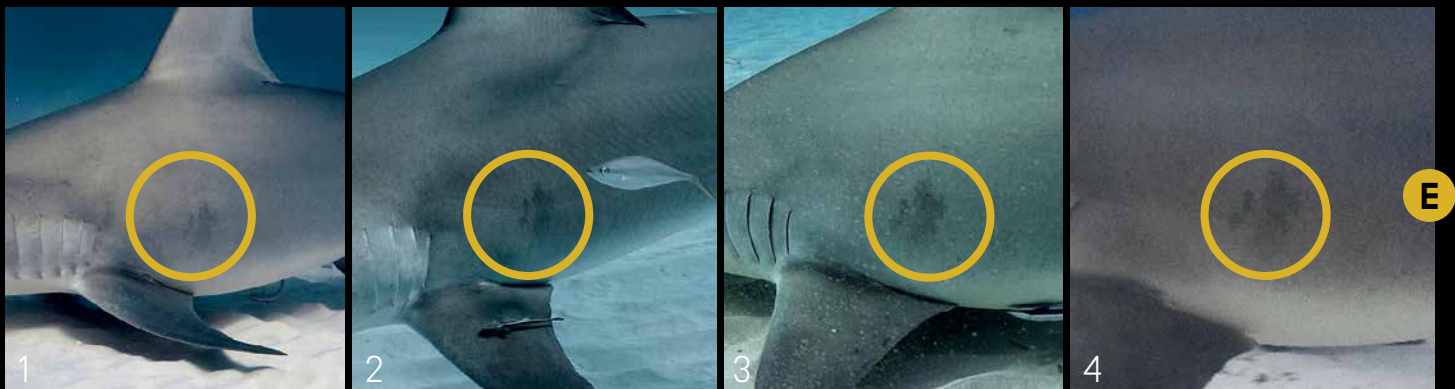
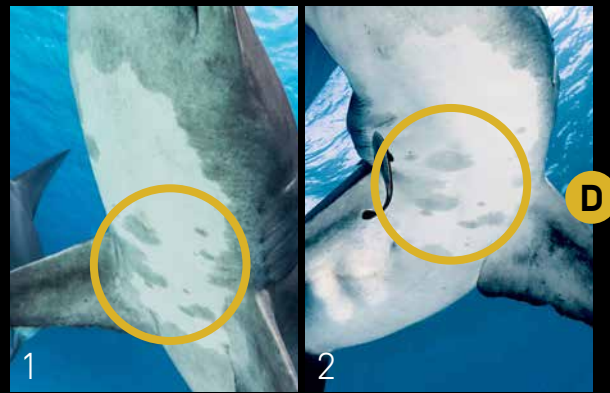
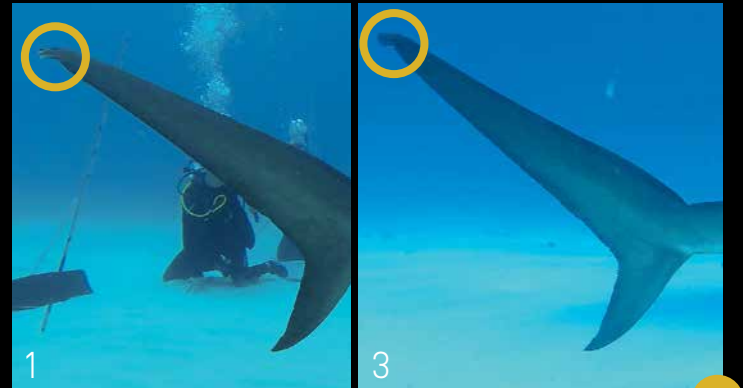
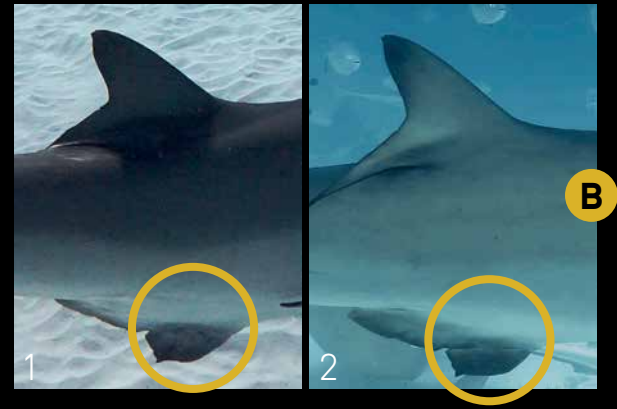


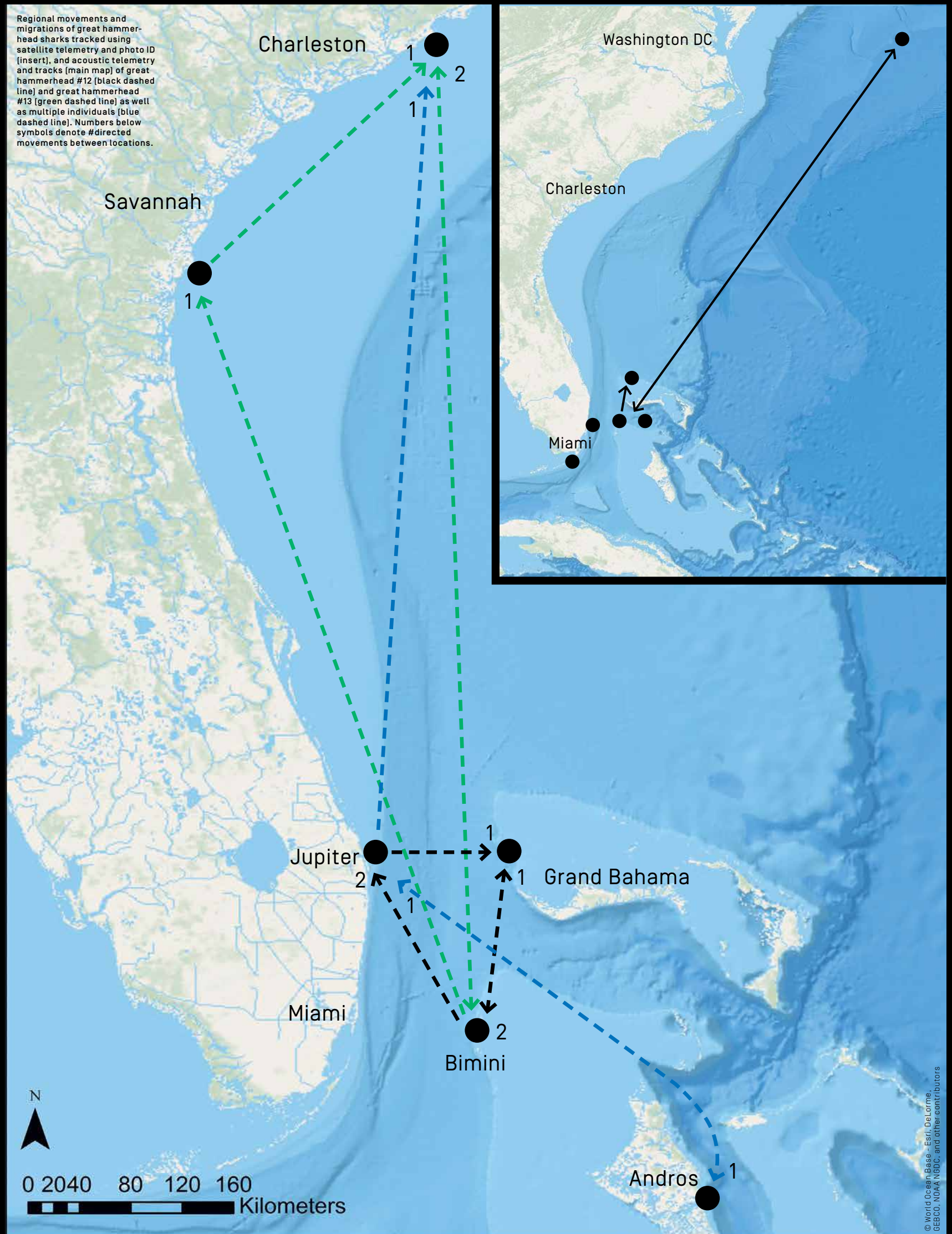
Photo identification

For decades, marine biologists have used external features such as natural marks, fin morphology, wounds and pigmentation patterns to identify individual animals. These have provided a valuable and reliable method for tracking individuals, often over long time periods, and they are particularly useful for animals that are difficult to work with logistically, such as large sharks and rays. At Bimini, we are blessed with superb underwater visibility, which enables us to make high-quality images of great hammerheads during dives. When we originally assessed these photographs, it was apparent that many individuals could be recognised by their external features. These characteristics are important as they supplement external dart and acoustic tagging information and provide important re-identification methods if tags fail. With detailed tagging and photographic information, our team has created profiles of named individual great hammerheads to ensure that they can be tracked throughout seasons and over a number of years.

Depictions of several shark characteristics used for individual recognition across multiple years:
A Dorsal fin trailing edge notches of great hammerhead shark, *Sphyrna mokarran* #17 | 1: Feb 2013 | 2: Mar 2014 | 3: Jan 2015 | 4: Apr 2016
B Damaged anal fin of great hammerhead #20 | 1: Jan 2013 | 2: Feb 2016
C Disfigured upper lobe of caudal fin and anal fin of great hammerhead #21 | 1 & 2: Mar 2014 | 3 & 4: Jan 2016
D Ventral spot pattern of great hammerhead #12 | 1: Mar 2014 | 2: Jan 2016
E Pigmentation visible on great hammerhead #13 | 1: Feb 2013 | 2: Jan 2014 | 3: Feb 2015 | 4: Mar 2016



Regional movements and migrations of great hammerhead sharks tracked using satellite telemetry and photo ID (insert), and acoustic telemetry and tracks (main map) of great hammerhead #12 (black dashed line) and great hammerhead #13 (green dashed line) as well as multiple individuals (blue dashed line). Numbers below symbols denote #directed movements between locations.



The Shark Lab team holds a large hammerhead upside down in order to insert an acoustic transmitter into its stomach cavity.







Great hammerhead sharks have been protected by CITES since 2013. The sharks have an important role to play in the Bahamian economy. A recent study estimated that shark diving is worth US\$109-million to the country, and great hammerhead tourism at Bimini contributes US\$1-million to the islands' economy.



Words by Lauren De Vos

Collaboration is perhaps inevitable in an increasingly connected world, but how do we ensure that it's effective? Lauren De Vos talks to Save Our Seas Foundation project leaders about their experiences of the value of collaboration, the ethics of how we approach it in an age dominated by social media and instant communication, and how we look to creating long-lasting partnerships to tackle our oceans' greatest challenges.

The Social Network

Eva Meyers [right] of the Angel Shark Project and Félicie Dhellemmes of the Bimini Biological Field Station work up a small shark at night.



February 1858. It's a hot summer in the Malay Archipelago, where jungles tumble to the sea and the air is redolent with the promise of spice and adventure. From the confines of his island cabin, a feverish naturalist lies stricken on his bed. He has been searching for birds of paradise, some too fantastic to be believed back home in cautious England. The room is strewn with eclectic samples: pinboards of insects are neatly labelled and an assortment of bottles stand to attention on the desk, reeking of ethanol and each one housing a specimen stranger than the one before.

Confined to his tangle of sweaty bed sheets, the naturalist now finds himself with the time to put some thoughts to paper that his otherwise nomadic existence doesn't usually allow. As the fever subsides, words tumble from his keen mind, finding structure in the ink blotted on paper. The letter takes shape and his pen scratches a title onto the page, at once excitingly scientific and stiffly formal: *'On the Tendency of Varieties to Depart Indefinitely From the Original Type'*.

By contrast, it's a mild midsummer day in June when the letter is delivered to a cottage in England. From his desk, a distinguished scientist gazes out to the country garden where butterflies flicker past his window. Here, an Adonis Blue on the wing in the buttery sunlight; there, a Duke of Burgundy skips lightly above the foxgloves. His gaze shifts to the envelope in his hand. With a slight sigh, he grasps his envelope knife and slides it under the red wax seal enclosing the letter.

In doing so, Charles Robert Darwin unwittingly opens one of science's most curious cases of partnership and publication ethics. The letter, signed by a certain Alfred Russel Wallace, details a theory strikingly similar to the one that Darwin has been nurturing for nearly 20 years. There can be no further delay. The theory of evolution by natural selection will now be detailed to the world, published as a joint paper without the consent of Wallace, and the two men will be launched into history as one of the strangest stories of collaboration and unlikely friendship.

The world has changed immeasurably since Wallace and Darwin grappled with their particular collaborative conundrum, but many of the issues their story raises have not. How do scientists reach out to each other for data, consultation or advice? How do we identify partnerships in which skills and equipment can be shared, getting more mileage from funding? In particular, given the scale of challenges faced in conservation today, how do we find unity in tackling interdisciplinary projects? In a sector that values knowledge, the adage 'It's not *what* you know, it's *who* you know' may grate a little.

Certainly, the science behind connections, teamwork and leadership is not outlined in the average undergraduate biology course. The image of the lone chemist pipetting samples or the

field biologist gone feral plays to our imagined concept of scientists as people who work in isolation. Collaboration is not new to science; it wasn't back in 1858. A quick Google search of 'science + collaboration' returns articles from *Nature News* and the American Academy of Sciences. Headlines celebrate 'The Rise of Research Networks', crying out that 'Two Heads Are Better Than One'. If it's not the novelty of collaboration, then perhaps it's our various experiences of its value and how best to make it work that differ most.

'There is definitely value in collaboration, of different sorts,' says Eleanor Yeld Hutchings. As the manager of the Shark Education Centre in Kalk Bay, South Africa, Eleanor is well acquainted with collaboration. In particular, she has done a fair amount of thinking about how we approach it to ensure that it's valuable for all involved. A scientist who obtained her PhD investigating the parasites of South Africa's endemic catshark species before moving into the realm of marine conservation as a practitioner and then into education with the Save Our Seas Foundation, Eleanor is most familiar with exactly this value of 'different sorts'.

'Effective, planned collaboration can boost the variety of skills that are available, increase the ingenuity and creativity on a project by widening the "brain pool", and allow for different approaches,' she explains. Pausing before giving a slight chuckle, she adds, 'In effect, if done correctly, it's more "bang for your buck". Collaboration would hopefully decrease the relative amount of effort each individual needs to put in to get a reasonable outcome.'

How we define collaboration is perhaps rather vague. When is it true collaboration as opposed to growing your network or skills-sharing? Or is it all much the same thing? 'The Youth Ocean Ambassadorship Programme was what I'd call a collaboration,' offers Eleanor. 'While the project itself was about the exposure to and teaching of skills, devising the vision behind this project and the planning that went into its conception were true collaboration.'

The Save Our Seas Foundation's Youth Ocean Ambassadorship Programme mentored six young women who showed potential as future leaders in ocean conservation. 'Ambassadors' from the Seychelles and South Africa participated in week-long modules focused on marine tourism, conservation, education and research. The programme was led by Sunnye Collins, an independent education consultant, and Abi March, project leader of the SOSF Island School Seychelles. 'The impetus came from Sunnye,' explains Eleanor, 'but we had to bring together our different realms of expertise to get the project off the ground. Deciding on the selection criteria for choosing participants, planning how to roll the project out between the two countries involved – it was there that I felt I could really contribute.'

So there is value in thinking things through before approaching collaboration? 'I think it really depends what kind of collaboration you're talking about,' Eleanor responds. 'If this is a collaboration with a specific output, it would have to be thought through pretty well because how you approach it will make the difference as to whether it's successful or not.'

That said, informal collaboration where a specific end goal hasn't been envisaged can also have value. Eleanor shares the recent visit to the Shark Education Centre by Daniela Vilema from the Charles Darwin Foundation in the Galápagos. 'This was much more about participation and skills-sharing, without a preconceived product to be achieved by the end.' The Save Our Seas Foundation flew Daniela to South Africa to participate in diverse activities with the centre's staff, sharing her experiences from the Galápagos and learning about how things are devised in South Africa. The result was new insights into each others' work. 'Often, when you're in something you don't question it – you don't see the wood for the trees. That's one of the benefits of this kind of collaboration, where it's really about keeping an eye open to what else might be going on.'

