SAVE OUR SEAS FOUNDATION

ANNUAL REPORT 2017

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foundation

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“AS LONG AS THERE ARE PEOPLE WHO CARE, WE CAN AND WILL MAKE A DIFFERENCE.”
THE FOUNDER I SAVE OUR SEAS FOUNDATION
Photo by Thomas Peschak

Photo by Michael Scholl

CEO'S NOTE

Having been born in the early 1970s, I grew up when the environmental movement was taking off. Although the plight of sharks was first highlighted in the '80s, the unfortunate timing of Steven Spielberg's *Jaws* in 1975 inhibited the general public's empathy for declining shark populations in those early years. Even today, the lingering effects of the film remain an obstacle to shark conservation, despite a much better understanding of these mysterious creatures of the oceans.

The IUCN Red List of Threatened Species registers more than a thousand species of chondrichthyan fishes (sharks, rays and chimaeras), close to half of which are classified as Data Deficient; an estimated quarter of all chondrichthyans are listed as Threatened. And while a significant number of new species have been discovered over the past couple of decades, some of these are likely to disappear before they are even described. These 'lost sharks' miss out due to the greater attention being paid to the more charismatic, and often less threatened, species.

In 2017, the Save Our Seas Foundation (SOSF) maintained its dedicated support for its three centres – the Shark Education Centre in South Africa, the Shark Research Center in the USA and the D'Arros Research Centre in the Seychelles. It also provided support for 59 projects, 23 of which were new, five were long-term (referred to as Partnerships), 12 were continuations of Keystone Grants, seven were new Small Grants and 12 were Sponsorships. In addition, the Foundation was represented at the regional scientific conferences of the American Elasmobranch Society (AES) in Austin, USA, and the European Elasmobranch Association (EEA) in Amsterdam, the Netherlands, as well as at the Southern African Shark and Ray Symposium in Hermanus, South Africa.

The four-year remodelling of the SOSF Shark Education Centre in Kalk Bay, South Africa, was completed in 2017, resulting in a range of new educational and interactive tools for children and visitors, and an optimised programme and curriculum.

We published two new issues of the *Save Our Seas* magazine in three editions (print, digital and web) and are distributing these worldwide for free. These issues presented a new series of exciting stories from around the world, inspired by the work, and life passion, of scientists, conservationists and educators. They highlighted the importance of collaboration and of alternative approaches to conservation, showcased personal stories from the last frontier of the world, dived with devil rays and traced the migrations of great hammerhead sharks and the current whereabouts of mythical sawfishes in Africa. They also explored the potential for learning from local fishers and encouraging them to take over the stewardship of species they used to target. Articles about projects in the Darwin and Wolf Marine Sanctuary in the Galápagos and in the West Side National Park on Andros Island in The Bahamas – one of the last healthy refuges for the smalltooth sawfish – also featured.

Our commitment to communication in science and conservation is a long-term priority. To celebrate our 2012–2016 funding strategy on Mobulidae, the Foundation published a reference book entitled *Manta: Secret Life of Devil Rays* and written by Dr Guy Stevens and Thomas Peschak. We also published an illustrated outreach book, *The King of the Fishes*, in four local languages; written by Dr Ruth Leeney, it is about sawfishes and is dedicated to the coastal communities of East Africa. The Foundation supported the publication of two reports – 'The Conservation Status of Sharks, Rays and Chimaeras in the Arabian Sea and Adjacent Waters' by Dr Rima Jabado and 'Angelshark Action Plan for the Canary Islands' by Eva Meyers – and was acknowledged in more than 40 scientific peer-reviewed papers.

As a result of our call for research applications for sawfishes last year, we are now supporting 11 projects worldwide on these five Endangered or Critically Endangered species. This sawfish strategy is following our Mobulidae programme and will run from 2017 until 2020.

Remaining true to the nature of the Foundation since its inception in 2003, and inspired by our Founder's passion, we continue to support research, conservation and education projects on charismatic marine megafauna worldwide, with a significant emphasis on endangered elasmobranchs. This support ranges from our primary role as a funder to helping projects and events from a logistical perspective and endorsing more effective and far-reaching communication to the public. The passionate synergy between our team and our project leaders has enabled the Foundation to grow further and mature, as well as to act as a leader in elasmobranch science and conservation.

Michael Scholl | Chief Executive Officer

CONTENTS

WHERE WE WORK 2017

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 300 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*

SOSF Centres

1 D'Arros Research Centre | Clare & Ryan Daly
2 Shark Education Centre | Eleanor Yeld Hutchings
3 Shark Research Center | Mahmood Shivji

AFRICA

4 Sawfish Children's Book | Ruth Leeney

MADAGASCAR
5 Sawfishes | Ruth Leeney

MAURITIUS
6 Sperm Whales | Fabrice Schnoller

SENEGAL
7 Sawfish Expedition in the Casamance River | Nigel Downing

SEYCHELLES
8 eDNA | Luca Fumagalli & Tony Dejean
9 Coral Bleaching | Elena Gadoutsis & Julie Hawkins
10 Humphead Wrasse | Kevin Weng & Andrew Gray
11 Juvenile Sharks | Ornella Weideli
12 Lemon Shark | Ryan Daly
13 Lemon Shark | Evan Byrnes
14 Lemon Shark | Jenna Hounslow & Adrian Gleiss
15 Marine Biodiversity | Ryan Daly & Guy Stevens
16 Oceanography | Phil Hosegood
17 Reef Manta Ray | Lauren Peel & Guy Stevens
18 Shearwaters | Danielle van den Heever
19 Stingrays | Chantel Elston
20 Turtles | Jeanne Mortimer
21 University of Seychelles | Karl Fleischmann & Terence Vel

SOUTH AFRICA
22 Shark Spotters | Sarah Waries
23 ATAP | Paul Cowley
24 Catshark Citizen Science | Lisa Schroeter
25 Sharks on the Urban Edge | Alison Kock
26 White Shark Population | Dylan Irion

TANZANIA
27 Artisanal Fisheries | Patroba Matiku

OCEANIA

AUSTRALIA
28 Project AIRSHIP | Kye Adams
29 Sawfishes | Barbara Wueringer

PAPUA NEW GUINEA
30 Sawfishes | William White

AMERICAS

BAHAMAS
31 Bimini Biological Field Station | Tristan Guttridge & Samuel Gruber
32 Sawfishes | Dean Grubbs
33 Sawfish Expedition in Andros | Dean Grubbs
34 Sawfish UAV | James Kilfoil
35 Shark Personality | Félicie Dhellemmes

BELIZE
36 Deep-sea Sharks | Ivy Baremore

CANADA
37 Cetacea Lab | Janie Wray & Hermann Meuter

CHILE
38 Lost Fishes of Rapa Nui – Motu Motiro Hiva Expedition | Naiti Morales Serrano

ECUADOR
39 Education in the Galápagos | Daniela Vilema

GUATEMALA
40 Fish Labelling | Ana Hacohen

MEXICO
41 Sawfishes | Ramón Bonfil

USA
42 Blacktip Shark Migration | Marianne Porter
43 Sawfish eDNA | Gregg Poulakis
44 Sawfish Population Genetics | Nicole Phillips
45 Shark Navigation | Bryan Keller

EUROPE

ALBANIA
46 Sharks | Rigers Bakiu

SPAIN
47 Angel Shark | Eva Meyers
48 Spiny Butterfly Ray | David Jiménez

ASIA

INDONESIA
49 Sawfishes | Dharmadi

IRAN
50 Turtles | Nicolas Pilcher

MALAYSIA
51 Shark & Ray Assessment | Mabel Matsumoto

PALESTINE
52 Giant Devil Ray | Mohammed Abudaya

UAE
53 Red List Assessment | Rima Jabado

WORLDWIDE

- Sawfish eDNA | Colin Simpfendorfer
- The Manta Trust | Guy Stevens
- White Shark Finprinting System | Michael Scholl & Ben Hughes

CONFERENCES & EVENTS

- American Elasmobranch Society (AES) Conference | Austin, USA
- 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

Photo by Deron Verbeck | I Am Aquatic

INSIDE STORIES

REPORTS FROM THE SAVE OUR SEAS FOUNDATION
CENTRES AROUND THE WORLD

Photo by Nicolas Scholl

Photo by Olivier Born

SOSF D'ARROS RESEARCH CENTRE

RYAN DALY & CLARE KEATING DALY

save our seas
d'arros research centre

OVERVIEW OF SOSF-DRC IN 2017

August 2017 marked the fifth year of the valuable partnership between the Save Our Seas Foundation (SOSF) and the D'Arros Research Centre (DRC). The mission of the SOSF-DRC – to be a regional centre of excellence for marine and tropical conservation – continues to motivate the activities and research undertaken on this small island in the Amirantes Group of the Seychelles. This was a particularly productive year in that the positive research activities supported by the SOSF-DRC were acclaimed by the people of the Seychelles and the international scientific community alike.

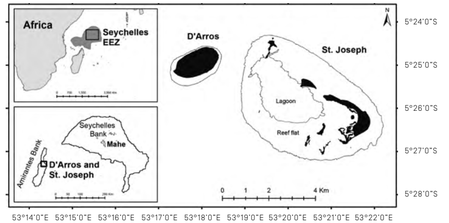


Figure 1. A map of D'Arros Island and St Joseph Atoll within the Amirantes Bank and in relation to the Seychelles Bank and Inner Islands, which include the main island of Mahé. The extensive Exclusive Economic Zone of the Seychelles occurs off the eastern coast of Africa.

With the generous backing of the Founder of the SOSF, the SOSF-DRC led seven long-term monitoring projects and supported 11 projects that were conducted by external project leaders hailing from 12 different countries. D'Arros Island and the facilities of the research centre hosted a total of 11 researchers, three PhD students, three MSc students and one Honours student.

Over its five-year partnership, the SOSF-DRC has consistently demonstrated a commitment to locally and internationally relevant research. Driven by the Founder's vision of conservation, we aim to understand objectively the importance of the marine ecosystems surrounding D'Arros Island and St Joseph Atoll. As in previous years, SOSF-DRC research activities in 2017 were pertinent to the surrounding environment. As seen in the rapid fish biodiversity assessment undertaken in May, the humphead wrasse study initiated in October and the long-term monitoring of green and hawksbill turtles, SOSF-DRC research addresses species of scientific, economic and cultural importance in the Seychelles.

Our research is also internationally important. Recognising international conservation concerns, the SOSF-DRC supports studies on species listed by the International Union for the Conservation of Nature (IUCN) and the Convention on International Trade in Endangered Species (CITES). We have established dedicated research projects on nine of the 18 IUCN Red List species found around D'Arros Island and St Joseph Atoll. In this way, locally relevant studies have international significance, while focused work on the Critically Endangered hawksbill turtle and the Endangered green turtle and humphead wrasse may help to inform conservation strategies worldwide. Additionally, the SOSF-DRC researches and monitors five of the seven CITES-listed species found at D'Arros and St Joseph: Appendix I-listed hawksbill and green turtles, and Appendix II-listed humphead wrasse, reef manta ray and Aldabra giant tortoise.