This ability to talk to each other, sharing insights and using different perspectives to shape a project, is raised at the outset by Isabel Ender, the head of conservation strategy at the Manta Trust. At the Convention on the Conservation of Migratory Species of Wild Animals [CMS CoP11] in Ecuador in 2014, a clear measure of success was that proposals to improve the conservation of 21 shark, ray and sawfish species were approved. Isabel believes this has much to do with the fact that the various conservation organisations were working together and supporting one another in a bid for a common goal: the conservation of these species. It was an objective to which they all subscribed and the groundswell support meant that the Manta Trust wasn't a lone voice on the floor. The interaction between organisations opened important communication channels that clarified their individual positions and motives. It seems an obvious connection, but if it's left murky, poor communication can stall otherwise valuable partnerships.

As she recounts the steps towards shark and ray protection at CMS, Isabel's tone warms and she raises the point that this solidarity was picked up by the media. 'If you Google it now, it was mentioned just how much there was a unified push for these species. You could really feel that force between all the different NGOs and IGOs that were there,' she says, a sense of satisfaction audible in her voice.

Similarly, the work ahead of the Convention on International Trade in Endangered Species

[CITES] CoP17, held in South Africa, was highly organised, with a Skype call in January 2016 facilitating serious forethought. 'All the different organisations working on sharks and rays talked through our strategy ahead of CITES: what resources we had to share with one another, what our media plan was, defining our focus and clarifying the objectives of each collaborator,' explains Isabel. There were follow-up calls in the months ahead of CITES, which she dubs the 'NGO coordination calls'. She believes they were very useful in keeping communication transparent, so that each organisation knew where it stood in relation to others and how each could refine its particular take on achieving the common goal.

The question of how best to identify potential collaborators draws a delighted chuckle from Isabel. 'It's like baking a cake!' she says brightly. 'Choosing who you collaborate with has partly to do with positive experiences of working together and looking for organisations that have a similar attitude when it comes to collaboration. Then it's also finding those collaborations that complement what your strengths are.' She goes on to explain her baking analogy. 'Some organisations might be really good at outreach and education, some others might be good at policy, while some might just have the money. You have to look for the right collaborators – the right mix to bake your cake.'

There was a fair amount of pressure riding on the success of this particular collaborative conservation cake. When getting your mix right determines the future of several species, it's an undertaking with more gravity than making an impression on an episode of *The Great British Bake Off* with your tray of perfectly executed éclairs. Devotees of a good Victoria sponge may disagree, but the push for the listing of mobula rays on CITES Appendix II was the critical outcome on which the Manta Trust had set its sights.

For Isabel, the CITES CoP17 experience is a useful case study of how choosing partners who complement your skills can better ensure collaborative success. 'The Save Our Seas Foundation has been supporting us for a really long time and believes in the Manta Trust, and I really think it adds to and complements what we have,' she explains. With its network, the foundation could offer media assistance, while the Pew Charitable Trusts brought considerable policy experience. The Manta Trust could then provide scientific expertise to inform the policy that Pew knew how to position, and the Save Our Seas Foundation could broadcast to a wider audience. 'For example,' says Isabel, 'if there's a workshop to inform government officials about the status of sharks and rays, Pew would organise but the Manta Trust could bring in the latest factual information.'

It's a point on which Isabel and Eleanor share common ground and it ties their respective experiences together. As Eleanor elaborates, 'You may not know them personally, but you should

know what sorts of role players you need. You may need someone who can give you insight into where you're deficient. You also need to know what skills you don't have. So I do think that thinking it through is pretty critical, especially because a collaboration will only really be successful if everyone buys into it.'

It's this question of everyone buying into a collaboration that seems to be sleight of hand. 'Setting expectations is the most important thing. I can't stress this enough!' Isabel grows animated on this point. For someone who has experienced both the power that effective collaboration can wield and the commitment to understanding how best to make the experience valuable, Isabel is both enthusiastic and pragmatic when doling out advice on the subject. 'You have to be realistic in your approach,' she cautions. Organisations will differ in their individual objectives, resources and expertise. Collaboration on every point simply might not be achievable, even if everyone is working towards an overarching common goal. 'You have to be very clear about which aspects you're working on together, to what extent you're sharing resources and skills, and how much freedom you afford one another because you can't melt everyone into one pot!' A defined vision, together with clear steps to achieving it and honest discussions on how each different organisation can contribute, goes a long way towards enabling each collaborator to integrate the project into their individual plans.

If only one thing has changed since 1858, it must be ease of communication. Only 14 days after his letter reached Charles Darwin, Wallace's theory was presented (without his knowledge or consent) at a meeting of the Linnean Society of London. His work was published in the Society's journal later that same year, together with Darwin's. For the other scientists to reach Wallace would have taken several months as he continued his explorations in the East.

If any aspect of this story enables us to see just how much some aspects of collaboration may have changed since the 19th century, perhaps this is it. The advent of the Internet, and along with it a host of instant communication services, makes the idea of publishing without consent seem inconceivable today. Access to research networks through Research Gate and Linked In has changed our ability to reach one another. Commercial flight places scientists face to face at conferences around the world, and Skype and Google Hangouts facilitate the kind of meetings the Linnean Society couldn't possibly have conceived in 1858.

'I really think it has changed a lot and I love it.' Eva Meyers dissolves into giggles at the mental image of Wallace sending a sad-faced emoticon to Darwin when he heard that his work had been

published without his consent. 'I mean, I've sent questions about a publication on Twitter. You can start a whole conversation just on social media.' Eva loves the idea that the ease of communication today levels the traditional academic playing fields somewhat, introducing a diversity of voices to conversations no longer relegated to the ivory towers of universities.

That you can get directly to your point and access networks where experienced researchers and young innovators alike are available for discussion is a major leap forward. There has been a change in the formality with which we approach each other and that, Eva believes, opens up a certain frankness. There are questions, however, about the etiquette of approaching fellow scientists on social media. 'Maybe I wouldn't put a smiley face in an opening e-mail to a researcher where I pose a serious question...' she concedes, bursting into an infectious chuckle.

Eva leads the Angel Shark Project in the Canary Islands. Early on in her work, she sent an exploratory e-mail to Dr Tristan Guttridge at the Bimini Biological Field Station (Shark Lab) in The Bahamas, seeking advice on tagging angel sharks underwater. She notes that we've all been in that position – hoping for an academic connection – and now that she is at a level of some expertise she takes care to extend to other researchers the same courtesy she received.

'I think it was Michael Scholl who thought it was a fantastic idea to send me over there [Bimini] to get some ideas on how we could develop the project.' So in 2016 the Save Our Seas Foundation facilitated Eva's visit to the Shark Lab to train in the art of PIT-tagging, a shark-related skill the lab's crew has been refining for years. 'For the project it was perfect because I gained a lot of security about what I was doing. I came back knowing that what I was doing was correct and all my fears that my ideas were ridiculous or not possible were...' She trails off, lost in her musing.

It's a point that may resonate with many researchers. The corroboration of ideas can propel projects forward. Fresh insights and a healthy dose of constructive criticism can guide a project to a better version of itself. Perhaps this is exactly what the nomadic Wallace sought from the well-respected Darwin. Eva concludes, 'Now I have a clear idea of what I can do and how to do it.'

There is a faint spectre looming behind all these conversations: the collaboration turned sour. For every story of a species protected, equipment shared or big data published, there are legends of stolen ideas and questionable ethics. For scientists who have experienced the darker side of collaboration, with its thorny politics and bruised egos, Eva's outlook seems rather magnanimous. 'Bad experiences shouldn't put you off for life!' she exclaims. Ironically, Darwin and Wallace might have agreed with her. Their partnership, in spite of its rather



questionable beginnings, grew into a lifelong mutual admiration for one another's work. Wallace even titled one of his books *Darwinism!*

It's worth pausing for reflection here. If these two scientists could face the minefield that was the publication of one of science's most influential theories, perhaps we should heed some of Eva's positivity. On the subject of taking a leap of faith, Isabel reflects, 'We all share this passion, and that's a major unifier. It's easy to make good friendships and find success through the spontaneous growth of our networks.'

In looking to the future, what of the role of collaboration in tackling the oceans' greatest challenges? The seas are our global commons and there is some thought that big challenges will need big teams to tackle them. The problems we face in marine conservation are not in silos. It seems that not only do we work with scientists within our respective disciplines, but there is increasing work across disciplines, and even outside the traditional scientific and conservation sphere. Is there still a space for scientists and conservationists working in isolation, or are we kidding ourselves if we think researchers have ever really worked alone at all?

'I think there is a place, conceptually, for solo working and probably the best example of this is the creation of *Monty Python's Flying Circus*.'

Eleanor pauses for brief effect, her mischievous grin betraying her delight at having referenced a British comedy in an ocean discussion, before she continues quite seriously. 'They tried to brainstorm comedy sketches as a group and it was complete chaos. The result was that they were only allowed to bring completed sketches to the group brainstorm. I think that illustrates that they still needed the group, you still need the collaboration, but it doesn't always work to start from scratch in a group.'

The point she raises brings us almost full circle, back to Darwin and Wallace working for years on an idea that would only come to full fruition once they brought it to each other. 'The point we're at now, we've had quite a long time of working on things, so if we're going to have a positive effect at scale, then we're going to have to approach this collectively,' Eleanor concludes.

In the face of some of the challenges we'll have to tackle in the coming years, the idea that 'no man is an island' is something of a comforting thought. Sometimes, even though the ideas are wrought in isolation, their presentation to the world requires a certain support and credibility that comes from collaboration. Perhaps that's what a feverish explorer once thought as he put pen to paper and sent his work to a more established scientist. If history is anything to go by, then perhaps collaboration isn't a half bad idea. ●

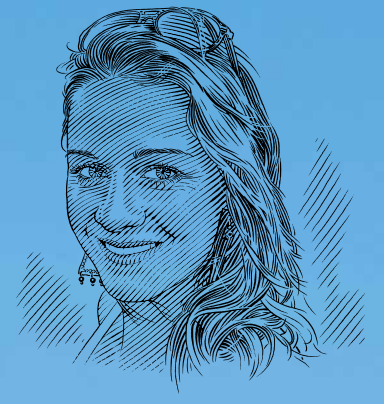
Matt Smukall of the Shark Lab works with Eva to record data.



Eleanor Yeld Hutchings



Sunnys Collins



Isabel Ender



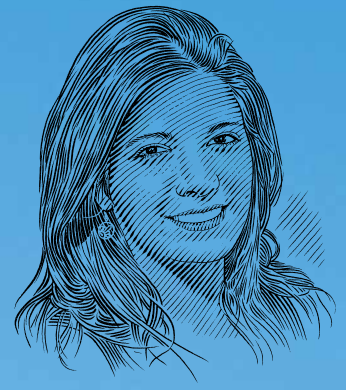
Daniela Vilema accompanies children during holiday clubs held in December by the Save Our Seas Foundation's Shark Education Centre in Cape Town.



Abi March



Eva Meyers



Daniela Vilema



Science at the far



Words by Lauren De Vos

Dubbed ‘the navel of the world’, Easter Island in the South Pacific is as much a place of startling marine biodiversity as it is of eyebrow-raising mythology. However, little marine research has been done before now, and establishing a baseline of data to inform future conservation management in this part of the world is no mean feat. Lauren De Vos speaks to SOSF project leader Naiti Morales Serrano about the challenges and triumphs of starting science in far-flung places.

end of the world



The rock art and petroglyphs of Rapa Nui are etched onto its basalt boulders, or carved onto the smooth, ancient lava flows called *papa*. Marine life around the island is linked to many legends, and tuna, swordfish, whales and crabs feature prominently in rock art, particularly on the island's north coast. Sharks sketched onto the rocks, swimming eternally against the passage of time, are another reminder why Naiti Morales's work is important.

Whitewash broils in an angry sea, building momentum before dashing itself against the island. Few have set foot here before; the only hint of human presence is a lighthouse that blinks forlornly at the night sky. The allure of an ecosystem both unexplored and unexploited is like the promise of a new land that guided the first Polynesian navigators to this region: magnetic.

Waves pulverise volcanic rocks, jagged teeth bared to the sky. A boat-load of researchers judge their approach. Spying a gap in the incessant pounding, the skipper gives the throttle rein and the boat shoots forward. The scientists and camera crew prepare to leap ashore. Water starts to heave back up the sides of the island, sucking the boat perilously close to the rocks. Timing is critical. The skipper must get close to the island to allow disembarkation without beaching their craft. As they backpedal, the motors growl in opposition to the pull of the water. In a nimble nanosecond, scientist Enric Sala leaps safely onto the island of Salas y Gómez.

Few people would find in this scene from the documentary *The Lost Sharks of Easter Island* the inspiration to start their PhD. Doing so would require that they cast aside serious misgivings about the isolation and challenges. But in Naiti Morales Serrano it sparked an idea. In the film, scientists Enric Sala, Carlos Gaymer and Alan Friedlander explore Easter Island and neighbouring Isla Salas y Gómez. Their mission? To highlight the region's biodiversity and muster support to address its challenges.

'I saw that and I thought "Okay, I want to work there!"' recalls Naiti. After graduating with a degree in marine biology, she had already worked at various jobs to nurture her passion for sharks. 'I worked with kids too, teaching them about sharks, and that was really cool!' She sought out Carlos, convincing him to take her on as a student. 'I said, I know you don't work with sharks, but I really want to do this, and I saw this documentary...' she pauses, 'and I have some ideas, so ... can I work with you?' Now a PhD candidate based at the Universidad Católica del Norte in Chile, she is one of those rare people who find meaning in taking up a challenge.

Easter Island, or Rapa Nui by its local name, is the most remote inhabited island in the world. Flung 3,700 kilometres west of the Chilean mainland into the Pacific Ocean, it is the easternmost of the Polynesian islands and forms part of what scientists call the Easter Island Ecoregion. Salas y Gómez, known locally as Motu Motiro Hiva, is its uninhabited island neighbour 400 kilometres to the east. Two rocks standing

sentinel in a vast sea, Motu Motiro Hiva has a combined area of a mere 0.15 square kilometres.

The whole Easter Island region has a volatile history, both geologically and anthropologically. Volcanic activity, thanks to the Easter Hotspot that boils deep below, gave birth to the islands and sea mounts that characterise this area. The sea mounts are essentially underwater mountains that range in age from 8.4 million to 13.1 million years, forming the Easter Sea Mount Chain and stretching eastwards from Rapa Nui for nearly 2,000 kilometres. Both Rapa Nui and Motu Motiro Hiva are considered geological youngsters, their youthful 0.8 million years recent history compared to volcanic elders like the Hawaiian islands.

'I'm trying to figure out how things work for top predators around Easter Island,' Naiti begins. The island is a territory of Chile, and a projection by that nation's Instituto Nacional de Estadísticas put the population of Rapa Nui at an estimated 6,600 people in 2016. Although there is a tradition of harvesting from local waters, there is currently no formal spatial protection for marine life around the island. However, in 2010 the Chilean government declared the waters around neighbouring Motu Motiro Hiva a marine protected area, with an extent of 150,000 square kilometres.

'My thesis looks at how top predators relate to these two areas,' explains Naiti. She wants to find out which predators are found around Rapa Nui, and to do so she deploys Baited Remote Underwater Video Systems (BRUVs) to assess their abundance and diversity. She is also exploring how these populations are connected between the two islands. 'For that, I'm doing genetics and tracking with satellite tags. I'm going to be using stable isotopes as well,' she elaborates. In effect, her project is a bid to tease out complex relationships in an ecosystem where top predators are both important and of conservation concern.

Starting a project in one of the most isolated regions of the world takes an uncommon kind of grit. I ask Naiti to describe what learning to work here has been like. Her response is measured: 'Unique, expensive, unknown, uncertain.' The weather, a growing list of field-work expenses and her reliance on local fishermen for access to their boats are persistent challenges. She first visited Motu Motiro Hiva in 2015 to tag sharks and fishes like *Seriola lalandi*, as well as to take genetic tissue samples.

The Save Our Seas Foundation has been helping to sponsor her work with BRUVs and in September and December 2016 she deployed her first cameras around Rapa Nui. The BRUVs film different species that swim into the camera's field of view, giving scientists a record of the composition of the community and the relative abundance of

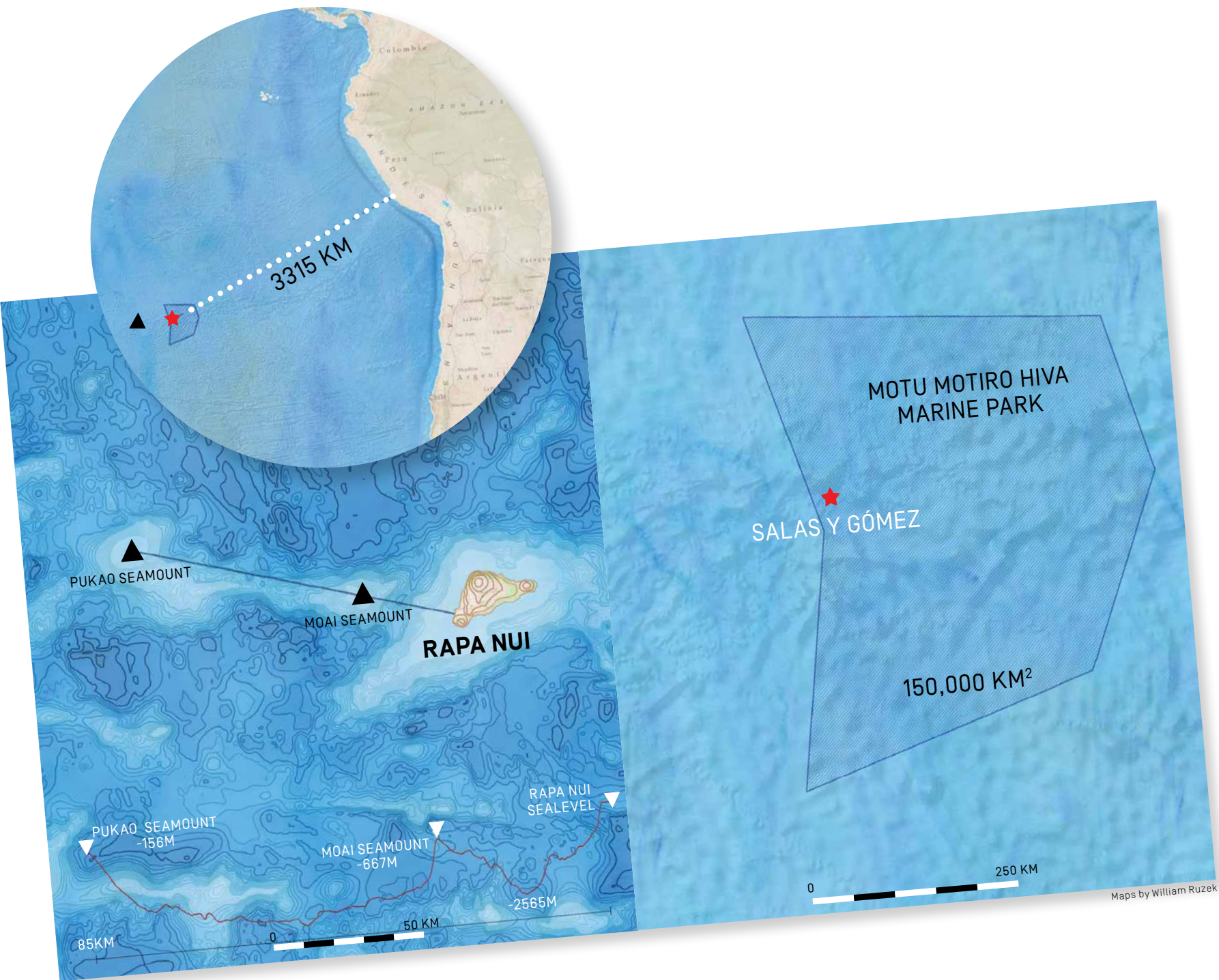
each species. The cameras are deployed from a boat and fish are attracted by the scent from a bait canister attached to the system. Naiti's BRUVs are pelagic, which means that instead of being deployed on the sea floor, the cameras hover at about 10 metres from the surface. This is a non-extractive way of recording the highly mobile, often diver-shy predators that rule the open ocean.

Adversity makes Naiti organised. 'Equipment and tools are expensive and really basic. These limitations mean I have to try to buy everything I might need in advance. Sometimes they're things I've never used before.' So what keeps her committed to this capricious place? 'Magic,' she replies.

Talking to Naiti, a region that I've only encountered in well-thumbed Lonely Planet guides leaps to startling technicolour life. My imagined Rapa Nui, dominated by the *moai* statues looming large in a windswept volcanic landscape, now extends well below the blue expanse that dwarfs the island. 'My favourite memory of it is actually from being on the water, looking down. Two years ago I worked on a Chilean Navy vessel that was travelling from the continent [South America] to Easter Island. Once we arrived at Salas y Gómez, I saw the cleanest water ever. There was no wind, so the water shimmered bright. We got into a smaller boat and threw the fishing line into the water to start our tagging work. In that moment, we realised we were totally surrounded by sharks and bony fishes. It was the perfect moment: the silence, the colour and the ocean.'

On a computer screen, a map of this region glows red, yellow and blue. This is how a satellite sees swathes of tiny marine plants called phytoplankton from space. Their populations blink back from the screen in colour codes that scientists use to model their abundance. High concentrations gleam in warm colours; low abundances in blue hues. Plankton, the building blocks that underpin the marine food chain, glow nutrient-rich red near the Chilean coast and yellow near the equator. By contrast, the expanse of water around Rapa Nui glimmers blue. Its waters are clear, but much of the Pacific Ocean here is nutrient poor. In the South Pacific Subtropical Gyre, the great swirling ocean circulation that dominates this region, phytoplankton are found deeper, at about 150 metres.

Prominent as 'biological oases' in this nutrient-poor water are Rapa Nui and Motu Motiro Hiva, located at the heart of the gyre. Here, tell-tale red glows around the two islands on satellite images. The result of this plankton profusion in the immediate vicinity of the islands is an ecosystem that is home to 142 endemic species – a collection of life found nowhere else on earth.



Were the biological interest of these islands not incentive enough, their conservation imperative surely is. Twenty seven of the species found here are listed on the IUCN Red List of Threatened Species. According to the Pew Charitable Trusts, 10 of these species are of special conservation concern, among them the Endangered loggerhead turtle and blue whale and the Critically Endangered southern bluefin tuna. The trusts' commissioned analysis found that the area is a spawning ground for predators such as marlin, swordfish, tuna and an assortment of shark species. Hydrothermal vents, the only features of their kind in Chilean territorial waters, hint at an ancient past that gave rise to the startling array of life found here.

For Naiti, the attraction lies in the importance of these waters to her favourite creatures on earth. 'I love sharks!' she says, passion steeped in her voice like a strong brew. She goes on to explain that in spite of the enormous interest in the region and its importance, there is little history of rigorous, sustained scientific research

there. 'Some work has been done, but not much. So actually, we are doing a baseline survey.'

Naiti works with the Millennium Nucleus for Ecology and Sustainable Management of Oceanic Islands (ESMOI). 'In this group, there are people working on different topics. It's a big group because we are trying to study everything!' she says. That's an ambitious undertaking, and with good reason. Rapa Nui is an oft-cited study on how we harm the environment at our peril.

In about AD 1200, ancient Polynesians settled on Rapa Nui and thrived, their ingenuity evident in the giant *moai* statues and *ahu* ceremonial platforms that form part of this UNESCO World Heritage Site. Scholars disagree about exactly what happened next. Jared Diamond writes in *Collapse* that Rapa Nui is the 'clearest example of a society that destroyed itself by overexploiting its own resources'. He blames farming for the deforestation, calling the islanders' fate 'ecocide'. New theories blame the introduced Polynesian rat, which amplified rates of deforestation and the loss of native species. Whatever

the reason, once European colonists arrived in 1722, introduced diseases coupled with Peruvian slave-raids felled the weakened population to 111 individuals in 1877. Today, Rapa Nui's inhabitants are a mix of descendants from the ancient population and diverse immigrants.

'When you live on an island, you're directly connected to the sea,' says Uri Erisa Tuki, a local craftswoman, in the documentary *Voices from the Sea*. The problem is that the impacts from local fishing are now amplified by threats from the outside world. New colonists from a modern world gone consumer-crazy wash ashore as plastic pollution, while illegal, industrial-scale fishing vessels have quickly sniffed out the most vulnerable underbelly of Rapa Nui: its isolation.

The depletion of fish populations elsewhere means that vessels, equipped with new technology, creep progressively further afield in search of fish stocks to exploit. That these fish are in another country's territorial waters is an obstacle only on paper. The Chilean Navy is responsible for enforcement, but the vast distances mean



Moai statues keep solemn watch at sunset over the South Pacific. They have baffled scholars through the ages, with the jury still out over what they represent and when and how they were carved. However, it's the world beneath Rapa Nui's waves that keeps marine scientists like Naiti Morales coming back to ask questions.





The ancient Polynesian mariners who first colonised Rapa Nui were celestial navigators, forging a route across the Pacific guided by the stars that light the night skies. Today, international flights and modern seafaring make Rapa Nui infinitely more reachable, but the region remains a challenging place for scientists to work in.

that much of this illegal fishing happens opportunistically. ‘The Subtropical Gyre also pulls the garbage towards the island,’ says Naiti. ‘The islanders try to manage the trash as best they can, but it comes from the sea. In one of my BRUVs videos, I saw a shark entangled in plastic.’

Naiti explains that for the scientists of ESMOI, a baseline survey is a step towards understanding the patterns of marine life in the region so that they can better protect it. ‘The Chilean government protected the waters around Motu Motiro Hiva because it’s really special. Its isolation means that there may be undiscovered species there. Yet the government protected the area without knowing too much about what’s going on in it. We’re trying to gather information so that we can expand the borders, or create better ones, for marine protection, while trying to figure out how to protect Rapa Nui too.’

That predators abounded around Rapa Nui is evidenced by petroglyphs depicting marlin, tuna and sharks. They hint at the past abundance of these hunters, as well as their importance to ancient Rapa Nuians. Colleagues initially advised Naiti that her quest for sharks would yield no results. She remained true to her convictions: previous surveys were diver-based and many sharks steer clear of divers. ‘When I started working, a lot of colleagues said there are no sharks there. I said, yes there are. The fishermen are saying that they see sharks every time they go out. They have to be somewhere!’

Fishermen spoke of the ubiquitous Galápagos shark, the tiger sharks that arrived in summer and of mako and blue sharks. They pointed out on her study map where they saw sharks and she designed her survey to target these areas. Naiti describes the heart-stopping moment when her first shark swam into view on video: ‘A lot of people told me I was wasting my time. When I saw the first shark, I got super excited. My dream was coming true! For the first time, we have a scientific record of these sharks around this island.’

I ask Naiti about this ‘baseline’, knowing as she does that Rapa Nui is a highly impacted system. She nods in agreement and I offer the term ‘shifted baseline’. We discuss this interesting conundrum: a place that for the most part is scientifically undescribed, but where the impacts of human activity echo across the ecosystem at all levels. The effects are usually felt most keenly in the declines of top predators: those large, aggressive fish that we tend to deplete first. Naiti has shown scientifically that there are still sharks to be found around the island, but it seems they are no longer as abundant as the old Rapa Nuian artefacts suggest.

She describes an ancient form of fishing still used today. Fishing line and bait are wrapped

alternately around a piece of volcanic rock, which is then thrown to the sea floor at a depth of about 100 metres. The rock rolls along the sea floor and unravels the line, while the fishermen wait at the surface for a bite to the hook. This method is juxtaposed with the nets used to catch small fishes near the coast and the rampant illegal fishing from foreign vessels. What is the reference point for recovery in a system that blurs the lines between ancient culture and encroaching modernity?

The concept of a shifting baseline is famously outlined by fisheries scientist Daniel Pauly. In his talk ‘Our Ocean’s Shifting Baseline’, he tells the story of Charles Darwin in the Galápagos, who wrote in 1835 that the sailfin grouper *Mycotoxoptera olfax* was very common. Indeed, Daniel continues, the species was a mainstay of a large fishery well into the 1980s. The sailfin grouper is now classified as Vulnerable on the IUCN Red List. ‘The point is, we come to Galápagos, we still think it is pristine. The brochures still say it is untouched. So, what happens here?’ he asks.

With a shifting baseline, we tend to adjust to a new normal. We measure change in ecosystems against reference points without accounting for the fact that those reference points may actually represent significant departures from an even earlier ecosystem state. We accept this, Daniel maintains, because we don’t know that it was so different. ‘We transform the world, but we don’t remember it. We adjust our baseline to the new level and we don’t recall what was there.’

Daniel argues for marine protected areas, where we can recreate the past in a way that people can see what it was like. Without this visual evidence of change, this comparison between exploited and unexploited ecosystems, the scale of declines is hard to conceptualise. ‘Nothing has changed, and yet everything has changed,’ he says.

If the baseline at Rapa Nui has shifted, then perhaps it’s to Motu Motiro Hiva that scientists will look as a reference point. Archaeologist Edmundo Edwards’s tone is reverential in a clip from *Lost Sharks of Easter Island*: ‘What you’re going to find in Salas y Gómez is much more spectacular. You’re going to see how Easter Island was before the first settlers arrived here. You’ll find the whole ecosystem there, intact. You’ll see how the world was 2,000 years ago.’ Named for two Spanish explorers who were the first Europeans to describe the island in 1805, its local name means ‘islet on the way to Hiva’. Hiva, meaning ‘far-off lands’, is the name for the homeland in Polynesian myths. With no freshwater sources and a precipitous coastline that makes landing on the island tricky, Motu Motiro Hiva gives us that tangible reference point of which Daniel speaks.

Deploying BRUVs around Motu Motiro Hiva will take the already complex logistics of Naiti’s project to new heights. Depending on funding and time, she hopes to survey this second island in April 2017. In the meantime, she looks forward to deploying more BRUVs around Rapa Nui to record new elasmobranch species for the region. Her excitement is infectious. ‘According to the fishermen, there are at least three other species: thresher shark, eagle ray and sometimes tiger shark. None of these species has been scientifically recorded ... yet!’ I ask Naiti whether the idea is for BRUVs to continue after her project wraps, as part of a monitoring programme. ‘That’s the idea, yes,’ she replies.

The work of the ESMOI scientists has already been compiled into a glossy publication packed with information and photographs to capture the public’s interest. *Mata ke te Moana* does for a wider audience what Naiti did for me: bring the magical underwater realm of Rapa Nui ashore, raising its profile to match the mythology of the ancient *moai* that stand silent sentinel on land.

The swirling ocean gyres and midnight skies in this part of the world have drawn pioneers, dreamers and explorers to its heart over millennia. The first Polynesian settlers are thought to have sailed by the stars from the Tuamotus, or the islands of Mangareva–Pitcairn–Henderson. For a group of modern scientists, the ocean hinted at as much as the starry skies had promised those first Polynesian sailors: a new world.