Conducting this research on D'Arros Island is possible through access to one of the most advanced research laboratory facilities in the Western Indian Ocean. An invaluable asset to Seychelles conservation goals, the DRC labs are furnished with equipment essential for the suite of studies described in this report. The infrastructure of the DRC wet and dry laboratory and resources such as an extensive library, digital microscopes, a -20 °C freezer, a drying oven and full diving equipment, along with running water, Internet access and uninterrupted electricity, provide logistical support to researchers and aid their field work.

The following pages, chronologically ordered based on field-work activities in 2017, highlight research conducted by the SOSF-DRC over the year. Following individual project reports, there is a summary of research outputs in the form of publications, presentations and anticipated outputs resulting from research in 2017.

The results of research conducted in 2017 speak largely for themselves: the SOSF-DRC recorded a number of species new to the Seychelles and to science. A greater level of observation, coupled with focused assessments, resulted in a record 23 new species listed for the Seychelles:

- 20 are fish records outlined in the rapid biodiversity assessment report;
- one bird species was the first record for the Seychelles and the second for the Indian Ocean;
- a new host (sicklefin lemon shark) for a marine leech species was observed, which is both a new host record for science and a new occurrence of the leech species in the Western Indian Ocean.
- a species of sea grass previously unknown in the Seychelles was collected and photographed off D'Arros Island.

The SOSF-DRC has identified what are potentially two fish species new to science. Both fish were photographed off D'Arros Island in 2017 and efforts are under way to collect samples for taxonomic clarification.

In addition to new species records, the SOSF-DRC has committed to keeping an ongoing list of bird species. From the period April 2016 to November 2017, 11 new D'Arros bird records have been confirmed by the Seychelles Bird Records Committee.

The presence of endangered species on and around D'Arros Island is important to the SOSF-DRC. Prior to 2017, there were no known estimates of the number of Aldabra giant tortoises, a Vulnerable species on the IUCN Red List, on D'Arros Island. In 2017, the SOSF-DRC compiled a photo-ID database of Aldabra giant tortoises on the island that comprises 21 individuals. At least five of these are juvenile recruits from D'Arros resident tortoises.

In February, Dr Jeanne Mortimer presented one of two workshops on turtle monitoring practices to the D'Arros turtle monitor team. Turtle monitors (from left) Edward Padayachy, Louis Boniface and Dennis Barra are part of a widening circle of interested Seychellois and inspire interest in both turtles and conservation in the Seychelles.

Photo by Ryan Eloy

MAIN RESEARCH ACTIVITIES

TURTLE MONITORING
PRINCIPAL INVESTIGATOR: DR JEANNE MORTIMER
FIELD PERSONNEL: SOSF-DRC STAFF, TURTLE TEAM WITH TEAM LEADERS MICHAEL LUC & LOUIS BONIFACE, LUKE GORDON, PRINCIPAL INVESTIGATOR
AUTHOR: DR JEANNE MORTIMER

Sea turtles have long been of economic importance to the people of the Seychelles. Historically they were killed to extract products for export: calipee from green turtles was used in Europe to make 'turtle soup', and the scales covering the shell of hawksbill turtles were removed to produce 'tortoise shell', a semi-precious material originally exported to Europe and later (between 1960 and 1992) to Japan. In addition, turtle meat has always featured prominently in traditional Seychelles cuisine.

In 1994 the Seychelles government passed a law (Wild Animals (Turtles) Protection Regulations) that offered complete legal protection to all sea turtles and their eggs. The export trade ceased, but some human customs and habits die hard and many Seychellois, especially the more traditional people living and working in the Outer Islands, retained a taste for turtle meat.

There was a need to get people to see turtles in a different light, and one of the best ways to do that is to encourage coastal people to take ownership of conservation programmes involving sea turtles. The DRC achieved this through the Community Monitoring of Nesting Sea Turtles Programme, which enlists Seychellois labourers who work on D'Arros Island and trains them to monitor daily the nesting beaches of D'Arros at the end of their work day, on a paid overtime basis. Once a week they also go across to the more remote St Joseph Atoll and monitor nesting activity on the beaches there.

In 2017, field recorders who conducted track count surveys were Michael Luc (team leader), Louis Boniface (team leader), Christopher Rosaline, Kenneth Padayachy, Eugene Songwar, Terry Omath, Terry Dubois, Ivan Hosier, Dennis Barra, Ryan Felice, Kelly Juliette and Luke Gordon. D'Arros Island was surveyed on 303 days and St Joseph Atoll was visited 33 times.

The part-time turtle workers develop a fondness for the living turtles, an appreciation of the need to protect them and a sense of ownership of the turtle conservation programme. As a result, they refuse to tolerate any poaching of turtles by members of their own community, and poaching ceases. None of the workers involved with the project have a scientific background, so the

Team leader Michael Luc (left) and monitor Eugene Songwar record data on a survey around D'Arros Island in early 2017.

Photo by Claire Keating Daly

programme reaches members of the Seychellois community who might not otherwise get involved in conservation.

In addition, the part-time turtle monitors usually enjoy the work and they appreciate the opportunity to do something meaningful outside normal working hours, while also making a bit of extra money. Most of them are adult men engaged in physical labour, so having to fill in the data sheets gives them a chance to revive and enhance their literary skills. Some have stayed with the turtle project for long periods (up to seven years in one case) and two of them, after leaving D'Arros, have gone on to become full-time conservation rangers on other islands in the Seychelles.

Initiated in 2004, the D'Arros/St Joseph turtle monitoring programme is the first such study to be implemented anywhere in the Amirantes Islands of the Seychelles. Over the years it has gathered valuable data that document many aspects of the status and biology of the turtle populations. These include:

What species of turtles occur?

- Nesting sea turtles: the hawksbill turtle *Eretmochelys imbricata* and the green turtle *Chelonia mydas*
- Foraging sea turtles: large numbers of hawksbill and green turtles; and evidence of small numbers of the loggerhead turtle *Caretta caretta* [a dead juvenile loggerhead that washed ashore was recovered by members of the Turtle Team].

How many turtles nest each year?

Based on the data collected during the past five seasons, we estimate the numbers of females of each species that nest annually to be approximately the following:

	Hawksbills	Green Turtles
D'Arros Island	~115	~35
St Joseph Atoll	~175	~145
TOTAL	~290	~180

Figure 2. The number of beach patrols (turtle track count surveys) conducted each month and at each island during 2017. The ideal schedule was occasionally disrupted by factors that included bad weather, problems with boats and engines, illness and resources allocated to groups of people visiting the island. Nonetheless, 2017 was a good year for monitoring.

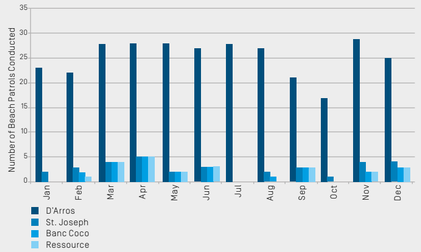
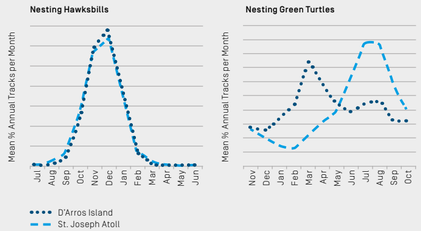


Figure 3. The hawksbill nesting season peaks between mid-October and mid-January, but the season for green turtles is more variable.



'This was a particularly productive year in that the positive research activities supported by the SOSF-DRC were acclaimed by the people of the Seychelles and the international scientific community alike.'

D'Arros Island and St Joseph Atoll, considered together as a single site, host the largest nesting population of hawksbill turtles not only anywhere in the Seychelles, but also in the entire Western Indian Ocean region. This is important given that the species is listed as Critically Endangered by the IUCN (Mortimer and Donnelly, 2008) and that the Seychelles hosts one of the four largest national populations of nesting hawksbills anywhere in the world.

What are the population trends?

In the early years of the D'Arros /St Joseph turtle project, numbers of nesting turtles remained relatively constant from year to year. In recent years, however, the numbers have increased – evidence that conservation efforts are paying off.

What is the nesting seasonality?

Hawksbill turtles everywhere in the Seychelles, including at D'Arros Island and St Joseph Atoll, have a nesting season that peaks between mid-October and mid-January.

Green turtles are more variable, with nesting seasons in the Western Indian Ocean that differ from one site to another. Generally, however, more northerly sites (near the equator) tend to peak during the austral winter and more southerly sites (away from the equator) during the austral summer (Dalleau et al., 2012). So we were surprised to find that the nesting season of green turtles at D'Arros Island (February to April) was consistently different from those nesting at St Joseph Atoll (June to October) located only two kilometres (1.24 miles) away. The reason for this difference remains a mystery, but it may be related to water temperature.

What are the genetic characteristics?

The genetic characteristics of nesting hawksbills appear to be relatively consistent at most nesting sites in the Seychelles. In fact, genetic studies indicate that hawksbill nesting populations here and those 2,000 kilometres (1,243 miles) to the east in the Chagos Islands belong to the same regional management unit (RMU). In contrast, preliminary data indicate that green turtles nesting in the Amirantes Group may be genetically distinct from those nesting in the southern islands of the Seychelles.

Conservation impact

D'Arros/St Joseph has been recognised as one of the most important and unique sites for sea turtles in the Western Indian Ocean, given the relatively high numbers of both hawksbills and green turtles sharing the same breeding beaches. With continued protection we can expect their numbers to increase.

Photo by Clare Keating Daly

Photo by Ryan Daly

Project leader and PhD student Ornella Weideli holds a juvenile lemon shark before releasing it. Ornella's study on blacktip reef and lemon sharks in St Joseph Atoll is the largest and longest-running mark-recapture study of juvenile sharks in the Seychelles.

HABITAT AND RESOURCE PARTITIONING OF JUVENILE SHARKS

PRINCIPAL INVESTIGATOR: ORNELLA WEIDELI (CRIOBE)
FIELD PERSONNEL: SOSF-DRC STAFF, PRINCIPAL INVESTIGATOR
AUTHOR: ORNELLA WEIDELI

In recent years numerous shark species in the Indo-Pacific have rapidly declined due to anthropogenic impacts such as fishing, pollution and climate change. Human developments and artisanal fisheries in shallow and near-shore areas represent additional threats to coastal sharks that use such habitats as nursery grounds for their pups. The blacktip reef shark *Carcharhinus melanopterus* is a common and wide-ranging species that coexists in certain areas with the rare and data-deficient sicklefin lemon shark *Negaprion acutidens*. Both species use shallow coastal areas as nurseries, but juveniles are also found in remote and reef-associated atolls throughout the Indo-Pacific. Such small and remote atoll nurseries can be invaluable for the maintenance of local shark populations, especially if no alternative nursery habitats are nearby.

In the Western Indian Ocean, the assessment of shark nurseries is very limited, even though they are very important for the management and conservation of sharks. The remote and uninhabited St Joseph Atoll is, after the renowned Aldabra Atoll, only the second atoll in the Seychelles in which blacktip reef sharks and sicklefin lemon sharks have been found to coexist. Given its remote location, St Joseph Atoll represents a relatively pristine ecosystem and provides a great opportunity to study these animals. Thus, the essential aim of this project is to assess the atoll's shark populations and investigate their population characteristics and ecology. Furthermore, a diverse set of methods, including active tracking, diet investigation and stable isotope analysis, are used to better understand how habitat and resources are partitioned between these two juvenile shark populations.

Juvenile sharks were captured in four locations within St Joseph Atoll using a standard gill net. Each shark was measured (length and girth), weighed and equipped with a PIT tag for later identification in case of recapture. A small fin clip was taken for future parental analysis.

Although the main study objectives focusing on niche segregations were completed in late 2016, the sixth sampling season in 2017 continued to collect basic data. During 18 field days in April 2017, 115 sharks were caught, of which 94 were new individuals (42 blacktip reef and 52 sicklefin lemon sharks) and 21 were recaptures from previous seasons. Data from recaptured sharks (24 blacktip reef and 62 sicklefin lemon sharks) enabled us to calculate annual growth rates. Both species show highly variable growth rates, with some individuals growing as much as 30 centimetres (12 inches) per year and others hardly growing at all.

This project is the longest mark-recapture study for blacktip reef sharks and sicklefin lemon sharks in the Western Indian Ocean. During field work spanning two and a half years, individual sharks were recaptured up to five times, giving us a better understanding of the juvenile sharks' growth rates during their early life stages. The growth rates recorded in this study are to date the most variable in wild juvenile sharks.

The field work for this project was completed in 2017. The overall results are currently being analysed and written up and will be published in peer-reviewed journals in 2018. The thesis will be submitted by September 2018.

In 2018, the sampling of juvenile blacktip and sicklefin lemon sharks established during this project will transition to a shark nursery monitoring programme as one of the long-term monitoring programmes of the SOSF-DRC.

A standard measurement when studying juvenile sharks is an individual's girth. Here a researcher draws a tape measure around the belly of a juvenile sicklefin lemon shark. This year marked the final field trip for this study, which sampled a total of 647 sharks.

Photo by Ryan Daly

Photo by Luke Gordon

RAPID MARINE FISH BIODIVERSITY ASSESSMENT

PRINCIPAL INVESTIGATORS: DR GUY STEVENS & DR RYAN DALY
FIELD PERSONNEL: SOSF-DRC STAFF, JUSTIN BLAKE, PRINCIPAL INVESTIGATORS
AUTHORS: DR GUY STEVENS & DR RYAN DALY

The marine fish communities of the Seychelles have, to date, been poorly studied. This is particularly true in the remote Amirantes Archipelago. Accurate and detailed knowledge of the fish species assemblages present on a coral reef and its associated ecosystems (such as sea-grass meadows, mangroves and lagoons) is essential when attempting to understand the health, function and biological significance of such areas. Rapid biodiversity assessments are a good means of quickly collecting information about the species present in a given area. Used to shape management plans and conservation actions, the results from such assessments provide a foundation for longer-term and more detailed studies.

In light of increasing negative pressures exerted on coral reefs globally, these baseline data are a necessary starting point for assessing the deleterious impacts of coral bleaching, habitat loss or fishing. In addition, they provide the benchmark against which potential positive trends of future protection actions can be measured. There are no known assessments of the fish assemblages within the Amirantes Archipelago. Therefore, the aim of this rapid fish biodiversity assessment was to establish a baseline of the fish species known to occur around D'Arros Island and St Joseph Atoll, and their relative abundance, in order to improve monitoring efforts and conservation management plans for the area.

From 2011 to 2016 DRC researchers kept a record of the fish species they encountered as part of their general research activities. The fish list, which contained 220 species at the beginning of the study, formed a starting point for the rapid fish biodiversity assessment. Notably, all but 18 of these species were subsequently re-recorded during the assessment.

Roving visual surveys were conducted around D'Arros Island and St Joseph Atoll. Additional surveys resulting from the original biodiversity assessment were then conducted ad hoc until November 2017. During surveys, scuba divers recorded and attempted to photograph each new fish species observed. Before recording the observation, all fish species identifications were confirmed using FishBase (*www.fishbase.org*), a global biodiversity information system on finfishes (Froese & Pauly, 2001), as well as several other reliable sources. A photographic library of each documented species was also created to

SOSF-DRC research director Ryan Daly during the rapid marine biodiversity assessment held in May 2017. Of the 514 reef-associated fish species recorded, 375 were photographed and added to the digital library on D'Arros Island.

Photo by Jay Stevens

serve as a reference point for future studies. The survey was conducted in all the major habitat types around D'Arros Island and St Joseph Atoll, including deep (approximately 25 metres; 82 feet) and shallow (approximately one metre; three feet) *Thalassodendron* meadows, the channel between D'Arros and St Joseph, reef crests, reef slopes (to a maximum of 30 metres; 98 feet), sand flats (to a maximum of 30 metres) and atoll lagoon.

From 5 to 24 May 2017, a total of 514 reef-associated fish species were recorded during 84 hours of underwater visual surveys around D'Arros Island and St Joseph Atoll. Of the 514 species identified, 375 were photographed (73%) and added to the photo-ID catalogue at the research centre. Considering the relatively limited spatial and temporal scales of the survey reported on during this study, the number of fish species recorded appears to represent an exceptionally diverse marine fish community. The diversity is most likely facilitated by the various marine habitat types (sea-grass, lagoon, coral reef and rubble reef) within a relatively confined area at D'Arros Island and St Joseph Atoll.

This rapid biodiversity assessment of the reef-fish community around D'Arros Island and St Joseph Atoll more than doubled the number of known fish species, adding 294 new species to the previous record. This is a remarkable finding considering the relatively small effort (84 hours over 19 days) and suggests that there are many more species yet to be discovered.

Fifteen of the 514 species recorded during this assessment are listed as Vulnerable or Endangered by the IUCN Red List of Threatened Species (*www.iucnredlist.org*). Of these, four are listed on Appendix II of CITES (*www.cites.org*).

From 5 to 24 May 2017, a total of 514 marine fish species from 71 families were recorded during the rapid biodiversity assessment. Of these species, 51% were represented by eight families: Labridae (66 species), Gobiidae (48 species), Pomacentridae (33 species), Serranidae (30 species), Acanthuridae (26 species), Chaetodontidae (20 species), Scaridae (20 species) and Carangidae (17 species).

Fifteen fish species listed as Vulnerable or Endangered by the IUCN were recorded during the assessment. Four of them are also listed on Appendix II of CITES.

Common name	Scientific name	IUCN Red List status	Cites Appendix II
Whale shark	*Rhincodon typus*	VU	II
Tawny nurse shark	*Nebrius ferrugineus*	VU	-
Sickelfin lemon shark	*Negaprion acutidens*	VU	-
Silvertip shark	*Carcharhinus albimarginatus*	VU	-
Greater hammerhead shark	*Sphyma mokarran*	EN	II
White-spotted guitarfish	*Rhynchobatus djiddensis*	VU	-
Mangrove ray	*Urogymnus granulata*	VU	-
Porcupine ray	*Urogymus asperrimus*	VU	-
Jenkin's whipray	*Himantura jenkinsii*	VU	-
Marbled stingray	*Taeniurops meyeni*	VU	-
Spotted eagle ray	*Aetobatus ocellatus*	VU	-
Reef manta ray	*Manta alfredi*	VU	II
Shot-jaw bonefish	*Albula glossodonta*	VU	-
Napolean/humphead wrasse	*Cheilinus undulatus*	EN	II
Black-saddled coral grouper	*Plectropomus laevis*	VU	-

These marine fish species recorded for the first time in Seychelles waters represent new range extensions in the Indian Ocean: *Iniistius naevus* (a), *Pseudocoris petila* (b), *Pseudojuloides labyrinthus* (c), *Trimmatom offucius* (d), *Trimma taylori* (e) and *T. winchi* (f).

Photos by Ryan Daly

Twelve species previously unreported from Seychelles waters were recorded during the rapid assessment in May and another four during ad hoc surveys between 1 July and 19 November. These 16 species represent seven families: Chaetodontidae, Congridae, Gobiidae, Labridae, Microdesmidae, Syngnathidae and Tetraodontidae. Ten of the new species (*Amblygobius nocturnus*, *Arothron caeruleopunctatus*, *Dunckerocampus boylei*, *Gorgasia maculata*, *Gunnellichthys monostigma*, *Heniochus diphreutes*, *Oxycheilinus orientalis*, *Trimma anaima*, *T. emeryi* and *Vanderhorstia ambanoro*) have relatively cosmopolitan regional distributions and were expected to occur in the Seychelles, so this report serves to confirm their presence. The discovery of the remaining six species (*Iniistius naevus*, *Pseudocoris petila*, *Pseudojuloides labyrinthus*, *Trimmatom offucius*, *Trimma taylori* and *T. winchi*) in Seychelles waters represents new range extensions within the Indian Ocean of between 2,000 and 4,300 kilometres (1,243 and 2,672 miles). Each species was photographed and notes on their occurrence, characteristics and distribution were recorded.

The previously unreported Seychelles records reported in this study appear to be in part due to the lack of previous survey effort in the region owing to the relative remoteness of the Amirante Islands. Some, being regionally cosmopolitan species, were expected, but the others were probably overlooked as they are small and relatively cryptic fish, occur in deep water and a turbid environment, or have only recently been described.

DETECTION OF CHONDRICHTHYES USING ENVIRONMENTAL DNA FROM SEA WATER SAMPLES
PRINCIPAL INVESTIGATOR: LUCA FUMAGALLI (UNIVERSITY OF LAUSANNE) & TONY DEJEAN (SPYGEN)
FIELD PERSONNEL: SOSF-DRC STAFF, NICO CATANEO, JONATHAN GRONDIN
AUTHOR: LUCA FUMAGALLI & TONY DEJEAN

Global biodiversity loss is one of the most critical challenges of the 21st century. Obtaining information about species, populations and communities by retrieving DNA from environmental samples (eDNA) has tremendous advantages for biodiversity monitoring compared to traditional surveys. This method has huge potential for contributing to the understanding of the ecology and conservation of terrestrial or aquatic species. Two main approaches using eDNA have been proposed: species-specific eDNA barcoding, which aims to detect a single species in the environment; and multi-specific eDNA metabarcoding, which simultaneously identifies several taxa from an environmental sample without a priori knowledge of the species likely to be present in the sampled ecosystem. Indeed, to monitor certain taxonomic groups, such as Chondrichthyes, the existing methods appear to be inefficient, selective, destructive or strictly dependent on a declining taxonomic expertise. Detecting species using eDNA methods, rather than directly sampling the organisms or adopting visual inspection protocols, can reduce impacts on sensitive species and increase the efficacy of field surveys conducted on rare and elusive species. In effect, eDNA can provide an alternative, cost-effective and extremely sensitive tool, and to test its reliability and sensitivity the two eDNA approaches were developed to assess the presence of Chondrichthyes species in St Joseph Atoll. The results obtained bring new insights to the evaluation of the reliability of eDNA technology for marine megafauna conservation, and for the under-studied Chondrichthyes in particular.