Naiti, equipped with her passion for sharks, the lens of modern science and the new eyes of evolving technology, is perhaps just the latest in this ancient procession of pioneers. As her cameras bring in evidence that sharks are still sovereign in these waters, we can all look to learn once again from Rapa Nui about how we live on this planet. With the new information that Naiti’s research will illuminate in the coming years, there is the chance that this time it might not be too late. ●



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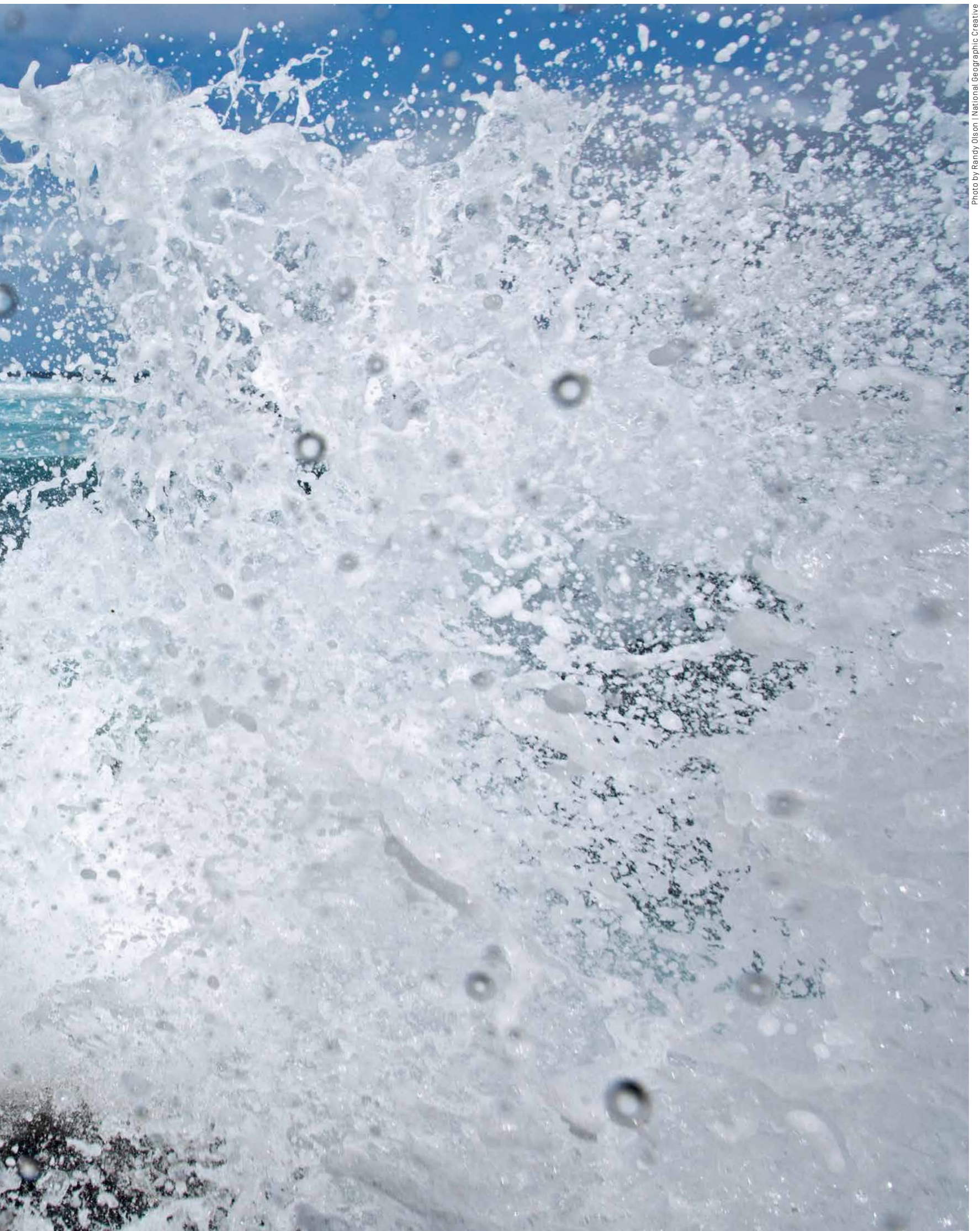




Windswept, rugged and largely devoid of the wooded trees that historians argue ancient inhabitants depleted, Rapa Nui is dwarfed by the South Pacific Ocean from which it emerged 0.8 million years ago. A caldera, the tell-tale scar left by a collapsed volcano, speaks to the island's volcanic origins.

Life on the most remote island in the world is closely linked to the ocean. The seas around Rapa Nui and neighbouring Moto Motiro Hiva can be wild, but they have been a source of income and sustenance for fishermen for centuries. The challenge now lies in how to manage this biodiversity in a rapidly changing social and ecological climate.





Each year large numbers of Chilean devil rays, the largest of the mobulid rays, visit remote sea mounts in the archipelago of the Azores. The discovery of these aggregations has transformed the region from an important fishing ground into a Mecca for divers wanting to encounter these graceful rays, which have become a major target in the gill-plate trade.

Ana Filipa Sobral is studying the mobulid rays of Santa Maria and has partnered with international organisations to ensure their protection.

Words by Ana Filipa Sobral

Between devils and the deep blue





Every summer, remote sea mounts in the Azores archipelago are visited by the deepest diving animals in the ocean: Chilean devil rays. The predictability of their aggregations, coupled with the rays' curious attitude towards divers, provided an opportunity for the rapid growth of a targeted diving industry. The Azores is one of only a few places in the world where Chilean devil rays are known to aggregate in large schools.

The Azores

Located in the middle of the Atlantic Ocean (37°–40°N; 24°–32°W) between the United States and Europe, the nine volcanic islands of the Azores form the most isolated archipelago in the North Atlantic. They are the emerging peaks of a vast submarine mountain chain called the Mid-Atlantic Ridge, which divides the entire length of the ocean from north to south. In fact, the highest point of this chain is the top of Mount Pico, the volcano that forms Pico Island.

The archipelago lies near the junction of three major tectonic plates: the North American, the Eurasian and the African. As a result of the high volcanic activity, sea mounts are a common feature of the region. Two branches of the Gulf Stream influence oceanic conditions around the Azores: the cold and nutrient-rich North Atlantic Current flows north of the islands, while the warm Azores Current passes to the south. The unique conditions they produce make the archipelago an important habitat for many large pelagic species that undertake Atlantic migrations and find here a good environment for breeding, feeding and growing. As a result, the Azores are of great interest to nature lovers and, especially, marine biologists.





Sea mounts are very common in the Azores – there are 461 in the islands' exclusive economic zone alone – and they generate specific conditions, such as an increased upwelling of nutrients and enhanced local productivity that supports organisms of the higher trophic levels such as dolphins and mobula rays. They are also believed to have unique geo-magnetic signatures that are used by large pelagic species for navigation during the course of their migrations.

It is 6.45 am and the sun has just appeared from behind the majestic Pico volcano as our boat leaves Horta marina and heads towards Princesa Alice, a sea mount located 45 nautical miles south-west of Faial Island in the Portuguese archipelago of the Azores. The sky is a mix of orange and purple and the sea is flat, its water the colour of platinum. A three-hour journey lies ahead.

Although I have done some diving before, this will be my first dive so far offshore. It's a long trip but there is plenty to see on the way, from resident sperm whales to turtles and sunfishes. I have just started my thesis on Chilean devil rays *Mobula tarapacana* but haven't come face to face with one yet, so a local dive operator has kindly offered to take me out to the sea mount. I've heard so much about Princesa Alice, my enthusiasm and expectations are at an all-time high as we get closer.

We finally arrive and there is no land in sight – we are in the middle of nowhere in the Atlantic Ocean. I feel incredibly small as I realise just how vast is the expanse of water around me. While the crew drops anchor, I give a short talk about the devil rays and ask the divers to try to get belly photos of them for photo identification. After the safety briefing everyone rushes to gear up before jumping into the ocean.

At last I am in the water and it is of the deepest blue I have ever seen, with a clarity that is unbelievable – from the surface it is possible to see the top of the sea mount 35 metres (115 feet) below us. I go down to it but ascend again rapidly, wanting to have as much time as possible to look for rays. Hanging onto the anchor line in a blue world, I wait for whatever may pass by. And I don't have to wait long. Within a few minutes, four golden shadows glide gently up from below. They swim by, performing a perfectly synchronised ballet: three males chasing a female and mimicking her movements. I watch in astonishment.

At the time it didn't occur to me that, exactly 116 years before, Prince Albert I of Monaco and his crew were probably experiencing the same sense of wonder. The leader of a research expedition aboard the *Princesa Alice*, Prince Albert was just starting a deep-water survey here. Expecting the sea floor to lie a few thousand metres below them, he and his crew discovered rocky ledges just 241 metres (790 feet) down. They explored

the area and realised they were floating above an extensive platform that supported an amazing diversity and abundance of life, especially of commercially interesting fishes. The following day Prince Albert sent a telegram to Carlos I, the king of Portugal, announcing the incredible discovery and telling him about its importance to the Azorean fishery. The sea mount was named after his research vessel and the prince continued to study it on subsequent visits.

Of the 29 oceanographic surveys that Prince Albert led between 1885 and 1915, 13 were conducted in the waters around the Azores. As well as being remote, these nine islands have a complex geological background that, together with the surrounding deeper waters, results in a unique diversity of marine habitats and of life within them. The objectives of the prince's surveys were primarily to investigate the deep-sea fauna, but also to study the oceanographic currents and meteorology and to map the sea floor. He ended up observing all manner of creatures, from bacteria and plankton to fishes, turtles and marine mammals, between the surface and a depth of 6,000 metres (20,000 feet). His surveys contributed immensely to the progress of oceanography, a fairly new science at the time, and also played a part in devising innovative methodologies, leading to the discovery of life forms and ecological relationships that hadn't been known about before.

Although Prince Albert realised at the time that the Princesa Alice sea mount would be an important fishing ground, it's unlikely that he could have imagined that, more than a century after its discovery, it would become one of the most important dive sites in the North Atlantic and that the revenue generated from diving would surpass by far the revenue that came from fishing. The main reason for this is the presence of majestic Chilean devil rays, which visit the sea mount every summer. The predictability of their aggregations, coupled with the rays' curious attitude towards divers, provided an opportunity for the rapid growth of a targeted diving industry.

Princesa Alice is, in fact, one of only a few places in the world where Chilean devil rays are known to aggregate in large schools. Another important aggregation site in the Azores is Ambrósio, also a sea mount, which lies three nautical miles off the north coast of the island

of Santa Maria. Elsewhere, the devil rays reportedly amass in Brazil's St Peter and St Paul Archipelago and around Cocos Island, Costa Rica. Aggregations such as these offer an incredibly rare opportunity to study the species in the wild. Nevertheless, collecting data on such oceanic and migratory animals is no easy task.

The Chilean devil ray is large – more than three metres (10 feet) from tip to tip – slow-growing and one of the least fecund of the elasmobranchs, producing a single pup every two or three years. These pelagic rays occur around the world in sparse locations in the Pacific, Atlantic and Indian oceans, appearing to visit productive areas around oceanic islands and offshore sea mounts on a seasonal basis. The size of the species' global population, like that of the other *Mobula* species, is not known. However, low fecundity, together with other life-history and ecological traits, make it particularly susceptible to overexploitation.

A combination of different approaches has enabled us to shed a little light on the rays' mysterious lives, especially while they are here in the Azores. We have learnt from data collected by dive operators that they start arriving in the region in June and stay until the very end of October, so they are here when the water is warmer and less productive. Satellite tagging has revealed that when they leave our sea mounts they head south; tagged Chilean devil rays have travelled distances of up to 3,800 kilometres (2,360 miles) in seven months, demonstrating their truly migratory nature. However, what they do and where they go after that remains a mystery.

Sea mounts are very common in the Azores – there are 461 in the islands' exclusive economic zone alone – and they generate specific conditions, such as an increased upwelling of nutrients and enhanced local productivity that supports organisms of the higher trophic levels. In addition, it is believed they have unique geo-magnetic signatures that are used by large pelagic species for navigation during their migrations. Chilean devil rays, however, aggregate only at specific sea mounts – those whose peaks lie at a depth shallower than 100 metres (325 feet). Shallow sea mounts such as these can be important aggregation sites for

highly migratory pelagic species, but we know little about what makes them so attractive, mainly because it is difficult to determine what drives these species. A combination of factors will probably lead to the most likely explanation. Even though the rays move long distances each day, they spend most of their time at specific shallow sea mounts. Why is that? What is so special about these particular places? Why do the rays return every year? These are all questions that remain to be answered.

It's possible that the shallow sea mounts around the Azores are important for mobulid rays from a social perspective, since the likelihood of interaction between individuals is higher at them. They could also play an important role as mating and pupping grounds, given that all the rays are adult, and pregnant females are often present. However, there have been no records so far of juveniles in the area.

One of the deepest-diving animals in the ocean, the Chilean devil ray can go down to 1,896 metres (6,220 feet), where it tolerates temperatures below 4 °C (39 °F). It is also an extremely fast swimmer, reaching a speed of six metres (20 feet) per second! Its dive profile suggests that it may be feeding at depth in high-density layers of pelagic organisms, possibly on fish and squid.

Although this particular devil ray species is the only one to form aggregations here, it is not the only ray to visit the Azores. We also encounter the giant manta ray *Manta birostris* and either the giant devil ray *Mobula mobular* or the spine-tail devil ray *M. japonica* (more research is needed to distinguish between these two species). The giant manta is seen less frequently than the Chilean devil, but sightings of it have increased in the past couple of years. The manta rays tend to be seen closer to shore, occasionally at sea mounts, and always as solitary individuals.

When Chilean devil rays and giant mantas occur together, they typically interact; usually the devil ray is observed following the manta. The third species is seen more rarely, and when it is encountered it is closer to shore and in groups of three to five individuals. We don't know where these animals come from or where they go when they leave our waters. Further research and the development of new methodologies will be key if we are to gain a better understanding of the ecology of devil rays.

What we do know is that the biggest threat mobulid rays currently face is fishing. In Asian markets there is a growing demand for their gill plates, which are used in a health tonic, and the animals are taken as by-catch as well as in targeted fisheries. In fact, the ever-increasing demand has led to a shift from incidental by-catch to targeted fishing. Throughout its wide range, the Chilean devil ray is caught both incidentally and as a targeted species, and by both artisanal and commercial fishers. It has the largest – and therefore most valuable – gill plates of all the mobulid rays and is thus in greatest demand. Its gill plates can be sold for up to US\$557 per kilogram in China, and a single ray can produce up to 3.5 kilograms (almost eight pounds) of dried gill plates.

Because the locations and timing of its aggregations are predictable, and because it is a highly migratory species, the Chilean devil ray is vulnerable to both coastal and offshore fishing. Even though it is not fished in the Azores, the species knows no boundaries and once the rays that we see at the sea mounts leave our waters, it is likely that they become targets for fisheries.

At the global level, *M. tarapacana* is listed as Vulnerable on the IUCN Red List of Threatened Species, while in South-East Asia, the Eastern Pacific and the Indian Ocean it is classified as Endangered. We suspect that its global population has declined by at least 30% over the past 30 years. Only a few decades ago, the aggregations seen in the Azores were much larger than those reported in the past five years. If the demand for gill plates continues to drive unsustainable fisheries, these local aggregations may be at risk of disappearing altogether.

In September and October 2016, representatives of governments from around the world gathered at the 17th Conference of the Parties to the Convention on International Trade in Endangered Species (CITES) in Johannesburg, South Africa. Here they debated a proposal presented by Fiji to include the nine *Mobula* species in Appendix II.

In the lead-up to the vote on the proposal, the Manta Trust launched a media campaign, #Love-MiniMantas, to encourage the delegates' support for the protection of *Jamantas* (the name for mobulid rays in Portuguese). The main component of the campaign was Daniel Copeland's

virtual reality (VR) film *The Mini Mantas of Maria*, which gave the delegates the opportunity to 'dive' with Chilean devil rays at Ambrósio sea mount as a 360-degree VR experience. During the seven days before the proposal went to the vote, the film was seen by 350 delegates, some of whom had no idea of what a devil ray looks like; most had never even dived before. There's no doubt that the VR experience had a positive impact on everyone who shared it.

Back in the Azores, the people of Santa Maria were very happy that their little island and the waters around it became the 'face' of this worldwide campaign for the protection of mobulid rays. When the campaign was over, the local municipality expressed its intention to propose the creation of a sanctuary for mobulid rays in the area. Even though these species are not fished here, the island wants to set an example to the rest of the world and at the same time draw attention to the importance of these unique and precious places on its doorstep. A sanctuary would also raise awareness among visiting divers of how vital it is that we protect this habitat and its species. The divers, too, can contribute directly to research on mobulid rays in the Azores through the SOSF-funded project 'Manta Catalog Azores'. All they have to do is report their encounters with the rays and take identification photos of them. Sightings at aggregation sites like Ambrósio and Princesa Alice are going to be fundamental in increasing our knowledge of mobulid rays in the future.

On 3 October 2016 history was made at the CITES conference when, as a result of the hard work of many different people and organisations, a staggering 85% of votes ensured that all nine *Mobula* species would be protected under Appendix II. In effect, mobulid-derived products can now only be traded legally in international markets if they come from sustainably managed fisheries.

While the CITES listing alone cannot guarantee protection for Chilean devil rays, it does represent a critical step forward in the bid to ensure that these golden shadows continue to grace the deep blue waters of the Azores during their annual migrations. And I will do my part by continuing to work on unravelling the secret behind why they come to our underwater mountains and what they do here. ●

People began settling in the Azores in the early 1400s. Those early settlers could never have known that these remote islands would become an important location for modern-day explorers in search of migrating pelagics like Chilean devil rays.









Mount Pico volcano on Pico Island is the highest point in the Azores, the most isolated archipelago in the North Atlantic. The islands were first discovered by explorers during the 14th century.





An aggregation of Chilean devil rays at Ambrósio dive site off Santa Maria Island in the Azores. Unique oceanic conditions make the Azores an important habitat for large pelagic species like mobulas.

An underwater scene featuring a variety of marine life. In the foreground, a large, light-colored shark swims towards the right. Below it, a coral reef is visible. Several colorful fish, including a striped fish and a blue fish, are swimming in the water. The background is a deep blue, suggesting a clear, deep ocean environment.