In order to choose the best sampling strategy that maximises the quantity of eDNA retrieved in sea water samples, is easy to implement in the field and avoids any risk of cross-contamination, a pilot study was carried out in the Mediterranean Sea close to an aquaculture site for the breeding of gilt-head seabream *Sparus aurata*. Different volumes of water were sampled using different filter capsules. The eDNA was extracted and amplified using a qPCR and species-specific primers for *S. aurata*.

In the Seychelles, a sampling strategy using Sterivex filters was implemented, partly for logistical reasons and partly to test its ease of use in the field, even though the retrieved eDNA was lower compared to the VigiDNA filter devices used in the pilot study.

Project leader Jonathan Grodin takes a water sample as part of the field work for the eDNA study. The study aims to test whether traditional eDNA methods, when applied to sea water samples, can provide reliable data on species presence and habitat occupancy for predetermined shark species.

Jonathan filtrates sea water collected from St Joseph Atoll lagoon using Sterivex filter capsules. The facilities of the DRC allow for field collection in St Joseph Atoll, but samples are processed and stored on D'Arros Island.

Photos by Ryan Daly

For the species-specific approach, water samples were collected at the surface inside and outside St Joseph Atoll. The sampling point coincided with the acoustic receivers used by SOSF-DRC for shark species telemetry. The eDNA was extracted in a dedicated room for rare DNA extraction and the eDNA analysis was performed by species-specific qPCR techniques (eDNA barcoding) using specific primers and probes (tested in 16 Chondrychthyes species as a reference) for tawny nurse shark *Nebrius ferrugineus*, tiger shark *Galeocerdo cuvier*, sicklefin lemon shark *Negaprion acutidens*, whitetip reef shark *Triaenodon obesus*, feathertail stingray *Pastinachus sephen* and mangrove whipray *Himantura granulata*. In addition, green turtle *Chelonia mydas* was assayed (with specific qPCR primers and probes tested in four marine turtle species). Twelve qPCR replicates/water sample have been performed for a total of 18 to 27 water samples (chosen from the 39 overall sites investigated in this study), for each of the seven tested species.

In order to evaluate the efficiency and sensitivity of eDNA metabarcoding for monitoring Chondrichthyes biodiversity, water was sampled at the surface and one metre (three feet) from the bottom in 10 sites around St Joseph Atoll. In addition, two pooled surface water samples and two pooled bottom water samples were also analysed to evaluate an integrative sampling strategy. The water samples were then filtrated using Sterivex filter capsules. The DNA was extracted in a dedicated room for rare DNA extraction and amplified using universal primers for Chondrichthyes that were designed specifically for this study. The amplified eDNA was sequenced using next-generation sequencing techniques. The sequences obtained were compared with a reference database to obtain a list of species using a threshold of 96% and 90% of identity with the GenBank reference database.

In the eDNA barcoding approach, the number of positive qPCRs obtained for all seven tested species was negligible. In the eDNA metabarcoding approach, using the 96% threshold, 155 taxa of ray-finned fishes and 10 of Chondrichthyes were found in total. All the species belong to the Seychelles or neighbouring regions. Of the 10 Chondrichthyes species detected, four were sharks (blacktip reef *Carcharhinus melanopterus*, whitetip reef *Triaenodon obesus*, tawny nurse *Nebrius ferrugineus* and sicklefin lemon *Negaprion acutidens*) and six were rays (feathertail stingray *Pastinachus sephen*, mangrove whipray *Himantura granulata*, porcupine ray *Urogymnus asperrimus*, manta ray *Manta birostris*, bentfin devil ray *Mobula thurstoni* and an unidentified *Mobula* species). When the threshold was set to 90% of sequence identity with GenBank, the number of taxa belonging to Chondrichthyes increases (16 vs. 10), meaning that the DNA region used for the eDNA metabarcoding approach is not exhaustively present in GenBank for all Chondrichthyes species.

No significant difference was found between the samples collected at the surface and at the bottom. On average, 23.6 taxa were found per sample in the 10 single samples versus 37.8 for the four pooled samples, meaning that a single point sample of two litres of water is not representative of the biodiversity of the site and an integrative sampling is needed.

These results suggest that an eDNA metabarcoding approach performed in only two days by a restricted number of people allows a large number of species to be detected. They also suggest that an integrative sampling strategy based on a transect instead of sporadic sampling, the filtration of a larger amount of water and a more comprehensive sequences reference database are crucial elements to improve the description of fish biodiversity efficiently, in particular for species that are not present in large aggregates.

IMPACTS OF THE 2016 CORAL BLEACHING EVENT ON HARD CORAL REEFS
PRINCIPAL INVESTIGATOR: ELENA GADOUTSIS (YORK UNIVERSITY)
FIELD PERSONNEL: SOSF-DRC STAFF, PRINCIPAL INVESTIGATOR
AUTHOR: ELENA GADOUTSIS

Coral reefs are one of the ecosystems most susceptible to global climate change, as they depend on specific thermal requirements to survive. Global environmental stressors, such as increases in sea surface temperature, have been found to cause mass coral bleaching that leads to coral mortality. The coral bleaching event of 1998 caused live coral to decline in many coral reef ecosystems around the world, including a decline to less than 3% in certain coral reefs in the Seychelles. The most recent coral bleaching event, from 2015 to 2016, was the longest and furthest-reaching in history, caused by a strong El Niño Southern Oscillation that created the warmest temperatures ever recorded. This altered the structure and function of many coral reef ecosystems globally, which could result in large-scale shifts in species dominance and extensive mortality of corals. Despite this, little is known about the status of coral reef ecosystems in the Seychelles, particularly the effects of the most recent coral bleaching event.

This project aimed to investigate the scale and consequences of the 2016 coral bleaching event at D'Arros Island and St Joseph Atoll. The main objectives were to analyse and summarise the long-term data (2011–2017) gathered from D'Arros Island and St Joseph Atoll to evaluate changes in hard coral coverage, the composition of benthic coverage and species-specific coral recruitment success.

To determine the proportions of benthic coverage, surveys were conducted across 11 sites, which were sampled at depths of either 5 or 12 metres (16 feet or 39 feet), depending on the reef type, to allow comparisons across depths and topography. At each site, 80 sampling quadrats (one square metre; 11 square feet) were randomly placed between five and 10 kick-cycles apart and photographed. A total of 880 photos per year were collected, covering a total of 880 square metres (9,472 square feet) of coral reef habitat. Benthic photographs were then analysed using Coral Point Count software with Excel Extensions. Each photo quadrat was calibrated to overlay 30 stratified random point counts per sample. To determine the number of new coral recruits, coral recruitment surveys were conducted across all 11 sites. Counts were made using 25 randomly placed circular plots of 3.14 square metres (34 square feet), which added up to 275 plots per year.

All objectives of this study were completed in 2017 and submitted as a thesis to York University in September 2017, earning Elena an MSc.

The study was the first analysis of the long-term (six-year) data collected by SOSF-DRC on coral reefs. Field work consisted of 19 hours spent scuba diving across 11 study sites, surveying a total of 1,743 square metres (18,762 square feet) of coral reef habitat around D'Arros Island and St Joseph Atoll.

The results showed that hard coral coverage declined significantly across all sites around D'Arros Island and St Joseph Atoll from 2015 to 2016 (28.5% to 18.1% coverage) and from 2016 to 2017 (18.1% to 14.7% coverage). There was a total significant reduction of 13.8% hard coral coverage after the 2016 coral bleaching event. Mean coral recruitment also declined significantly, by 73.1% from 2015 to 2017. There was an increase of 12% in coralline algae coverage following bleaching, indicating a potential for recovery as coralline algae cements coral together. Macro algae coverage remained around 3% post-bleaching, which also indicates a high recovery potential as this allows more substrate to be available for coral recolonisation.

Although there were large losses of coral coverage overall, certain study sites (numbered 2, 3, 7, 10 and 11) showed little to no decline, indicating their ecological resilience. Ecologically resilient reefs can provide key information for coral reef conservation and mitigation, creating an opportunity to focus conservation efforts on risk reduction and reef restoration to strengthen these ecosystems for the changing future. Strategic marine protected area networks could target these sites to ensure appropriate prioritisation for protection.

Overall, coral reefs around D'Arros Island and St Joseph Atoll show high potential for recovery when compared to other reefs in the Seychelles and the Indian Ocean due to the presence of high coralline algae, low macro algae and the abundance of herbivorous fish. This study highlights the extent and impacts of coral bleaching in a remote location. Since coral reef ecosystems provide vital services for humans, maximising coral reef resistance to future threats will be beneficial and cost-effective for coastal communities like D'Arros Island. Reefs that could serve as climate refugia, such as D'Arros Island and St Joseph Atoll, require identification and protection to preserve their value.

Coral reefs also buffer against wave action and generate livelihoods and sustenance relating to fishing. D'Arros and St Joseph have a unique coral reef ecosystem because of distinctive oceanographic conditions, as well as a low human population and perceived anthropogenic impact. This could indicate potential resilience to coral bleaching impacts that could provide insight into future coral conservation for the Seychelles. Coral bleaching presents a difficult management challenge, but identifying resilient reefs could help to provide insurance and long-term solutions for the changing climate. This study also supports the formation of a D'Arros and St Joseph marine protected area and helps to prioritise conservation hotspots.

The thesis resulting from this study will progress to a publication submitted to a peer-reviewed journal in the first quarter of 2018. The SOSF-DRC will continue its long-term monitoring of the coral reefs surrounding the island and atoll for further analysis in the future.

Photos by Ryan Daly

Project leader and MSc student Elena Gadoutsis dives over a patch of *Acropora* coral during field work in July 2017. Elena's study is the first analysis of long-term data on coral reefs around D'Arros and St Joseph. Results showed an average decline from 28% to 14% hard coral coverage due to coral bleaching in 2016. The reefs around D'Arros and St Joseph show potential ecological resilience that may lead to faster recovery over time.

A *Porites* colony off northern St Joseph Atoll remains healthy after the coral bleaching event. Ecologically resilient reefs, such as some of the study sites that had no declines after the bleaching event, provide an opportunity to focus conservation efforts.

Photos by Ryan Daly

DEVELOPING TOOLS FOR BEST-PRACTICE CLASSIFICATION OF SHARK BEHAVIOUR
PRINCIPAL INVESTIGATOR: JENNA HOUNSLOW (MURDOCH UNIVERSITY)
FIELD PERSONNEL: SOSF-DRC STAFF, EVAN BYRNES, PRINCIPAL INVESTIGATOR
AUTHOR: JENNA HOUNSLOW

This project set out to create a best-practice framework for the programming of bio-loggers that incorporate accelerometer, gyroscope and magnetometer movement sensors. To achieve this, it aimed to develop statistical models that translate ground-truthed data into behavioural classes (such as resting, swimming and feeding) using machine learning algorithms. Motion-sensor tags record data at very high resolutions to distinguish fine-scale differences in movement that characterise behaviour. This results in millions of data points, which means that tags are battery- and memory-hungry and the manual analysis of data is time-consuming. The optimisation of sampling frequency and sensor combinations allows for the monitoring of shark behaviour for longer periods in the wild. This research will enable future researchers to refine their programming of bio-logging tags to gather more data for every tag deployed for every wild shark tagged. This in turn will promote the uptake of these new technologies and generate valuable knowledge in the discipline of ecology in sharks, resulting in improved conservation and management practices in the long term.

Even the most remote, pristine marine ecosystems are threatened by impacts from coastal development, pollution, climate change and overexploitation. St Joseph Atoll acts as a valuable nursery habitat for juvenile and sub-adult sicklefin lemon sharks *Negaprion acutidens*. This species of lemon shark is assessed as Vulnerable by the IUCN due to heavy fishing and its narrow habitat range in coral reefs, lagoons and mangroves. St Joseph Atoll sustains a healthy breeding population of lemon sharks, which prefer shallow-water lagoons and thus lend themselves well to research based on captive trials.

Once a machine learning algorithm has been developed to classify behaviour correctly and accurately from tag data, it can be applied to data from both previous and future deployments on wild free-swimming lemon sharks. Ultimately this improves our understanding of lemon shark ecology, leading to more informed conservation and management decisions. By refining the classification of behaviours using bio-logging data, fewer lemon sharks will need to be tagged in future studies.

A temporary pen enabled researchers to observe four sub-adult lemon sharks. Once acclimatised to captivity, the sharks were tagged with CATS Daily Diary tags and were watched visually and recorded on video. Photo by Clare Keating Daly | © Save Our Seas Foundation

Photos by Clare Keating Daly

Project leader and Honours student Jenna Hounslow checks her watch before releasing a lemon shark with an accelerometer tag into an observation pen during field work in August 2017. Applying the findings from Jenna's captive studies to data from wild deployments may shed light on lemon shark behaviour and movement patterns in St Joseph Atoll, resulting in a greater overall picture of the species' habitat use.

Jenna spent nearly all her time at the DRC in St Joseph Atoll, collecting 40 hours of ground-truthed data in August by observing the behaviour of captive lemon sharks in a temporary enclosure. Along with direct observation and field notes, a GoPro camera (on a pole behind Jenna) helped to record the behaviour of the sharks.

On a local scale for the Seychelles, applying the findings from this project to data from wild deployments using the same tags may shed light on the behaviour and movement patterns of lemon sharks in St Joseph Atoll, resulting in a greater overall picture of their habitat use.

Field work took place in August 2017. Sixteen of the 18 days at the DRC were spent in the field at St Joseph Atoll. A captive trial pen (12 x 8 metres; 40 x 26 feet) was built against a sandbar in the atoll lagoon, using plastic mesh fencing so that ambient conditions were experienced inside the pen. Sharks were caught nearby in the lagoon, using hand lines and barbless hooks, then transported directly to the pen.

Once the sharks had got used to being held in the pen, CATS Daily Diary tags were attached to their first dorsal fins. Behavioural observations (direct, video and drone) were time synchronised per second, then validated to the tag data. Ethograms were produced for each shark. Sharks that showed no signs of stress in captivity were used for more than one trial before they were released back into the lagoon. The trials were conducted on four sub-adult lemon sharks whose total length ranged from 154 to 198 centimetres (60 to 78 inches). A machine learning algorithm was then written to classify the sharks' behaviours automatically and test the research objectives.

The objectives of the study have been reached by completing all research activities during the field work in August 2017 and gathering the required data during this time. Forty hours of ground-truthed data were collected and four behaviours (swimming, resting, burst and prey manipulation) were identified.

A machine learning algorithm was written to classify the behaviours of the lemon sharks. As sampling frequency is reduced below a certain rate, distinguishing and classifying behaviours become less accurate. Certain fine-scale behaviours (such as prey manipulation and burst) are more difficult to classify than others (swimming and resting). Tags should therefore be pre-programmed at a minimum frequency that will classify the desired behaviours with the highest possible accuracy.

Photos by Clare Keating Daly

FORAGING STRATEGIES OF WEDGE-TAILED SHEARWATERS FROM D'ARROS ISLAND AND FOUQUET ISLAND

PRINCIPAL INVESTIGATOR: DANIELLE Z KEYS (NELSON MANDELA UNIVERSITY)
FIELD PERSONNEL: SOSF-DRC STAFF, LUKE GORDON, PRINCIPAL INVESTIGATOR
AUTHOR: DANIELLE Z KEYS

Certain movement sensors, or combinations of sensors, are more accurate for classifying and distinguishing behaviours. Data analysis will continue for movement sensors, involving each individual movement sensor as well as different combinations of sensors. While some behavioural studies on turtles found gyroscopes to be sufficiently accurate for behavioural classification, others on fish found that a combination of all three movement sensors (accelerometer, gyroscope and magnetometer) provided a more holistic view of three-dimensional movement relating to different behaviours. However, in the past, gyroscopes and magnetometers have required a much higher resolution than accelerometers to achieve similar accuracy in classifying behaviours. All the different sensors and combinations will be tested in case one is more accurate than another.

Limitations have been identified during analysis, with some classification accuracy being lost due to the relatively small dataset resulting from time constraints in the field. The more ground-truthed data available (especially for more rare behaviours) for training a machine learning model, the better its performance and accuracy.

This project will come to an end when the Honours thesis is submitted in June 2018. It is planned that at least two research articles will be submitted for publication during 2018. This research will also be presented at the Australian Society for Fish Biology's annual conference in Melbourne in October 2018.

The wedge-tailed shearwater *Ardenna pacifica* is very sensitive to environmental change and can give us early warnings about changes relating to climate or fish abundance, which is important for fisheries. These shearwaters are abundant in the tropical Western Indian Ocean, with large numbers coming to several islands in the Seychelles during the breeding period. However, their populations are currently declining. Fouquet Island in St Joseph Atoll is home to the third largest population of breeding wedge-tailed shearwaters in the world and is therefore of conservation importance. With the advancement and miniaturisation of technology, scientists can now track the fine-scale movements of small birds like the wedge-tailed shearwater with lightweight GPS, as well as how deep and how long they dive with Time Depth Recorders (TDRs). These devices were used to determine important foraging areas for the shearwaters from Fouquet and D'Arros islands. Unlike many terrestrial birds, male and female seabirds generally look the same, so DNA was extracted from the feather tips of the studied shearwaters to determine their sex and hence find out whether males and females compete for the same resources. In addition, diet samples were opportunistically collected to determine what the birds were eating.

During field work in September 2017, 28 wedge-tailed shearwaters were tracked and data retrieved: 15 from D'Arros Island (male n = 8; female n = 4; sex not identified n = 3) and 13 from Fouquet Island (male n = 6; female n = 7). Five TDR loggers were retrieved, three from D'Arros Island (male n = 1; female n = 2) and two from Fouquet Island (male n = 1; female n = 1). It was found that both male and female shearwaters foraged over a large area (40 square kilometres; 15.5 square miles), mostly within the Seychelles' Exclusive Economic Zone. Populations from both islands had similar flight characteristics and travelled on average 1979.0 ± 759.46 kilometres for a single foraging trip over 12.2 ± 2.97 days. This means they travelled on average 469.3 ± 211.04 kilometres per day. The average furthest distance travelled from the colony was 469.3 ± 211.04 kilometres, with one bird flying 1071.4 kilometres. The shearwaters reached speeds of up to 22.57 $km.h^{-1}$ and were probably using the wind while foraging (average 18.57 ± 2.37 $km.h^{-1}$). Diet samples showed that they feed mostly on juvenile squid and flying fish that are driven towards the surface by other marine top predators such as dolphins and tuna, since the shearwaters cannot dive deep; on average they reach less than five metres (16 feet), but can dive to a maximum of 13.18 metres (43 feet 3 inches).

Photos by Luke Gordon

Project leader and MSc student Danielle Keys holds a wedge-tailed shearwater during normal tagging proceedures in September 2017. A record 52 GPS loggers were deployed on D'Arros and Fouquet islands during Danielle's second and final work with the DRC. This is the first study in the Seychelles that has deployed and successfully retrieved GPS loggers on wedge-tailed shearwaters during the incubation period.

THE ASSESSMENT OF D'ARROS AND ST JOSEPH AS A REFUGE AREA FOR THE ENDANGERED HUMPHEAD WRASSE

PRINCIPAL INVESTIGATORS: DR KEVIN WENG & DR RYAN DALY
FIELD PERSONNEL: SOSF-DRC STAFF, LUKE GORDON, ANDREW GRAY, PRINCIPAL INVESTIGATORS
AUTHORS: DR RYAN DALY & CLARE DALY

D'Arros Island and St Joseph Atoll provide habitat to a diversity of marine life, including 15 species on the IUCN Red List. One of these species, the Endangered humphead wrasse *Cheilinus undulatus*, is an iconic reef-associated fish that is important internationally for fisheries, tourism and a healthy coral reef ecosystem. Throughout its range, from the Red Sea and Western Indian Ocean into the Indo-Pacific and stretching north to Japan and east to French Polynesia, the species is naturally uncommon but increasingly rare. Like most large fishes, the humphead wrasse is biologically vulnerable and able to withstand only the lightest fishing pressure, which makes it highly vulnerable to overfishing – and consequently dependent on conservation. Details of the spatial ecology of this species are insufficient, due in part to its meagre populations. However, the Seychelles may contain some of the highest densities of humphead wrasse known in the world, providing a unique opportunity for study.

Effective conservation relies on an understanding of the spatial ecology of a species, but little is known about the humphead wrasse's spatial ecology as only two studies have been conducted worldwide. In general, humphead wrasse are typically found along outer reef slopes and channel walls within coral reef ecosystems.

The general aim of this study was to assess the importance of the reef-associated habitats around D'Arros Island and St Joseph Atoll as a refuge for Endangered humphead wrasse in the Seychelles. There were two preliminary objectives: firstly, to assess the distribution and abundance of humphead wrasse; and secondly to generate movement and home range data for the species by using the existing acoustic receiver network and deploying acoustic tags.