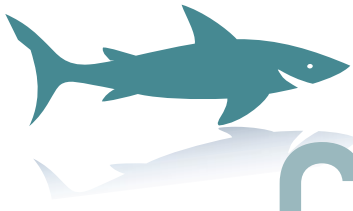
Uncovering secrets in the ‘Aldabra of the Amirantes’

Words by Clare Keating Daly

Worldwide, our oceans are in trouble and island nations like the Seychelles are especially vulnerable to changes to marine ecosystems. International organisations have called on countries to safeguard their marine resources by creating an effective network of marine reserves that protect important habitats and make fish stocks more sustainable in the long term. St Joseph Atoll, a critical nursery site in the Outer Islands, would play a valuable role in the Seychelles’ network of marine protected areas.



A blacktip reef shark darts among schools of reef fish above the coral at D' Arros Island.



Celebrated and protected for its natural splendour and heritage value, Aldabra Atoll is the pride of the Seychelles. Although few places in the world compare to Aldabra, the Seychelles shelters another gem in its Outer Islands: St Joseph Atoll. Being surrounded by a distinct, uninterrupted reef flat at low tide sets St Joseph apart from all other atolls in the Seychelles, giving it significance as a nursery, breeding and feeding area for multiple species. Although small, St Joseph is as important to the Seychelles as Aldabra is.

Together with neighbouring D'Arros Island, St Joseph Atoll provides an outstanding ocean observatory for scientific research and discovery. From its base on D'Arros, the Save Our Seas Foundation D'Arros Research Centre (SOSF-DRC) has demonstrated its commitment to research and discovery in the area. Showcasing the national and international significance of the island, the atoll and the surrounding waters, the SOSF-DRC aims to conserve the integrity of the natural environment for the Seychellois people today and in the future.

For more than a decade, the research centre on D'Arros has conducted baseline monitoring of the marine environment and, after combining with the Save Our Seas Foundation in 2012, it initiated additional new and innovative research projects. Coupled with long-term monitoring, these new projects help not only to provide a reference for the entire Amirantes Group, but also to answer crucial questions about the life histories of important marine species.

The SOSF-DRC supports 15 research projects, which include studies of 17 megafauna species such as the Vulnerable manta ray *Manta alfredi*, the Critically Endangered hawksbill turtle *Eretmochelys imbricata* and the Endangered green turtle *Chelonia mydas*. Broader ecosystem concerns relating to biodiversity and habitat rehabilitation are also among the research topics. Along with Danah Divers, the SOSF-DRC maintains the largest acoustic receiver network in the Western Indian Ocean, which consists of 88 receivers that track marine life over the entire Amirantes Bank. Over and above its commitment to research at St Joseph and D'Arros, the SOSF has supported an additional seven projects elsewhere in the Seychelles.

While the comprehensive research projects based at the SOSF-DRC focus on important conservation issues relating to both ecosystems and species, they also

have future generations of the Seychellois people in mind.

Above the sea

Of course, the marine realm includes more than just what lies under the waves. What happens within the reefs, flats and lagoon of D'Arros and St Joseph are inextricably linked to what occurs above sea level on each tiny coralline island and sand cay in the group. The SOSF-DRC understands that to undertake the best research, a holistic approach to tropical island ecosystems must incorporate studies above the sea as well as below it.

While the heavy rain of coconuts from unmanaged former plantations continues to fall on D'Arros and the largest islands within St Joseph Atoll, forest rehabilitation efforts have expanded relic stands of indigenous broadleaf trees. Thus a new rain of nutrient-rich guano from returning seabirds enhances efforts to restore parts of the islands to their former ecological state. Because all islands in the group have been rat-free for more than a decade, these rehabilitated indigenous forests provide potential areas for the introduction of endangered endemic land birds – and a possible stronghold for Seychelles bird species under threat. Indeed, forest rehabilitation is likely to increase biodiversity within the whole system.

In 2017, the SOSF-DRC plans to initiate a terrestrial biodiversity assessment of the area by partnering with the University of Seychelles. This project aims to contribute to the broader national biodiversity database, such as the National Environmental Data and Information portal, as outlined in the most recent Seychelles National Biodiversity Strategy Action Plan. The opportunity for the SOSF-DRC to work closely with the University of Seychelles promotes capacity building for the Seychellois people and adds to the vision of a knowledge-based society.

Birds, including 15 breeding species, make up a large part of the biodiversity of St Joseph and D'Arros. Accordingly, the SOSF-DRC currently supports a research project on the most abundant seabird found in the area, the wedge-tailed shearwater *Ardenna pacifica*. Soaring in after foraging at sea for days at a time, the shearwaters, or *fouquet* in Seychellois Creole, gather in their tens of thousands as night falls on St Joseph and D'Arros. The colony is estimated to be the third largest in the Western Indian Ocean and the sheer numbers of these

nesting seabirds provide an opportunity to uncover significant feeding areas for the species. As shearwaters frequently associate with tuna, studying this population may help the government of the Seychelles, a major tuna-fishing nation in the Western Indian Ocean, to better understand and manage its tuna stocks.

Between the shores and in the shallows

Similarly to above sea level, much happens between the land and the reef crest around St Joseph Atoll and D'Arros Island. While hawksbill and green turtles trust the undisturbed beaches to safeguard their precious nests, shallow sand flats provide crucial habitat and nursery grounds for various fish species, sharks and rays. The beaches and shallow waters of St Joseph and D'Arros have largely been protected from the resource harvesting, increasing human activity and excessive coastal development seen on many other islands in the Indian Ocean. Consequently, there exists an exceptional opportunity to study the animals and processes within this zone.

As a link between the ocean and islands, turtles rely on both healthy marine habitats and undeveloped beaches. Seychelles resident Dr Jeanne Mortimer heads the nesting turtle monitoring programme that is carried out predominantly by members of the Seychellois community living on D'Arros. Notably the longest-running programme of its kind in the Amirantes, this initiative has involved no fewer than 17 Seychellois individuals over the years. The direct decline in poaching observed as a result of their efforts speaks to the success of the programme. By taking ownership of the turtles and responsibility for their well-being, the monitors have ensured that more turtles are able to reproduce and carry on the species.

The additional long-term monitoring of juvenile turtles that forage in the safety of the waters around St Joseph and D'Arros has led to the recognition that these shallow waters are important for hawksbill and green turtles both locally and internationally. Since the 1970s, the local population of turtles has increased, presumably due to the undisturbed and undeveloped beaches. The SOSF-DRC's commitment to turtle research has contributed to a better understanding of the nesting behaviour and population sizes of the turtles, as well as the growth rates and movements of the juveniles.



The significant impact that these long-term research projects have had on the well-being of turtles in the Seychelles stretches well beyond the small area around St Joseph and D'Arros.

As much as the beaches are an important nesting area for turtles, the shallow waters of St Joseph Atoll provide shelter for newborn blacktip reef *Carcharhinus melanopterus* and sicklefin lemon *Negaprion acutidens* sharks. Accordingly, since 2014 the SOSF-DRC has supported the largest neonatal shark study in the Seychelles, which examines the habitats of the two species and the role of competition between them. Early results highlight the importance of St Joseph Atoll as a healthy nursery ground that, if protected, could help protect entire species from increasing threats. The study provides a better understanding of how sharks operate in a remote coastal ecosystem, which is applicable in the broader Seychelles as well as in local waters. Furthermore, understanding these complexities could help to provide a template for the management of communal shark nurseries in the Indian Ocean.

Although St Joseph Atoll teems with rays of three species – cowtail ray *Pastinachus sephen*, mangrove whiptail *Himantura granulata* and porcupine ray *Urogymnus asperrimus* – and is the feeding, breeding and nursery area for all three, very little scientific attention has been given to this role. The porcupine ray in particular is classified as Vulnerable on the IUCN Red List and although it is considered rare over much of its range, it is found in abundance in the atoll. Since 2014 an SOSF-DRC project has been studying the ecology of stingrays in St Joseph Atoll and aims to discover how these species link between apex and lower trophic levels within the atoll system. Studying and protecting them within the isolated system of St Joseph Atoll is vitally important for the conservation and management of each of these three species throughout their distributions.

Beneath the waves

Under the sea exists a kaleidoscope of colour, a treasure trove of life. But because overexploitation, pollution and damage aren't as visible beneath the waves as they are on land and beaches, extra precautions and special reserves are required to safeguard marine ecosystems. From the study of oceanographic systems to coral reef monitoring and manta ray ecology, the dedication of the SOSF-DRC to marine research is unmistakable.

Understanding oceanographic trends is the backbone for recognising broad drivers of animal movements and ecology. For this reason, the SOSF-DRC monitors relevant ambient environmental data such as tidal movements, light intensity and temperature. Every five minutes since 2011, no fewer than 100 temperature loggers have recorded the sea temperature in the waters surrounding the island and atoll. Early analysis of data from loggers at five metres highlights a significant annual temperature change of nearly 7 °C, which probably affects animal movements and foraging around both St Joseph and D'Arros. These results may ultimately help to predict the severity of bleaching events and estimate the mortality or recovery of corals after the events.

By monitoring the marine environment around St Joseph and D'Arros, researchers are able to detect changes in good time. The earlier they perceive these changes, the sooner they can try to understand them, answer questions about why they are happening and put measures in place that could help to reverse or mitigate them or encourage adaptation to them.

Monitoring oceanographic conditions feeds directly into the uninterrupted five-year coral and reef fish monitoring programme run by the SOSF-DRC. In the coral aspect of the programme, the most detailed such programme in the Seychelles, the data collected include benthic cover and composition, growth rate and recruitment of corals and both broad- and fine-scale bleaching surveys. These surveys were particularly relevant during the bleaching event in mid-2016, as without prior monitoring of composition, recruitment and growth prior to the bleaching, there would be little to compare for recovery. Without baseline data such as these, it is difficult to pinpoint what constitutes a healthy reef. In the second part of the monitoring programme, data from reef fish surveys have shown abundant and diverse fish populations that have the potential to act as replenishing stock for the wider Seychelles.

A healthy coral reef system with abundant reef fishes provides support for larger top predators such as giant trevally *Caranx ignobilis*. Although this species is commercially and recreationally important throughout the Indian Ocean, virtually nothing is known about its life history. In 2016 the SOSF-DRC set out to use behavioural ecology and genetic analysis to investigate the population connectivity of this large species. For

the Seychelles, a better understanding of the giant trevally could lead to improved management of the species and the prioritisation of exploiting it sustainably, which would benefit both the tourism economy and local food security.

Finally, another ocean giant, the reef manta *Manta alfredi*, is a popular resident in the waters surrounding St Joseph and D'Arros and it too has an established research project associated with it. With a local population exceeding 120 identified individuals, the mantas studied by the SOSF-DRC make up the largest and densest aggregation known in the Seychelles. Because the reef manta faces population declines throughout its range, understanding its ecology and movements is crucial to its survival as a species and its participation in the tourism industry. The conservation needs of the reef manta in the wider Seychelles are generally not known, but the species' global ecotourism value of roughly \$50-million makes finding out how best to protect it worthwhile in terms of both conservation and the economy.

Just getting started

Ultimately, the SOSF-DRC has a strong history of supporting research to enhance and promote the conservation of important Seychellois ecosystems, species and heritage. Yet these projects are only the beginning; the centre has merely scratched the surface of the potential for St Joseph Atoll and D'Arros Island to unlock the natural secrets of the Seychelles.

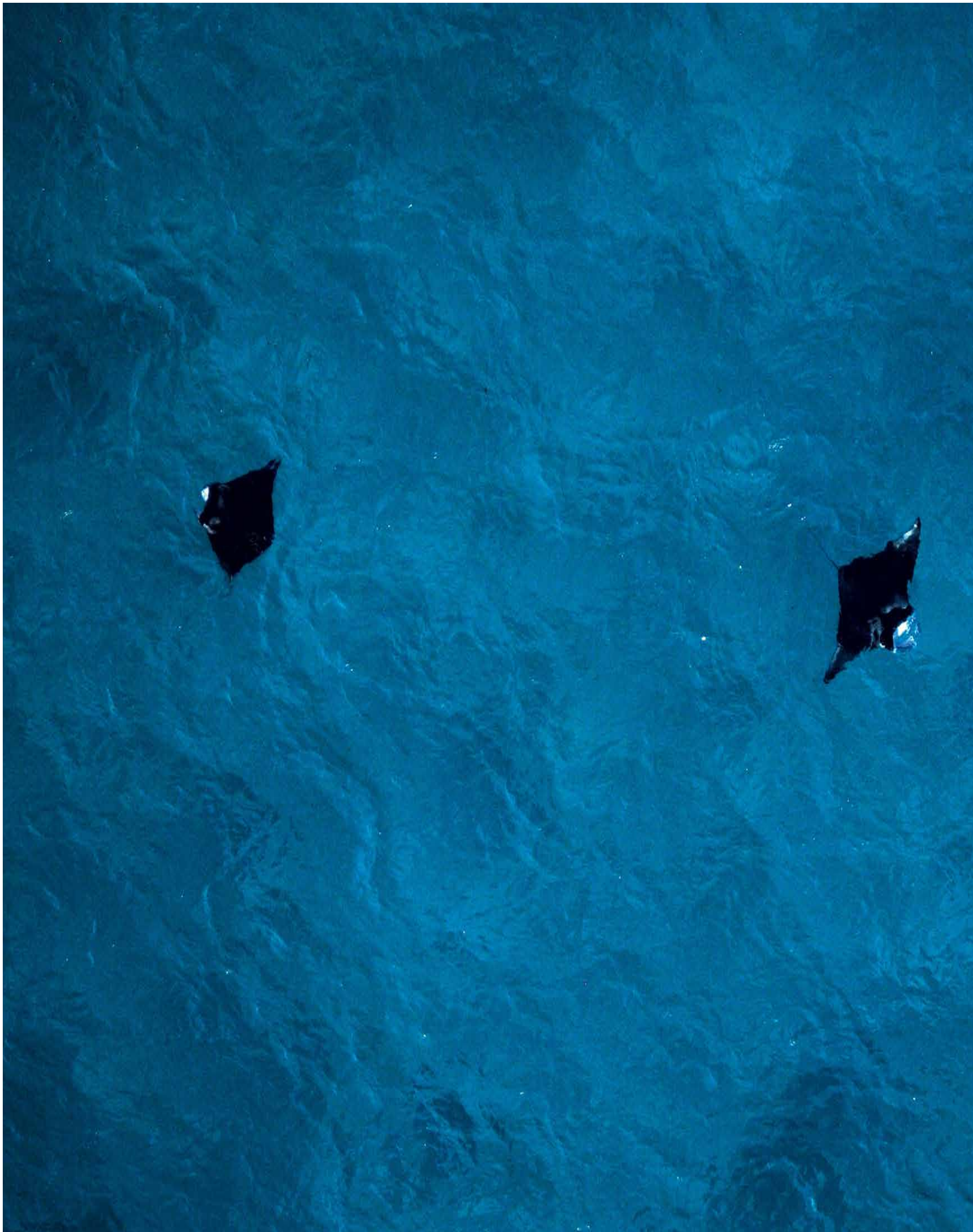
The SOSF-DRC is ambitious when it comes to delving deeper into the ecosystems of D'Arros and St Joseph. In addition, its staff welcome the opportunity to work more closely with institutions such as the University of Seychelles to involve a growing number of interested Seychellois in this process. St Joseph Atoll and D'Arros Island are a national treasure, providing an almost pristine marine environment that is prime for both research and discovery.