A diver-capture method developed by Dr Kevin Weng and Andrew Gray during a previous study on humphead wrasse at Palmyra Atoll was used to catch the fish. A GPS point was taken at the point of capture. Captured fish were placed in a specialised holding tank aboard the DRC research vessel, where measurements and a fin clip were taken from each fish. An internal acoustic tag was inserted into each fish and the small incision was closed with one to three

Photos by Ryan Daly

Project leader Kevin Weng releases the largest tagged humphead wrasse in the world, which was successfully sampled in October 2017. The Seychelles may contain some of the highest densities of humphead wrasse known on the planet, providing a unique opportunity for study. Twenty humphead wrasse, ranging from 52 to 133 centimetres (20.5 to 52.5 inches) in total length, were tagged during the field work.

surgical sutures. All the fish were given a temporary innocuous visual marker to prevent recapture during the study period.

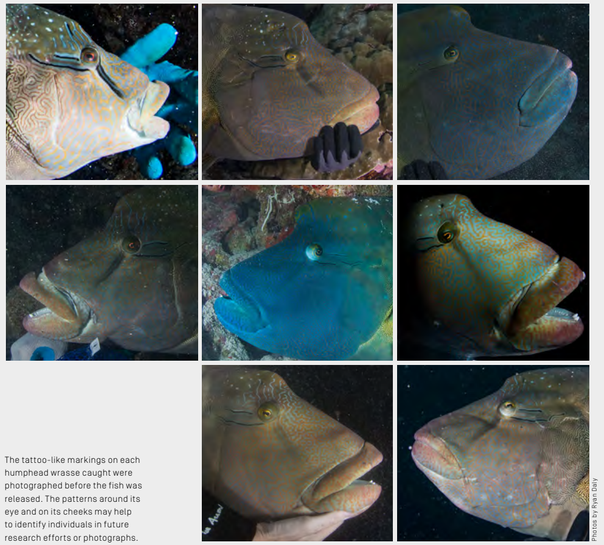
The field work took place over three weeks in October 2017. To establish initial target areas, divers undertook visual surveys around D'Arros Island and St Joseph Atoll, focusing on reef drop-offs and areas of preferred humphead wrasse habitat. During surveys, groups of up to 11 wrasse were observed, with the largest congregations occurring along the channel walls between D'Arros and St Joseph. Based on this information, four areas were targeted.

The fingerprint-like markings on the humphead wrasse's face can be used for identification and were therefore photographed. An underwater diver released each tagged fish into a cave for protection during recovery at or close by the capture spot as determined by GPS. All the fish appeared healthy upon release and nearly all were subsequently seen swimming on the reef. During the annual receiver downloads on 21 October, all 13 of the tagged fish were detected.

In total, the field work resulted in the capture and tagging of 20 humphead wrasse, which ranged in size from 52 to 133 centimetres (20.5 to 52 inches) in total length. The number and size of humphead wrasse tagged during this assessment were larger than in any previous study.

For the Seychelles and the entire Indian Ocean, the population of humphead wrasse at D'Arros and St Joseph may be significant. This study is the first step towards a better understanding of this population and adds to the limited body of knowledge about the spatial ecology of humphead wrasse.

The first data available for this study will arrive in March 2018 with the download of the acoustic receiver networks. The second download, in November 2018, will mark the beginning of the data analysis for this study, as a year's worth of data will be available. A final report and publication will follow. We believe this study highlights not only the significance of D'Arros and St Joseph for humphead wrasse, but also the potential for ongoing data collection to assist the effective management of these iconic fish and the communities associated with them.



The tattoo-like markings on each humphead wrasse caught were photographed before the fish was released. The patterns around its eye and on its cheeks may help to identify individuals in future research efforts or photographs.

Photos by Ryan Daly

Photos by Michael Scholl

MOVEMENT PATTERNS AND TROPHIC ECOLOGY OF REEF MANTAS
PRINCIPAL INVESTIGATOR: LAUREN PEEL (MANTA TRUST, UNIVERSITY OF WESTERN AUSTRALIA, AUSTRALIAN INSTITUTE OF MARINE SCIENCE)
FIELD PERSONNEL: SOSF-DRC STAFF, LUKE GORDON, PRINCIPAL INVESTIGATOR
AUTHOR: LAUREN PEEL

Very little is known about the manta ray population in the Seychelles, as few sightings have been reported around the populous Inner Islands of the country. The presence of a reliable, near year-round aggregation of reef manta rays *Mobula alfredi* at D'Arros Island and St Joseph Atoll in the Outer Islands of the Seychelles is therefore highly significant and provides a unique opportunity to study the biology of this population in the absence of major anthropogenic influences. Using a suite of research techniques, the SOSF-DRC and Manta Trust's Seychelles Manta Ray Project aims to investigate the population dynamics, movement patterns, feeding ecology and genetics of the reef manta ray population at D'Arros Island and St Joseph Atoll in order to further the understanding of the biology and conservation needs of this species in the Western Indian Ocean.

As this research encompasses multiple aspects of manta ray biology, numerous methods are used to collect data during field work. Population dynamics are investigated using photo-identification techniques, as manta rays possess unique pigmentation patterns on their bellies that do not change with time. Reef manta ray movement patterns are monitored by a combination of acoustic and satellite telemetry, and stable isotope and fatty acid analyses will be used to investigate the trophic role of this species within the coral reef ecosystem at D'Arros Island and St Joseph Atoll.

In 2017, 55 new reef manta rays were added to the Seychelles database, bringing the total number of individuals observed throughout the country to 213. Of these, 147 (82%) were first identified at D'Arros Island and St Joseph Atoll. Males (48%) and females (49%) are still equally represented within the population, and the maturity status of individuals continues to range from juveniles (28%) through to sub-adult (9%) and mature (46%) adults. Sexual maturity was unable to be assessed for 37 individuals.

Acoustic telemetry within the Amirantes Island Group has revealed that reef manta rays tagged at D'Arros Island display high rates of residency, spending on average half of the days that they were tracked around the island and neighbouring St Joseph Atoll. For a large pelagic species, this indicates that D'Arros Island and St Joseph Atoll are important to the life history of reef manta rays in this part of the Seychelles and supports the proposed marine protected area at this location.

In early 2017, data were successfully retrieved from the two satellite tags that were deployed on mature female reef manta rays at D'Arros Island at the end of 2016. In November 2017, an additional three satellite tags were deployed at D'Arros Island: two on mature male mantas and one on a mature female. Data are expected to be retrieved from these tags by June 2018, with the final two tags for this research project planned for deployment in March 2018.

In addition to the sampling completed in 2016, a total of 40 manta, 167 fish, 10 sea-grass and 56 plankton samples were collected at D'Arros Island in November 2017. All these samples will be analysed in 2018 to generate stable isotope and fatty acid profiles that will be collated in order to place manta ray feeding ecology and preferences in the context of the coral reef ecosystem of D'Arros Island.

The 40 collected manta biopsy samples will also be used for genetic analyses that will expand our understanding of the relatedness of individuals within this reef manta ray population and provide insight into the connectivity of this population within the Seychelles.

On a global scale, manta rays have suffered drastic declines in the past 75 years as a result of targeted fishing practices that aim to supply manta gill plates to the traditional Chinese medicine market. Assessing the population dynamics and movement patterns of reef manta rays at D'Arros Island will provide a critical insight into the health of the little-studied Seychelles manta ray population and how individuals are moving between the islands of the archipelago. Furthermore, in 2017 this study recorded the first known manta courtship in the Amirantes Island Group as well as the first manta pregnancy recorded in the Amirantes, highlighting the area as a potential mating and pupping area. This information is key when designing conservation strategies aimed at protecting these vulnerable elasmobranchs and is expected to contribute a great deal of support to the establishment of the proposed marine protected area around D'Arros Island and St Joseph Atoll.

Photo by Ryan Daly

Photo by Lauren Peel

An acoustic telemetry manuscript based on the data collected from the first two seasons of field work and historical data from the DRC is being prepared for submission in early 2018. In addition, the analysis of tissue samples for the trophic ecology component of this project and the associated manuscript will continue in 2018. The deployment of the last two satellite tags and subsequent analysis of satellite telemetry data will take place late in 2018, when field work for the project will come to an end.

Dr Guy Stevens and PhD student Lauren Peel prepare to deploy one of three satellite tags during field work in November 2017. A combination of satellite and acoustic telemetry is helping Lauren to answer questions about the movement patterns of manta rays around D'Arros Island and the wider Seychelles. This was her second field trip to the DRC.

Three satellite tags were deployed on mature manta rays at the end of 2017. The tagging focused on large, mature manta rays, which are more likely to undertake large-scale movements and provide a better understanding of the full range of movements by the Seychelles manta rays.

PERIODICITY AND VISITATION RATES OF MANTA RAYS TO A CLEANING STATION AT D'ARROS ISLAND

PRINCIPAL INVESTIGATORS: DR RYAN DALY & LAUREN PEEL (MANTA TRUST, UNIVERSITY OF WESTERN AUSTRALIA, AUSTRALIAN INSTITUTE OF MARINE SCIENCE)
FIELD PERSONNEL: SOSF-DRC STAFF, LUKE GORDON, PRINCIPAL INVESTIGATORS
AUTHORS: DR RYAN DALY & LAUREN PEEL

It is hypothesised that the visitation and subsequent occupation of cleaning stations by reef manta rays *Mobula alfredi* at D'Arros Island will show patterns in frequency that are related to tidal phase and time of day. Moreover, it is believed that these patterns would be consistent at temporal scales ranging from days to months. Establishing such temporal patterns will help to shed light on the habitat use of reef mantas at D'Arros Island, which will contribute to ongoing research currently being conducted at the DRC. In addition, this project aims to contribute photo IDs to the ongoing long-term monitoring of reef mantas at D'Arros Island.

Over a two-month period, MantaCam, a remote underwater camera system, was deployed 30 times and captured 203,227 photographs during its 599.5 hours submerged at the cleaning station. Of these photographs, 3,160 (1.5%) showed manta rays and these were used to contribute an additional 344 confirmed sightings of 84 individuals to our records. Six of the individuals were new additions to the Seychelles manta ray database. MantaCam sightings now comprise 23% of the total manta sighting records for the Seychelles.

MantaCam will be deployed for another two full lunar cycles in 2018, once during the calm period between the NW and SE monsoons and once during the SE monsoon in order to investigate any seasonal patterns in cleaning station visitations. The visitation patterns will then be analysed and the data used in models to investigate the environmental drivers of visitations.

MantaCam was deployed over two months at the end of 2017. It captured the equivalent of 800 dives' worth of data. These records represent 15% of the sighting record database. .

Underwater MantaCam hours	Manta ray images captured	Most manta images captured in one day	Confirmed IDs	New Mantas
600	3160	174	194	6

Photos by Luke Gordon

MantaCam, a remote undewater camera system, is contained in an underwater housing (below) and kept on a fixed mooring block next to the cleaning station reef off D'Arros Island. Ryan Daly uses a stereo video camera system (above) to measure the manta visiting the cleaning station. He is visiting the station to change the battery that powers the camera.