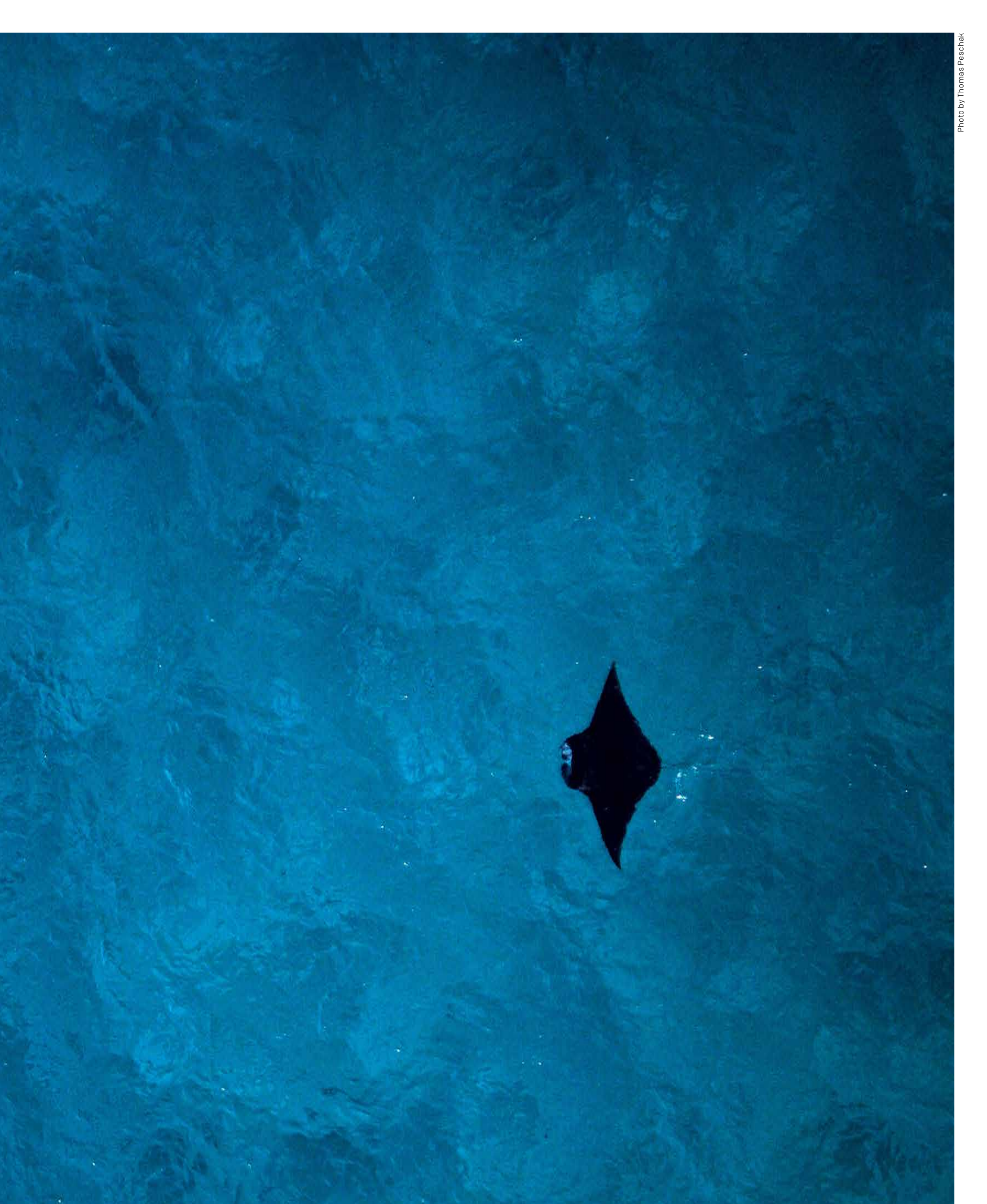
Recognised globally as a UNESCO World Heritage Site, Aldabra is a shining example of the Seychellois people's commitment to their natural heritage. By continuing to study and protect the unique elements of the 'Aldabra of the Amirantes' – St Joseph Atoll and neighbouring D'Arros Island – the Seychelles sends the message that it cares about future generations. The SOSF-DRC takes pride in joining in the commitment to and care of this special area. ●



Manta rays can have wingspans of more than six metres, yet they are filter feeders that eat only small planktonic organisms. Almost 100 reef mantas utilise the area around D'Arros and St Joseph as a feeding ground all year round, representing the largest and densest manta ray aggregation known in the Seychelles.







Manta rays bask in the channel between D'Arros and St Joseph. These waters are home to a large population of resident individuals. The DRC is investigating the ecology and movement of the rays using acoustic transmitters.



In conversation with Pelayo Salinas de León

Dr Pelayo Salinas de León has been working as a senior marine scientist for the Charles Darwin Foundation in the Galápagos for the past five years, with the ecology and conservation of sharks and manta rays as one of his major themes. Philippa Ehrlich talked with him about the archipelago's sharks and the effects of the recent El Niño event.

What is it like to work in a place that every biologist dreams of?

It sounds very stereotypical, but for me that dream actually came true. I am still trying to figure out why, but since I was a kid I wanted to work in the Galápagos for the Charles Darwin Foundation. I had been e-mailing the station since my early university days: after my thesis, before my Masters, after my Masters and after my PhD. I was like a stalker. Eventually, in 2012, the job ad for the position of fisheries ecologist came up and I applied. I was called for an interview and I guess I knew a lot about the Galápagos and the station by then. Anyway, I got the job, and then from there it has been a very steep learning curve. Funding is tight and there are not many of us, so I had to take on a lot of work at once. But you know, when you do something that you are passionate about it becomes kind of easy.

Can you describe your shark research specifically?

We have done a lot of work on sharks over the years, but for our project funded by the Save Our Seas Foundation (SOSF), which is a collaboration between the Charles Darwin Foundation, Curtin University in Australia and Massey University in New Zealand, we wanted to determine the influence of different factors on shark abundance and diversity and establish a baseline to determine the benefits of the Galápagos marine reserve. This is a 130,000-square-kilometre (50,000-square-mile) area where sharks have been protected since 1998. We

chose to use Baited Remote Underwater Video Systems (BRUVs) because they work very well for sharks and they could feed the global initiative to use the same methodology to establish a baseline for shark abundance across the world. We used bottom-water BRUVs to quantify sharks close to the reef and mid-water BRUVs to monitor pelagics. Also, the Galápagos waters are influenced by different currents and, depending on the time of the year, those currents change, resulting in a warm season and a cold season. So, starting in 2015, we sampled twice a year at about 30 sites to see changes across seasons and bio-regions.

What made 2015 so remarkable in terms of your BRUVs work?

At the end of the second sampling survey that year there was an El Niño event in the Pacific. Under normal conditions, cold water coming from the Antarctic circulates up to the Galápagos during the cold season, but in some years that current changes and rather than flowing in from the south, it comes from the Indo-Pacific in the west. So in an El Niño year, really cold water is replaced by really warm water.

What does that mean for the ecosystem?

Obviously, during El Niño things change a lot in the Galápagos. Even though we are right on the equator, there are a couple of cold-water masses that bring a lot of nutrients to the surface and that is why the environment is so productive and why we have phenomena like penguins



Photo by Thomas Peschak

swimming in the tropics and fur seals and other cold-water animals that require a lot of food. During the warm El Niño years that productivity stops, so there is a massive die-off of algae and plankton and the food chain changes completely. A lot of the animals die because they do not get enough to eat. There is massive die-off of marine iguanas and sea lions and penguins.

Then, normally after El Niño there is another cycle that is called La Niña, which brings really cold water instead of really warm water. This is good for the ecosystem because it results in high productivity. It is a natural phenomenon, and it has a huge impact. We already have good information about the impact of El Niño on iguanas and sea lions, but we know little about the effect it has on highly mobile species like sharks or pelagic fish. So we asked the SOSF for an extension to the grant so that we could go back in 2016 and thus have data from both El Niño and La Niña.

And what did you find?

Well, this is preliminary because we have not analysed all the videos, but basically in an El Niño year when the water is warmer, sharks tend to disappear. We believe they migrate to deeper waters. It is possible that they go somewhere else, but El Niño extends across the entire region, not just in the Galápagos, so we believe they just stay in deep waters. That's why we didn't see them on dives during our trip to Darwin and Wolf islands in northern Galápagos in December 2015. These islands have an incredible abundance of sharks and

December is right at the peak of the season for hammerheads and other species. The conditions were unusual – warm water and excellent visibility, 50 metres (165 feet) or more. This is very useful for the BRUVs, but while the visibility was great, there were hardly any sharks to see. It is too early to say for sure, and we are still trying to quantify it in terms of numbers, but our hypothesis is that the sharks go down to deeper waters rather than migrate to a different area.

When sharks disappear like that, does it have a big impact on dive tourism in the Galápagos?

Well, this was just a temporary disappearance, but we did some work on the importance of shark tourism in the Galápagos and that research has had a powerful conservation impact. We did it with National Geographic's Pristine Seas Project in 2015. We partnered with a very good bio-economist and he did an economic evaluation of sharks in the Galápagos. There is a lot of tourism here and the dive industry alone makes about US\$15-million a year. We did some quite complex mathematics and quantified the value of a single shark as more than US\$5.4-million during its lifetime. That became an important part of our message to the government that further protection was required for sharks. We also had the help of a famous singer, Miguel José, who is very big in South America. In the face of all those factors combined, President Rafael Correa saw the benefit of protecting sharks – indeed, the need

to protect them – not only for Ecuador, but for the planet too. So he signed the President's Decree to make Darwin and Wolf islands a 40,000-square-kilometre (15,500-square-mile) reserve, which we have shown contains the highest shark biomass in the world. Those were happy times for our team.

Given the global pressure that natural systems are under worldwide, how do you see the long-term conservation prospects for the Galápagos?

Well, it is hard because, like everywhere else on the planet, there is a trade-off between economic development and nature conservation. I believe that Ecuador has done an amazing job so far. I always like to use the example of Hawaii in the USA and the Canary Islands in Spain: two volcanic archipelagos very similar in size to the Galápagos. These places receive millions of visitors, but the natural heritage is pretty much gone. And you know the Galápagos only receives about 200,000 visitors a year. But the Ecuadorian government chooses to keep the Galápagos as close to pristine as possible and it has been doing a great job. Obviously, there are a lot of problems with illegal fishing and the introduction of invasive species, but so far we are in a very good situation. It is a very fragile ecosystem and we need to do our best – and beyond – to make sure that it stays as it is now: probably the best conserved tropical archipelago on the planet.

Euan Harvey, Pelayo Salinas de León and Etienne Rastoin prepare for work using stereo BRUVs that are able to measure the size and abundance of animals in the area.

While the individual projects supported by the Save Our Seas Foundation (SOSF) come and go over the years, there are several relationships that we have maintained for some time and will continue to maintain for the foreseeable future. Three centres – two focusing on research and one on education – are managed directly by the SOSF, and five independent NGOs have engaged in mutually supportive partnerships with the foundation. All these organisations are dedicated to tackling, in one way or another, the huge amount of work involved in protecting the marine environment and the diverse creatures within it. Research and education are kingpins in this work and through the Shark Research Center in the USA, the D'Arros Research Centre in the Seychelles and the Shark Education Centre in South Africa, the SOSF can extend its on-the-ground reach to these countries and beyond. The NGOs Bimini Biological Field Station (also known as the Shark Lab), Cetacea Lab, the Manta Trust and Shark Spotters are carrying out long-term research and conservation work and, in terms of funding and communication, the foundation's partnership with them, as well as with the Acoustic Tracking Array Platform (ATAP), is closer than its relationship with our individual, shorter-term projects. We rely heavily on our partners' respective areas of expertise as we reach for shared conservation goals and are inspired by the passion of the individuals involved. In the following pages are accounts of the invaluable work carried out by these centres and partners.





INSIDE STORIES

On a Saturday afternoon in early November 2004, house painter Jean-Claude Camille made his way to the D'Arros Research Centre to embark on a walk that changed his life. Activities surrounding the arrival of a particular woman on the island included an after-work meeting. The woman, a researcher who had visited D'Arros many times before, was looking for Seychellois volunteers to participate in a study of the sea turtles that nest on the beaches of D'Arros Island and St Joseph Atoll. She had already enlisted one worker, Mike Botsoie, and she hoped on this trip to find at least one more. A call had gone out the day before that there would be a training session at 4 pm on the Saturday. Jean-Claude and three other men showed up, drawn by the promise of rewarding recreational activity on their quiet and remote island home.

The woman was Dr Jeanne Mortimer and she was in the process of establishing community-based monitoring of nesting hawksbill and green turtles as one of the programmes of the newly constructed D'Arros Research Centre. The premise was nothing new to Jeanne. Back then, she had been studying turtles in the Seychelles for nearly 24 years and had set up long-term turtle-monitoring programmes at many locations around the country. But the D'Arros programme would be different from the others. To begin with, it would be the first to be set up in the Amirantes group of islands in the Seychelles. More importantly, the staff of this programme would consist not of professional or conventional conservation workers, but of Seychellois labourers interested in collecting data about the turtles and doing so outside their normal working hours. That Saturday afternoon, Jeanne was not optimistic about the crew that showed up for training.

'At that time,' Jean-Claude told me, 'every weekend we were supposed to have our drink.' Recalling perhaps more care-free days and still finding humour in the fact that Jeanne thought the volunteers would show up sober, he continued, 'But we couldn't stay without our drink when Jeanne took us on a walk that Saturday.' He let out a deep, rolling laugh. 'And that day was a lot of fun on the beach!'

Clearly none of the aspiring crew had heeded the call for sobriety. But Jeanne was, and still is, an exceptionally dedicated researcher. Optimistic and open-minded, she embraced the challenge – and the fun – and led the stumbling men around the island, training them how to measure tracks, tag turtles and record data.

'I wasn't interested in turtles,' explained Jean-Claude. 'Not then, before Jeanne came. Nobody was working on the turtles. Some people were even killing them. For me that was a bad idea, the killing.' Yet his interest was sparked

on that first walk with Jeanne. Although she had to leave the island the next day, Jean-Claude continued the walks, and his training, with Mike Botsoie until she returned two months later.

Jeanne's progressive approach to turtle monitoring has paid off. Today, the community-based turtle-monitoring programme on D'Arros is the longest-running such initiative in the Amirantes. Even more remarkably, it is the only one of its kind that consists entirely of Seychellois workers, who join the team with no previous conservation experience.

'It was obvious almost from day one that Jean-Claude developed an attraction for the turtles,' recalled Jeanne. 'During those early months both Mike and Jean-Claude were working on a volunteer basis, without pay.'

In January this year I travelled to meet Jean-Claude on Aride Island, where he now works as a conservation ranger for the Island Conservation Society. His love for turtles was palpable in the way his posture straightened and his normally steady voice became sharply staccato when he talked about protecting turtles from poachers. When he described tagging and monitoring turtles, his voice smoothed again and his intent stare settled on me, making sure I understood the significance of his work. I asked him about the seabirds and rare endemic birds of Aride Island whose calls were punctuating our conversation, but he waved the topic off, gesturing, but not actually saying, that the birds were a waste of his time; he needed to be with the turtles. 'When the feeling comes, the interest comes, you forget about the money. It's not for the money,' he told me.

Back in 2004, Jean-Claude also knew from that first day that he wanted to work more with Jeanne and the turtles. But to monitor turtles full time, to go from house painter to conservation ranger, would require commitment and some lifestyle changes. 'After that first day,' remembered Jean-Claude, 'afterwards I said, I want to take the job seriously. I have to stop drinking, take things seriously, learn to drive the boat.'

And he did all of that. In 2011, after collecting data on D'Arros Island for seven years, Jean-Claude co-authored with Jeanne a paper titled 'Seasonality and status of nesting hawksbill and green turtles on D'Arros Island, Amirantes Group, Seychelles', which was published in the journal *Chelonian Conservation and Biology*. Previously, in 2010, he had been the co-author of a poster presented at the 30th Annual International Symposium on Sea Turtle Biology and Conservation.

'Lots of Seychellois have an aptitude for this kind of work,' Jeanne told me. 'But they may not have liked school when they were young, and never received formal training.'

One of Jeanne's challenges when setting up community turtle monitoring has been to find people in the Seychelles who perhaps doubt their ability to collect scientific data or contribute to conservation, but show an appreciation for nature. 'I try to understand their perspective and then interact and work with them in a manner that will make them feel confident that they can in fact do this sort of work and make an important contribution,' she said. 'And I tell them that in the process they can do interesting things and also have a lot of fun.'

The longevity of the community turtle-monitoring programme on D'Arros and its success in significantly reducing the number of poaching incidents, along with the life-long commitment to conservation of past monitors like Jean-Claude, suggest that Jeanne's approach is a good one.

'A lot of people in the Seychelles are interested in conservation,' Jean-Claude said. 'Me? I never collected data before starting with the turtles. Before we started people were eating turtles, but because of our work they stopped and now they also want to protect them.'

Jean-Claude's journey, from D'Arros to Aride, from house painter to conservation ranger, is an important reminder that – perhaps above all else – it is passion that drives conservation of the natural world. At D'Arros Research Centre, Jean-Claude was presented with the chance to learn a skill, to uncover a passion and, ultimately, to change his life and that of countless turtles.

Community turtle monitors 2004–2016

Jeanne's approach to working with people in a manner that makes them feel comfortable and her recognition of passion when she sees it are integral to the success of the community-based turtle-monitoring programme. The dedication and interest of Seychellois workers on D'Arros over the years have contributed significantly to turtle research and conservation. The following Seychellois are recognised for their service as community turtle monitors in the years from 2004 to 2016:

Eugene Songoire	Ericson Rousseau
Terry Omath	Nigel Boniface
Ralph Belle	Darrel Bristol
Gerard Lucas	Roy Rene
George Jeremie	Jean-Claude Camille
Christopher Rosaline	Dorothy Marie
Kenneth Padayachy	Darrel Ernesta
Michael Luc	Christian Marcelin
Nait-Flor Hettimer	Mike Botsoie



Photo by Pep Nogueira | Island Conservation Society

A



D'Arros Research Centre
Words by Clare Keating Daly

feeling for turtles

Born into a life of perpetual motion, manta rays must keep swimming to survive. Driven forward by powerful beats of their wing-like pectoral fins, they search the ocean currents for concentrated patches of the tiny planktonic food on which they feed. They are giants of their kind, ranging throughout the tropical and subtropical oceans of the world, with horn-like cephalic (head) fins that gave rise to ancient mariners' tales of fearsome devilfish dragging boats into the ocean depths.

Today we know that these gentle giants are harmless to humans, though much of their lives still remains a mystery. Fundamental questions such as how long they live, their reproductive cycles and their fecundity have yet to be answered satisfactorily. Areas of key habitat use, migration corridors and population estimates, both nationally and internationally, must also be clearly defined if we are to make the informed and educated decisions needed to provide effective protection for these animals and the world they inhabit.

For the past decade I have devoted my life to answering these important questions. Joining forces six years ago with the Save Our Seas Foundation (SOSF) and award-winning National Geographic photographer Thomas P. Peschak, we decided to create the world's first natural history book about manta rays. Ground-breaking photography, personal experience and the latest scientific research would be combined to create *Manta – Secret Life of Devil Rays*, the definitive publication about these charismatic animals. Tom and I hope that the book's iconic images and enlightening words not only convey the true grace and inquisitive nature of these threatened rays, but also capture what is at stake if we choose not to protect them and our oceans.

I have always been fascinated by the natural world; it sparks my natural curiosity, motivating me to learn more about our planet and the animals and plants we share it with. Growing up in the countryside of the United Kingdom's south-western corner, I was surrounded by nature. A seemingly limitless supply of weird and wonderful creatures lay just beyond my doorstep, waiting for me to discover them.

I always knew I wanted to make a career of studying animals, but it was not until I was given a tropical fish tank at the age of 11 that my passion for the underwater world began. From that moment, when people asked what I wanted to do when I grew up, I would say, 'I want to study fish.' And true to my word, I went through school and college with this in mind until in 2002 I graduated from the University of Plymouth with a degree in marine biology and coastal ecology.

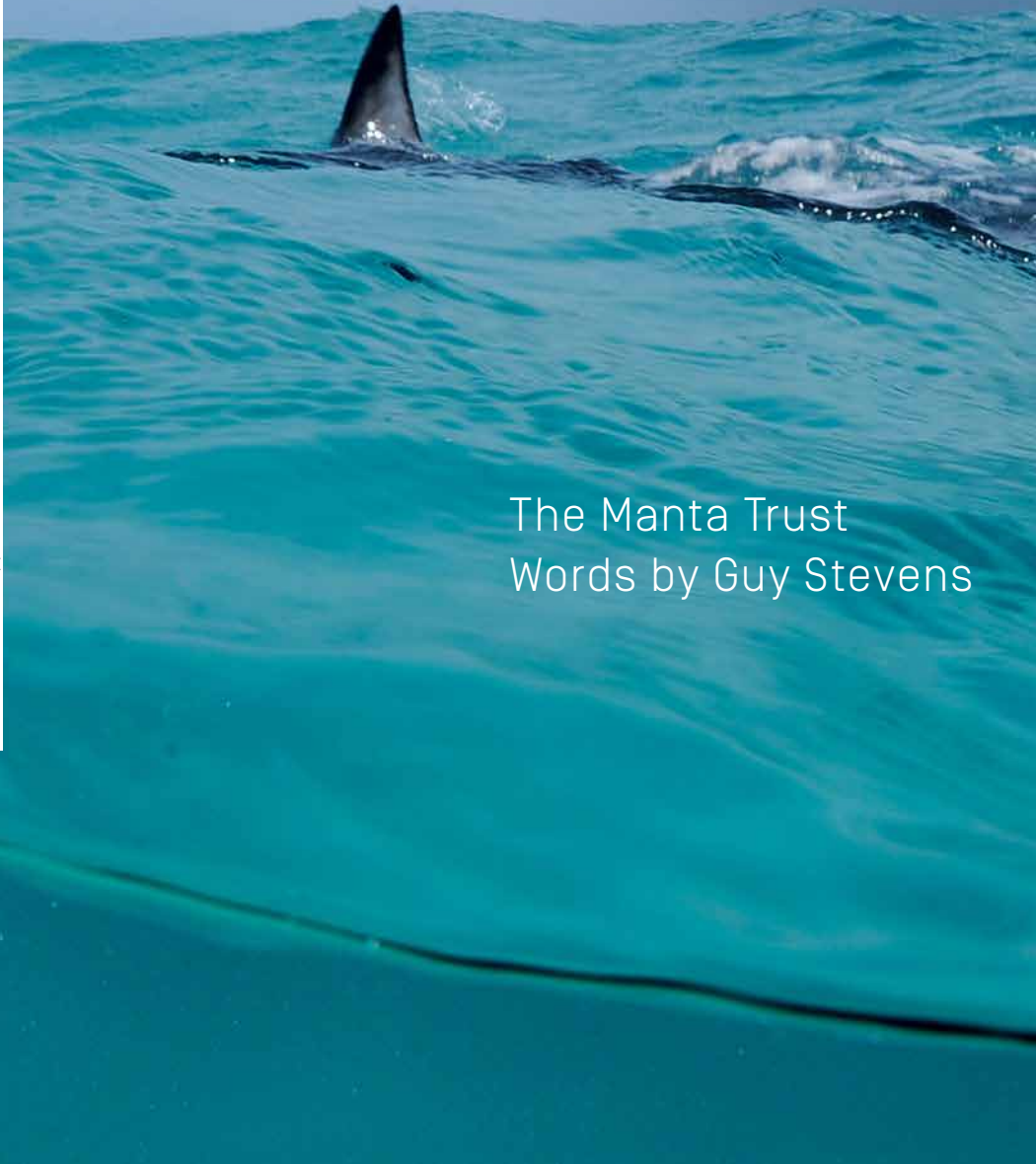
University opened my mind to the rest of the world and I was hungry to travel and explore as much as I could. After visiting and diving in the Caribbean, Africa and Asia, I knew I wanted to work in one of these tropical destinations. So in 2003, when I saw a job advertisement for a marine biologist in the Republic of Maldives, I knew it was the position for me.

The Maldives is a marine biologist's paradise and it was there that I had my first underwater encounter with a manta ray. Enthralled by these graceful and inquisitive rays, I became driven by a desire to learn as much about them as possible. As I dived deeper into their fascinating lives I started to better understand the threats they face, which drove my desire to ensure their protection.


With this in mind, in 2005 I founded the Maldivian Manta Ray Project with the aim of helping to understand and conserve the Maldives population of manta rays. In 2012 I launched the Manta Trust, a UK- and US-registered charity founded to tackle the increasing threats that face manta rays and their marine environment globally. Although my work now takes me all over the world, for me the Maldives will always be the best place to see and study these remarkable animals.

People often ask me why I decided to study manta rays. Why would a British marine biologist move halfway around the world and devote the past decade to unravelling the lives of manta rays? It's a good question, a seemingly simple question, yet one I had not truly taken the time to consider until I was first asked many years ago. I still find it difficult to answer satisfactorily today. Certainly, manta rays are beautiful creatures, their grace and inquisitive nature captivating. They engage and stir my natural curiosity as no other marine creature does, driving my desire to protect and learn as much about these poorly studied animals as possible. Yet these words never seem to fully express my passion or satisfactorily project the empathy and connection I feel for manta rays and their marine world.

My favourite answer does not require words; it's simply an introduction between those who wonder why and the manta rays themselves. While this book cannot physically create that introduction, I hope it will evoke the desire and empathy within readers to follow my words and seek out their own underwater encounter with these intriguing animals.



The Manta Trust
Words by Guy Stevens



Manta – Secret Life of Devil Rays, like my research, will always be a work in progress. Manta ray science is still in its infancy. With so many questions still unanswered, it is impossible to write with absolute certainty about all aspects of these animals' lives. However, much has been learnt about manta rays in recent years and this book is the first-ever attempt to bring together the global knowledge about these charismatic species. In those areas of the manta rays' lives that we still do not have all the answers, I have tried to fill in the gaps by proposing new theories to explain the most interesting unsolved behaviours. I hope I never tire of seeking the truths behind these unanswered questions, and that by writing down my knowledge and observations I can promote imaginative thought in others, so that together the science and conservation of manta rays will be driven forward.

In 2007, Guy Stevens' manta ray research project in the Maldives became one of the first conservation projects to be supported by the SOSF, and in the intervening decade this collaboration has evolved into a proud partnership. With funding and guidance from the SOSF and Guy's passionate and enduring dedication to manta rays, the Manta Trust has grown into a highly influential organisation at the forefront of global manta ray conservation. We are delighted to support the creation of this book, which highlights the great advances in science and conservation the trust has achieved since its inception.

**INSIDE
STORIES**

Secret Life of Devil Rays



INSIDE STORIES





Summer holidays at the Shark Education Centre

Words by Eleanor Yeld Hutchings

Nothing says Cape Town summer holidays like the sun shining brightly, a light south-easterly wind blowing off the sea, and the Dalebrook tidal pool packed with people before 8 am. At the Save Our Seas Foundation's Shark Education Centre in Kalk Bay we have opened the doors, put out the sea creatures made from recycled materials, turned on the exhibits and are eagerly waiting for our first arrivals of the morning. The name labels are ready, the arts and crafts supplies are laid out and the train tickets are booked. Yes, it's Holiday Club time, a favourite with all the centre's staff!

The South African school year is divided into four terms, with holidays over December/January, March/April, June/July and September/October. During each of these holidays, the Shark Education Centre's Holiday Club is an event that ranges in duration from one to three days. It is billed as, 'For kids who would like to have fun while learning more about our oceans! The programme is designed to suit children aged between six and 11 years old, with activities to entertain and educate them about our marine environment. The programme includes exploring rock pools, going on beach hunts and swimming (depending on the weather and tide), as well as hiking, doing arts and crafts, baking and watching shark documentaries.' All of which essentially means that we get up to anything and everything under the sun – and sometimes indoors too.

The Holiday Club is a perfect opportunity to experiment with new activities and ideas. Because we are limited to 20 children per day and have a specific age range, we have a bit more freedom to test things out than we do in formal education programming. So all of us store up ideas for activities and games and crafts and pretty much anything that we see throughout the year, so that when the next Holiday Club comes around we can bring out all the new things to try. Some of them prove to be extremely popular, like the game 'Feeding Frenzy', which was inspired by an activity taught by uShaka Marine World education staff at the 2016 Marine and Coastal Educators Network national meeting. These then make their way into regular rotation as part of our arsenal of activities for children's camps and clubs.

One of the challenges of Holiday Club is the fact that, as the name says, the events are held during the school vacations. Holidays are very different from term-time days! During a normal school outing to the Shark Education Centre, learners are still 'at school' (at least in their expectations) and so learning is at the forefront of their minds. When on holiday, the expectation is most certainly to have fun – and learning takes a back seat. We need to be aware of that and to make sure that Holiday Club lives up to its name and that the children taking part get to have a real holiday experience ... and then we can sneak some learning in as well! Luckily December in Cape Town is usually beautiful and summery – perfect beach weather – and so spending time outside is easy and the fun practically makes itself.

December 2016 was no exception, and the lovely summer weather suited us perfectly. Over three days we went rock-pooling in the Dalebrook Marine Sanctuary; took the train from Kalk Bay to the nearby Muizenberg beach, where Nicole from the Shark Spotters did some fun activities with the kids; painted marine-themed T-shirts; found out exactly how big a whale shark is from Daniela Vilema from the Galápagos; made festive cards from beach debris; explored the fishing harbour; and of course spent time swimming and playing on the beach. The only down side was choosing which of our favourite activities to leave out. Luckily the Easter holidays are not too far off and so our next Holiday Club event is within sight, with more fun, new and old games, and some more learning through play!

INSIDE STORIES

Tiger sharks show unexpected global population patterns

A key issue in the world of managing and conserving globally distributed shark species that are captured in fisheries is finding the answer to a basic question: how many populations of a particular species are there? This typically refers to identifying how many genetic stocks exist, where they occur and how different they are (genetically) from each other.

Why is this important? A fundamental paradigm in managing exploited wildlife (on land and in the sea) is to conserve genetic variation in a species, since it is this variation that can provide a buffer against extinction. In other words, genetic variation allows some individuals in a species to adapt to changes in their environment that might wipe out other individuals. And the individuals that can adapt because of their genetic make-up will be able to survive, find mates and reproduce, leaving offspring with their genes – the very definition of biological fitness (also known as Darwinian fitness) – and thus ensuring survival of the species.

Sharks are no exception when it comes to their management. It is generally assumed that the large-bodied sharks that migrate vast distances are likely to interbreed with one another across large sections of the ocean – and therefore belong to either a single stock or, at most, very few genetic stocks. After all, if you can swim huge distances, the chances of running into prospective mates all over the place should be high. And both female and male sharks are known to mate with multiple partners, so no worries there. But are these long-distance genetic romances typical?

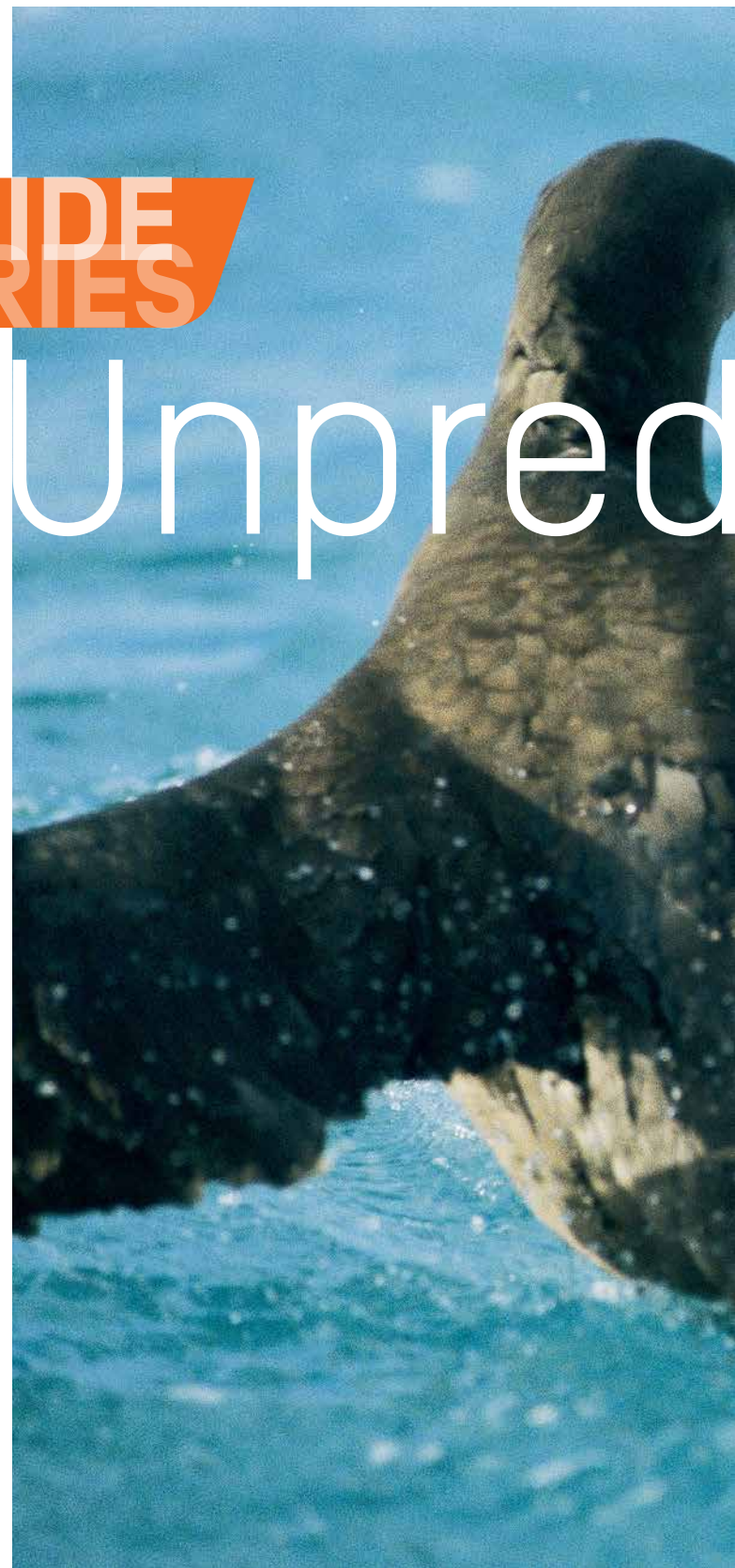
Dr Andrea Bernard, a research scientist at the Save Our Seas Shark Research Center (SOSSRC), investigated this question in relation to the magnificent tiger shark. Previous and ongoing research by scientists from the Guy Harvey Research Institute and the SOSSRC on tracking

tiger sharks shows that these apex predators are quite at ease undertaking enormously long migrations. Tiger sharks are also well known to be non-fussy about their diet – they are not too discriminating when it comes to selecting things to eat – and they are found in a range of habitats, from shallow coral reef to truly oceanic ecosystems. This combination of lifestyles suggests that tiger sharks are well equipped to be large-scale ocean wanderers – and the more sea you cover, the more mating opportunities you should encounter, right? This being the case, Andrea investigated the prediction that tiger sharks would be amorously exchanging genes across huge expanses of ocean and therefore would consist of only a single genetic population – or at best very few populations that are genetically different.