A reef manta ray swims over a cleaning station off D'Arros Island with MantaCam in the foreground. Over a two-month period, MantaCam was deployed 30 times, remaining submerged for nearly 600 hours.

Project leader and PhD student Chantel Elston prepares to release a porcupine ray in St Joseph Atoll after collecting dietary samples during field work in 2015. The paucity of information on batoids, particularly in remote places, means that the results of Chantel's work are novel. This project is significant for St Joseph Atoll and the Seychelles, putting the atoll on the map as a critical nursery area and drawing attention to the country's contribution to the increase in scientific knowledge about three species of stingray.

ECOLOGY OF STINGRAYS AT ST JOSEPH ATOLL

PRINCIPAL INVESTIGATOR: CHANTEL ELSTON (RHODES UNIVERSITY)
FIELD PERSONNEL: *NO FIELD WORK IN 2017*
AUTHOR: CHANTEL ELSTON

There is little information available about what makes up the diet of many stingray species, particularly in difficult-to-reach places such as remote oceanic atolls. This is unfortunate, as stingrays play important ecological roles and understanding their dietary habits is vital in determining how ecosystems function. The remote St Joseph Atoll hosts an abundance of stingrays, notably the feathertail *Pastinachus sephen*, the mangrove whiptail *Urogymnus granulatus* and the porcupine ray *U. asperrimus*. The first objective of this study was to determine the dietary composition and feeding selectivity of the porcupine ray, given its rarity and IUCN status as Vulnerable.

Stomach contents from juvenile porcupine rays were sampled using non-lethal gastric lavage to determine the dietary composition, degree of prey selectivity and whether sex or size affected their diet. Sediment samples were also collected at each capture location to find out how much prey was available so that prey selectivity could be estimated.

Stomach contents revealed that the porcupine rays prey largely on polychaetes and crustaceans. In particular, they specialise on one polychaete family, Capitellidae, which occurred in almost all stomach contents and at the highest volumes. However, this polychaete was also the most abundant in sediment samples, which suggested that porcupine rays were opportunistic predators, preying on what was most available. There also appeared to be an effect of size on diet, as small individuals consumed crustacean families in different proportions compared to larger individuals.

Given the understudied nature of batoids, all information gathered by this project is novel. During the course of 2017 one paper was published, another submitted and a final paper is in preparation for submission to scientific journals. In addition, data analysis conducted this year provided evidence to support the long-held hypothesis that St Joseph Atoll is an important nursery area for the three species of stingray that occur there. Analyses conducted on stable isotope data also revealed resource partitioning in a stingray nursery for the first time.

Determining the feeding habits of the porcupine ray not only adds to a holistic ecological understanding of St Joseph Atoll, but also helps to identify the

Photo by Rainer van Bijlevelds

St Joseph Atoll hosts an abundance of stingrays, including perhaps some of the greatest known densities of porcupine rays. In November 2017, more than 50 porcupine ray were seen in a concentrated area off Fouquet Island. Understanding dietary composition and feeding selectivitiy in these rays adds significant information to the limited knowledge about the ecological roles of stingray species.

Photo by Clare Keating Daly

ecological impact of this species throughout its large range. Knowing which prey species porcupine rays rely on may also help to protect this vulnerable species. Finally, establishing that porcupine rays feed on fauna in the sand flats of the atoll added to the growing evidence that this habitat is vital to the survival of numerous species.

2018 will see the completion of this project: all remaining data will be analysed and written up and the leader's PhD thesis will be handed in. Papers on the project will be prepared for submission to peer-reviewed journals.

MOVEMENT ECOLOGY OF TWO TREVALLY SPECIES IN THE SEYCHELLES
PRINCIPAL INVESTIGATORS: DR PAUL COWLEY (SAIAB) & DR RYAN DALY
FIELD PERSONNEL: *NO FIELD WORK IN 2017*
AUTHOR: DR RYAN DALY

The giant trevally *Caranx ignobilis* and the bluefin trevally *C. melampygus* (family Carangidae) represent iconic recreational angling species throughout their tropical distribution. Both species are important targets of the growing fly fishing industry in the Seychelles, yet there is little information about these species in the south-western Indian Ocean. This study aims to contribute to the understanding of the movement ecology of these species around the near-pristine environments of the D'Arros Island and St Joseph Atoll complex in the Seychelles. Specific objectives include investigation into their habitat use patterns and movement behaviour and the identification of spawning aggregation sites. The findings of this study will aid the management of these species and the sustainability of localised stocks.

Understanding the movement patterns and habitat use of top predatory reef fishes is important as they play a key role within their respective ecosystems. The giant trevally in particular is one of the largest predatory fishes associated with coral reefs, reaching up to 87 kilograms (192 pounds), and as such it plays an especially important role in the coral reef community. Giant and bluefin trevallies may also be susceptible to targeted fishing pressure by recreational anglers in the Seychelles and it is important to understand how to manage and regulate the fisheries in the region effectively in order to maintain a healthy stock of top predatory reef fish. The long-term results of this study will enable us to prioritise key areas of giant and bluefin habitat for protection.

In April and May 2016, 13 adult giant trevallies ranging from 725 to 1,200 millimetres (28.5 to 47 inches) fork length were tagged with VEMCO V16 acoustic transmitters in the coastal waters of D'Arros Island, and four juveniles ranging from 405 to 470 millimetres (16 to 18.5 inches) fork length were tagged in St Joseph Atoll with VEMCO V13 transmitters. In the same period, 17 bluefin trevallies were tagged with V13 acoustic transmitters.

The fish were caught on conventional fishing gear and artificial lures from a small vessel or from shore. They were handled with care and during the surgical procedure they were held in a large tub filled with fresh sea water. After the transmitters had been implanted, each fish was measured and a small fin clip was taken for genetic analysis. The tagged fish were then released at the site of their

Photo by Paul Cowley

Research assistant Dr JD Filmalter prepares to release a giant trevally off D'Arros Island during field work in 2016. Although all the fish for this study were tagged in 2016, data are still being collected. Analysis for the first year of deployment is now available.

capture. They were monitored by a permanent array of 88 acoustic receivers in and around D'Arros Island and St Joseph Atoll. The data obtained from the first six-month period were analysed and are highlighted in this report.

In 2017, an additional 21,938 detections were recorded for giant trevally, bringing the total number of detections to 83,375. For bluefin trevally, an additional 7,686 detections were recorded in 2017, bringing the total to 24,512. The detections for both species were consistent with those of 2016, showing that giant trevallies prefer the reef slope whereas bluefin trevallies appeared to prefer the shallower reef crest around D'Arros Island and St Joseph Atoll.

The movement of giant trevallies in 2017 remained consistent with the movement patterns of fish analysed in 2016. Juvenile giant trevallies exhibited a preference for the lagoon in St Joseph Atoll, where they were tagged, while sub-adults (of fork length 60 to 100 centimetres; 23.5 to 39.5 inches) frequented the north-western reef slope of St Joseph and the north-eastern reef slope of D'Arros Island. In 2017 adult fish (larger than 100 centimetres) continued to undertake larger-scale movements than smaller fish, consistent with the results of 2016. Adult giant trevallies were detected to the south at Boudeuse Cay, Etoile Cay and Marie Louise Island as well as to the north at African Banks, which confirms that adult fish are capable of large-scale movements throughout the Amirantes.

This study is the first in the Seychelles to describe the movement patterns of top predatory fish associated with coral reefs. So far, the results suggest that bluefin and giant trevallies may have non-overlapping habitat preferences and that different size classes of the giant trevally may exhibit ontogenetic changes in movement patterns. They also suggest that adult giant trevallies may move over areas larger than previously thought, while the sheltered lagoon of St Joseph Atoll may be especially important for recruits. These results will help to inform effective conservation management and planning for the region in the years to come.

Downloads of acoustic receiver data from the acoustically tagged bluefin and giant trevallies will continue in 2018. Additional data on the movement of both trevally species will be analysed as available, with the goal of publishing the data within three years.

OTHER RESEARCH ACTIVITIES

Four research or long-term monitoring projects started in 2017 but have not yet yielded significant results to report. Nonetheless, 2018 will see the continuation of these projects, whose early field work and first findings are reported below.

PhD student Evan Byrnes and DRC programme director Clare Keating Daly prepare to release a tagged lemon shark. Evan plans to investigate further the energetics of sharks and how their energy requirements relate to their habitat use and home range.

BIO-ENERGETICS OF SICKLEFIN LEMON SHARKS

PRINCIPAL INVESTIGATOR: DR RYAN DALY
FIELD PERSONNEL: SOSF-DRC STAFF, EVAN BYRNES
AUTHORS: DR RYAN DALY & CLARE KEATING DALY

Many shark species utilise protected bays or atolls as nursery areas due to the relative abundance of food resources and low level of predation. In theory, these factors increase the survival of juveniles that use nursery areas, but it is unclear how these areas contribute to a reduction in the expenditure of energy on foraging and avoiding predation to increase survival.

As the survival of juveniles is a critical factor influencing the health and growth of populations, understanding the mechanisms associated with it is important. Various factors such as life history (growth rate and reproduction) and ecology (competition and predation) can influence survival and this study will focus on understanding how juvenile lemon sharks interact with their environment at St Joseph Atoll to reduce the expenditure of energy and thus maximise survival.

In February, a series of dead reckoning trials were completed on lemon sharks in St Joseph Atoll. Dead reckoning works by using the recorded acceleration and direction of a tagged shark to calculate its fine-scale movement, which can then be analysed to understand its use of habitat within the atoll. Because dead reckoning is a new method of determining shark tracks, it needs to be tested to ensure that it is accurate. Ultimately, the work undertaken in February aims to combine the precise habitat use calculations from dead reckoning with the behavioural and energetic dynamics of the shark.

The SOSF-DRC hosted PhD candidate Evan Byrnes from Murdoch University in Australia to join the field work undertaken in February. Evan plans to expand the current project by incorporating a more detailed investigation into the energetics of sharks and how their energy requirements relate to their use of habitat and their home range.

Photos by Ryan Daly

DIVERSITY, ABUNDANCE AND DISTRIBUTION OF ELASMOBRANCHS

PRINCIPAL INVESTIGATOR: DR RYAN DALY
FIELD PERSONNEL: SOSF-DRC STAFF, EVAN BYRNES, LUKE GORDON
AUTHORS: DR RYAN DALY & CLARE KEATING DALY

Baseline data on the abundance of elasmobranchs and turtles in St Joseph Atoll is currently deficient. For effective conservation management plans, basic baseline abundance estimates of stingrays, sharks and turtles are necessary. Furthermore, baseline data on these species will contribute to ongoing and long-term studies at present and in the future. Ultimately the proposed investigation will provide an abundance estimate and long-term monitoring data on these species to assess the health of their populations and measure changes over time.