But who says that tiger sharks are predictable? By looking at DNA markers from tiger sharks from across most of the species' global distribution, Andrea found that tiger shark males have a genetically roving disposition, freely exchanging genes (via mating) across much of the Indo-Pacific – although interestingly enough, not so much between the Indo-Pacific and Atlantic oceans! So there appears to be a barrier that prevents males from these two oceanic regions from routinely crossing over and fraternising with the females, thus keeping populations from these two areas genetically different. The picture with tiger shark females is quite different and equally interesting. Despite growing even bigger in size than males and therefore seeming physically capable of just as extensive travels, the DNA markers indicated that tiger shark females prefer to stay closer to home – or at least if they do wander far away, they return to specific areas to give birth. This behaviour of the females serves to create even more populations of genetically different tiger sharks across the species' distribution.

The bottom line revealed by DNA is that despite the tiger shark's ability to travel enormous distances, its impressive

Unpred



facility for using very different habitats (shallow coastal to deep, open-ocean environments) and its quite unfussy dietary preferences, this species still forms many more than anticipated genetically differentiated populations. The management implication is that in order to conserve these different genetic pools (and thus genetic variation) of tiger sharks, attention will have to be paid, via fishery management practices, to ensuring that none of the individual populations get extirpated due to inadvertent overfishing. Andrea's work on this and related findings on tiger sharks was recently published in the journal *Molecular Ecology*.



ictable sharks

Moving internationally but behaving regionally

The shortfin mako is an imposing shark by any standard. Aside from being a close cousin to the great white shark made famous by Hollywood and one of only a handful of sharks that can maintain a body temperature higher than its surrounding water environment, the shortfin mako is claimed to achieve the fastest swimming speed of any shark, at least in short bursts. One look at its sleek torpedo shape and powerful tail makes

this claim entirely believable. Research on the movement behaviour of this oceanic speedster by SOSSRC scientists working in collaboration with the Guy Harvey Research Institute shows it making long-distance, round-trip migrations of up to 18,000 kilometres in a year.

Our current studies in the Atlantic show makos travelling through the national management jurisdictions (Exclusive Economic Zones) of at least 12 countries, underscoring the need for internationally coordinated management of this heavily fished species. Surprisingly, however, the research also shows makos behaving in distinct patterns, depending on where they are.

Despite their ease of long-distance and speedy travel, makos tagged in the Caribbean and Gulf of Mexico stay mainly in this region, undertaking relatively short migrations. In contrast, makos tagged in the Atlantic show extensive journeys ranging from Canada to South America. Research to verify these early observations is ongoing at the SOSSRC. If confirmed, it will mean that management efforts will not only require coordination among multiple nations, but will have to take into account the shark's regionally different movement behaviours if this unique apex predator is to be conserved.

Eye in the sky

A great white patrols the shallows off South Africa's Cape coast.

Exciting new technologies are emerging in all areas of conservation and none more so than in the field of sustainable shark bite mitigation. From sonar detection to electronic repellent barriers, millions of dollars are being invested in looking for new, high-tech solutions that will reduce the risk of shark bites and keep our beaches safer.

At Shark Spotters we have always prided ourselves on the low-cost, low-tech, but highly effective shark safety measures we implement at Cape Town's most popular swimming and surfing beaches. Using trained spotters strategically positioned on the mountainside and equipped with nothing more than polarised sunglasses, binoculars and a keen knowledge of and passion for the ocean, we have recorded more than 2,100 shark sightings since the programme began operating in 2004. This simple, affordable and easily replicable system has proved very successful and over the past 13 years it has considerably increased safety at the beaches where we operate.

However, recent advances in drone technology have caught our attention, as they have the potential to add a whole new perspective to our shark safety programme. Always wanting to stay at the forefront of sustainable shark bite

mitigation measures, we were delighted to be approached by local South African tech repair company WeFix, which saw potential for a collaborative partnership to enhance beach safety and test new technologies at the same time. WeFix generously donated two top-of-the-range DJI Phantom 4 drones, including all maintenance and support, to our programme and provided training and licensing for the spotters to ensure that they were properly equipped for flying the drones in public open spaces.

The drones were deployed at the two busiest beaches where we operate, Fish Hoek and Muizenberg, over the 2016–2017 summer season as a supporting mechanism for our existing safety protocols. The use of drones did not replace any of the current processes and routines Shark Spotters employ to safeguard the beaches, but instead offered the extraordinary advantage of being able to investigate shark sightings remotely and identify large sharks close to shore more accurately, as well as track them.

Continuous visual surveillance was maintained by the spotters on the mountainside and if they saw a shark, the beach spotter would launch the drone to locate the animal in question. After confirming the species and assessing

whether it might pose a threat to water-users, the drone operators had the rare opportunity to get an up-close and completely new perspective on shark behaviour in the inshore region.

The drones have enabled us to easily differentiate between similarly sized shark species, such as great white and bronze whaler. Both are large sharks seen close to shore in our area, but each poses a different level of threat to water-users. The drones also enable the spotters to monitor the behaviour of the shark closely and establish whether it is patrolling or feeding in the area, or just passing through. All this information feeds into the spotters' assessment of risk and enables them to make a more accurate decision about the action they need to take to protect water-users from a potentially dangerous shark encounter.

In addition to adding great value to the shark safety programme on our beaches, the drones have served as a fantastic education and research tool. All the data they record feed into our own shark research programme, as well as those of other organisations conducting research in Cape Town. With the aid of the drones, we have logged a wide variety of marine life and observed behaviour that we otherwise would not have seen from land

Shark Spotters

Words by Sarah Waries

INSIDE STORIES

or from a boat. From solitary stingrays to large groups of bottlenose dolphins, the drones have given us a new appreciation for the wonderful abundance and diversity of marine wildlife in False Bay.

And then we have been able to share this footage with our supporters and followers, through our *#EyeInTheSky* campaign on social media and with visitors to our information centre on Muizenberg beach. The response has been phenomenal. People are fascinated to see how much interesting marine life we have within a few hundred metres of our beaches. The excitement and joy they express when they see footage of sharks and other animals swimming close to shore helps to create a greater appreciation of the importance of conserving all animals in our marine ecosystem.

But it is not just the abundant wildlife that has captured people's attention; we have shared footage of a number of human activities on our beaches that has given people a better understanding of how we utilise our coast. These include the deployment and retrieval of our eco-friendly shark exclusion barrier, as well as footage of the artisanal beach-seine (treknet) fishermen catching large shoals of migratory game fish, such as yellowtail and skipjack tuna, from shore.

The drones have enabled people to engage with the ocean, and our use of it, from a perspective that was previously inaccessible to them.

While the drones have been a great additional resource for the programme, and a fantastic opportunity to incorporate new technologies into our existing successful shark bite mitigation strategies, the practical experience of utilising them on a daily basis has enabled us to identify some of their limitations as a stand-alone shark safety measure. These include limited flying time due to short battery life (approximately 25 minutes), reduced field of view compared to the naked eye, difficulty in detecting sharks on a small screen, and the constraints of wind and rain on the deployment of the drones. Recognising these restrictions has in turn highlighted aspects of our existing spotting programme that are key to reducing the risk of shark bite at our beaches, such as the value of continuous, uninterrupted visual surveillance over a large area to ensure maximum coverage and the detection of potentially dangerous animals, and the ability to spot sharks in a wide range of environmental and ocean conditions, especially strong winds.

Through the practical experience of

comparing both drones and trained observers [spotters] we have been able to identify strengths and limitations in both methods and combine them to provide the best possible safety service to our beach-goers. While detection of sharks continues to be carried out primarily by the spotters, the drones add huge value to our response protocols, enabling us to identify the species and behaviour of the shark and adjust our safety response according to the accurately assessed level of threat. Furthermore, it has opened up the possibility of incorporating further vision system technologies into the programme to enhance and improve the current spotting system. We have therefore begun investigating the development of cost-effective automated shark detection software, which is sure to be an exciting development for Shark Spotters in the years to come.

We would like to thank WeFix for its generosity in providing the two DJI Phantom 4 drones and logistical support to Shark Spotters, and look forward to the enhanced shark safety and educational opportunities they present for the programme in the future.



Cetacea Lab | Words by Janie Wray

My emotions were intense when I first witnessed a pod of transient orcas chasing a group of sea lions. When you add to this encounter two humpback whales that, from my perspective, had charged in to protect their marine companions, my mood changed entirely. I was torn, especially when the tables turned and suddenly one of the humpbacks had become the orcas' new target. This did not last long, though, as the other, larger humpback suddenly flanked the younger whale. Its one-ton pectoral fin with razor-sharp barnacles and its massive tail flukes slammed the water and the transients, deterred, were soon on their way. Stories like this are becoming more common around the world, causing people to wonder about interspecific relationships and the altruistic behaviour of humpback whales.

Transient orcas prey on marine mammals, and a study that reviewed 115 interactions between them and humpback whales has recently been published. The results are both extraordinary and tantalising, leaving room for further exploration. Very few records exist of transient orcas hunting humpback whales. They are known to target smaller cetaceans and marine mammals such as porpoises, dolphins, seals and sea lions. It is possible that in pre-whaling times, when the abundance of humpbacks was much higher, transient orcas may have preyed on these whales without our knowing about it. Now, as the population of humpbacks continues to increase, we may be witnessing the return of a once-lost behaviour.

Among the humpback calves returning to northern feeding grounds after their long migration from the south, we have noticed a definite increase in the number of them that have obvious rake marks from orca teeth on their tail flukes and pectoral fins. In 2013 we observed a female humpback with her new calf, a male, and were stunned to see the large number of rake marks all over the young whale. It was surprising that he had even survived. We could also see recent rake marks on the mother's fluke. We imagined she must have put up quite a battle to protect her little one. We named the calf 'Champ' as he had clearly survived a life-threatening encounter. We also noticed that he loved to breach all the time and decided that he was probably practising this manoeuvre in case of another attack.

This type of experience at a young age could certainly explain why an adult or sub-adult humpback might charge in to protect its own kind from a group of transient orcas. Interestingly, though, on 85% of the occasions when humpbacks

respond to an attack by transients, they defend species other than their own. These interactions most certainly come at some cost for the humpback and appear to be maladaptive, since they too are a target for transients. So why do they behave in this way?

It is possible that the behaviour is a territorial response on the part of these whales. The humpbacks we have catalogued demonstrate strong site fidelity, so much so that we refer to most of them by name. We have observed social bonds between members of this population that extend well over a decade, as well as mothers that have brought their third or fourth calves to these waters. This population has grown from 42 to more than 400 and relies on the pristine waters around the Great Bear Rainforest as its summer feeding ground. As in many species that maintain the same habitat range year after year, an instinct to charge at a known predator may have evolved. Humpbacks may respond to the distinctive calls of transient orcas without knowing what species is at risk during the hunt. Once they arrive, the act of chasing the transients away could still benefit the humpback population, even if they are not defending one of their own kind or if the kill has already occurred. If this behaviour is repeated throughout the season, hindering the transient orcas' ability to feed, chances are that the predators would travel elsewhere to forage. As a result, there would be certain safe areas in which young humpback whales are able to live without the constant fear of an attack by transients.

This does not preclude the idea that we are witnessing altruistic behaviour in humpback whales. The first time we recognised that marine companionship was developing between humpbacks and sea lions was in 2006. In the late fall of that year we were fortunate enough to witness a massive return of pilchards (sardines) to our research area. In a harbour close to the lab we observed more than 200 sea lions and up to 15 humpback whales, all involved in a gleeful feeding frenzy. They were spread out in groups and in each one there were one or two humpbacks with 10-15 sea lions. The feeding technique employed by the humpbacks brought many pilchards to the surface and the sea lions took full advantage of the glut. The humpbacks were not bothered by the crowd of sea lions waiting at the surface after every feed. We sat back and watched as the relationship developed, and although recently we have not seen this interaction repeated to such a high degree, we are

witnessing the results of a door having been opened between the two species.

Groups of sea lions often seek out juvenile humpbacks, although they appear to prefer mother-and-calf groups. The mother does not seem to mind as her calf twists and turns within a play group of young sea lions. Perhaps for her this is a break, a time to relax while her calf is entertained by the energetic antics of its travelling companions. I have often wondered whether encounters like these between species, when both are so young, have encouraged the altruistic behaviour of humpbacks that is now seen along the coast.

Another example of cetacean companionship – between resident orcas and fin whales – is developing along the north coast of British Columbia, and at first glance it is quite alarming. There are two types of orca that frequent this area: transients that hunt marine mammals, and residents that feed primarily on salmon. Marine mammals that make up the prey species of the transients recognise the difference between the two types and know they need fear only the transient orcas. But how do they distinguish between them? Probably underwater. Resident orcas, unlike transients, are extremely vocal and their calls are quite distinctive. And, just like the humpback whales, resident orcas will charge or chase transients out of an area. So it should not have been so surprising the first time we saw a young fin whale swimming with a pod of resident orcas. There could be no safer place for this large whale than within this group of guardians. There has never been a documented case of transient orcas attacking residents – only the other way around!

When we brought up the subject of interactions between humpbacks and transient orcas with Paul and Helena, who have been managing OrcaLab on the south coast of British Columbia for more than 35 years, the conversation became extremely animated. They encounter a larger population of transients and a smaller population of humpbacks in their research area than we do. Yet the number of incidents of humpbacks putting themselves between sea lions and a group of hunting orcas is even higher than the number we have observed along the north coast.

There is no doubt that a significant relationship is developing between these species. Although researchers around the world may have differing opinions about what is occurring, we can agree that there is still so much we do not yet understand.



A helping fluke?



**INSIDE
STORIES**

↑ Photos by Janie Wray | North Coast Cetacean Society ↑



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Journey with us
to a place of
Darwinian dreams
– and nightmares –
where dinosaurs
still rule on land
and in the ocean.
In this issue we
will showcase the
work of Pelayo
Salinas de León
and the Charles
Darwin Foundation
on shark com-
munities in the
Galápagos.

Next Issue



The *Save Our Seas* magazine invites you on a digital expedition across the world's oceans, accompanied by top marine researchers and conservationists. Our dedicated website, *SaveOurSeasMagazine.com*, is an interactive portal for all our magazine stories, plus additional content that includes videos and unpublished images. You can also read the magazine while on the go by accessing it on *issuu.com* or *zinio.com* from your tablet or phone.



ABOUT THE FOUNDATION

In the effort to protect our oceans, the Save Our Seas Foundation (SOSF) funds and supports research, conservation and education projects worldwide, focusing primarily on charismatic threatened wildlife and their habitats. From a small not-for-profit organisation funding just five projects, in just over 10 years the Save Our Seas Foundation has grown to become a major player in the fight to save the world's oceans and the wealth of marine life they contain. While the SOSF itself is not a research institute, its generous contributions of financial, practical and scientific support have, to date, facilitated more than 200 marine research and conservation projects around the world.

To find out more about the foundation, visit: saveourseas.com

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