In 2017, drone transects and test flights were completed. Five one-kilometre (0.62-mile) transects, each covering 90,000 square metres (22 acres), will provide baseline data on the abundance and distribution of the targeted species in St Joseph Atoll.

Fixed drone transects were established in 2017 to solve the challenge of surveying sharks, rays and turtles over the vast shallow reef flats of St Joseph Atoll. Five one-kilometre (0.62-mile) transects provide baseline data on the abundance and distribution of these species.

In 2017, the SOSF-DRC began an island census and monitoring programme on Aldabra giant tortoises. 'Thomas', estimated to be the third largest tortoise on D'Arros, appears to have a home range that rarely extends past the office.

Photo by Ryan Daly

TORTOISES

PRINCIPAL INVESTIGATOR: CLARE KEATING DALY
FIELD PERSONNEL: SOSF-DRC STAFF, LUKE GORDON
AUTHOR: CLARE KEATING DALY

Monitoring and research at the SOSF-DRC prioritise species that are threatened with extinction as defined by the IUCN, so in 2017 a project was begun to monitor the Aldabra giant tortoise *Aldabrachelys gigantea*, which is classified as Vulnerable. There had been no previous monitoring of giant tortoises on D'Arros Island and no known estimates of their numbers. The Aldabra giant tortoises were first introduced to the island sometime after 1975, but there are no known records of the number introduced or of additions to the population through reproduction or additional introductions.

The coralline islands of the Amirantes Bank and the granitic Inner Islands are not native habitat to these endemic tortoises. However, large populations of introduced tortoises exist on many inhabited islands. Even so, little research has been done on the Aldabra giant tortoises introduced to islands outside the Aldabra Archipelago. Understanding the population dynamics, abundance and recruitment of free-ranging introduced tortoises is important to the broader conservation and understanding of Aldabra tortoises on islands beyond Aldabra.

In 2017, the SOSF-DRC compiled a photo-ID database of Aldabra giant tortoises on D'Arros Island, which contains 21 known individuals. At least five of these are juvenile recruits from tortoises resident on D'Arros. This long-term monitoring study will provide targeted objectives for understanding this Seychelles endemic.

Photo by Clare Keating Daly

RARE, VAGRANT AND BREEDING BIRD RECORDS

PRINCIPAL INVESTIGATOR: CLARE KEATING DALY
FIELD PERSONNEL: SOSF-DRC STAFF, DANIELLE KEYS, LUKE GORDON, DINANTIS BEUKES, BARRY LUCKMAN
AUTHOR: CLARE KEATING DALY

D'Arros Island is listed as one of BirdLife International's Important Bird and Biodiversity Areas (IBAs) due to the presence of the introduced Seychelles fody. St Joseph Atoll is considered a Potential IBA as there are insufficient data on IBA threshold criteria. Although the formal application to upgrade St Joseph Atoll to an IBA is not currently under way, supporting data on threshold criteria are essential for the success of future applications. In addition, changing trends in breeding seabird numbers may be early indicators of regional ocean health, as a continuous, stable supply of pelagic fish is necessary if chicks are to be reared successfully.

In 2005, an exploratory visit to St Joseph Atoll was led by Adrian Skerrett to investigate potential sites for ground-nesting roseate and black-naped terns and to observe other seabirds and shorebirds in the atoll. From 2006 to 2009, DRC staff monitored breeding terns and recorded sightings of rare and vagrant bird species. Records of such species ended in 2009, while the monitoring of breeding roseate terns and nesting wedge-tailed shearwaters has been intermittent between 2010 and 2016.

The data from 2005 to 2009 established that St Joseph Atoll met the IBA criterion for congregations of waterbirds and seabirds (Criterion 4). A site qualifies for A4i if it is known or thought to hold, on a regular basis, at least 1% of the African population of a congregatory waterbird species (breeding roseate and black-naped terns both fulfil this criterion) and it qualifies for A4ii if it is known or thought to hold, on a regular basis, at least 1% of the global population of a congregatory waterbird species (roseate tern and wedge-tailed shearwater fulfil this criterion). Furthermore, counts of shorebirds in the 2005 exploratory visit suggested that other species such as migratory crab plovers and ruddy turnstones may also qualify for A4ii status. Nonetheless, without recent and sufficient data, the future application for the listing of St Joseph Atoll as an IBA is threatened.

Finally, new range records and species records may be quite common for D'Arros Island and St Joseph Atoll, and they could make a significant contribution to the records of rare and vagrant bird species of the Seychelles as a whole.

Keeping accurate records of breeding seabirds, along with maintaining a species records list of rare and vagrant birds, ensures that sufficient data are available for conservation appeals and future applications for IBA status.

In 2017, opportunistic surveys of islands and islets of St Joseph Atoll were conducted during the relevant breeding seasons. Bi-weekly surveys of D'Arros Island resulted in range extensions of migratory birds into the Outer Islands and Amirantes Bank, along with a first species record for the Seychelles, Franklin's gull.

In September, *Marine Ornithology* published a note on the first record of a Franklin's gull in the Seychelles, observed by SOSF-DRC programme director Clare Keating Daly. Known to breed in central Canada and north-western United States, the species has provided only one previous record for the Indian Ocean, nearly 5,000 kilometres (3,100 miles) from D'Arros.

RESEARCH OUTPUTS

SOSF-D'ARROS RESEARCH CENTRE PUBLICATIONS & REPORTS

Publications and reports on SOSF-DRC projects throughout the year are key to sharing the work of project leaders and the research centre. Many SOSF-DRC projects consist of long-term monitoring or multiple seasons of data collection, which limits the possibilities of publishing annually. Nonetheless, in 2017 project leaders faced greater pressure to publish their findings, resulting in six publications submitted to peer-reviewed journals, of which two were accepted and four are still in the review process. In addition, three publications from 2017 research are being prepared for submission in the first half of 2018. Despite limitations on scientific publications, two research reports and 11 research updates were submitted to the director general of the Biodiversity Conservation and Management Division of the Ministry of Environment, providing regular updates on D'Arros Island research activities during 2017.

The SOSF-DRC submitted two research reports, including one on the success of the humphead wrasse tagging programme, and 11 research updates to the Ministry of Environment in 2017.

During field work in August, two lemon sharks were observed with marine leeches on their upper jaws. This species of leech had never before been recorded parasitising sicklefin lemon sharks, nor had it been recorded in the Western Indian Ocean.

Photos by Ryan Daly

PAPERS IN PEER-REVIEWED PUBLICATIONS

Elston C, Von Brandis RG, Cowley PD. 2017. Dietary composition and prey selectivity of juvenile porcupine rays *Urogymnus asperrimus*. *Journal of Fish Biology* 91(2): 429–422.

Daly CK. 2017. First record of Franklin's Gull *Leucophaeus pipixcan* for Seychelles. *Marine Ornithology* 45: 223–224.

PAPERS SUBMITTED TO PEER-REVIEWED PUBLICATIONS IN 2017

Daly R, Hounslow JL, Byrnes EE, Daly CK. New host record for the marine leech *Pontobdella macrothela* (Hirudinida: Pisciolidae) from sicklefin lemon sharks *Negaprion acutidens* (Chrondrichthyes: Carcharinidae) in St Joseph Atoll, Republic of Seychelles, West Indian Ocean. *Comparative Parasitology*.

Daly R, Stevens G, Daly CK. Rapid marine biodiversity assessment records 20 new marine fish species for Seychelles, West Indian Ocean. *Marine Biodiversity Records*.

Elston C, Cowley PD, Von Brandis RG. Evidence of a nursery for porcupine rays *Urogymnus asperrimus* at a remote atoll: Implications for a proposed Marine Protected Area. *Environmental Biology of Fishes*.

Lea JSE, Daly R, Leon CA, Daly CK, Clarke C. Life after death: behavior of multiple shark species scavenging a whale carcass. *Journal of Fish Biology*.

PUBLICATIONS IN PREPARATION FOR SUBMISSION IN 2018 (LEAD AUTHOR LISTED)

Elston C, et al. Influences on habitat selection by a marine mesopredator: an interplay between behavioural thermoregulation and predator avoidance. *Endangered Species Research*.

Gatoutsis E, et al. Impact of 2016 bleaching event on hard coral coverage of a remote Indian Ocean reef system. *African Journal of Marine Science*.

Peel L, et al. Patterns and environmental drivers of reef manta ray (*Mobula alfredi*) movements at the Amirantes Islands, Seychelles. *Proceedings of the Royal Society B: Biological Sciences*.

DEGREES AWARDED TO SOSF-DRC PROJECT LEADERS

The research of two SOSF-DRC project leaders resulted in the awarding of their MSc degrees:

Gadoutsis E. 2017. Impacts of the 2016 coral bleaching event on the hard coral reefs of D'Arros Island and St Joseph Atoll, Seychelles. Master's Thesis. University of York: England.

Moxham EJ. 2017. The spatial ecology of *Albula glossodonta* in the St Joseph Atoll, Seychelles. Master's Thesis. Rhodes University: South Africa.

CONFERENCE AND UNIVERSITY PRESENTATIONS OF SOSF-DRC PROJECTS

The Save Our Seas Foundation supports the travel of project leaders to conferences around the world to present their work to the international scientific community. In 2017, six projects supported by the SOSF-DRC were presented at four international conferences. At the International Conference on Fish Telemetry, four SOSF-DRC researchers presented data from the extensive acoustic telemetry network of the DRC. In addition to talking about their research at conferences, project leaders presented their work at universities in five different countries, giving a total of seven presentations.

Photo by Samantha Andrzejaczek

In June 2017, the SOSF supported DRC project leaders at the International Conference on Fish Telemetry, resulting in four oral presentations. From left to right: Dr Ryan Daly, Lauren Peel, Emily Moxham and Chantel Elston.

Lauren Peel (right) answers students' questions about her work on manta rays in the Seychelles after a presentation at the University of Seychelles in November 2017.

Project leader Ornella Weideli (second from right in second row) presented her work at the University of Seychelles in Mahé in April.

Photos by Terence Vel

CONFERENCE PRESENTATIONS

Daly R et al. 2017. Investigating the utility of dead reckoning to calculate accurate shark tracks over space and time. Oral presentation. International Conference on Fish Telemetry, Cairns, Australia.

Elston C et al. 2017. Stingray residency and spatial use of an isolated atoll. Oral presentation. International Conference on Fish Telemetry, Cairns, Australia.

Elston C et al. 2017. Stingray residency and spatial use of an isolated atoll. Oral presentation. South African Shark and Ray Symposium, Hermanus, Cape Town.

Mortimer J. 2017. Turtle Action Group of Seychelles (TAGS). Oral presentation. 37th Annual Symposium on Sea Turtle Biology and Conservation, Las Vegas, Nevada, USA.

Mortimer J et al. 2017. Satellite tracking the migrations of post-nesting hawksbill turtles (*Eretmochelys imbricata*) in Seychelles. Poster presentation. 37th Annual Symposium on Sea Turtle Biology and Conservation, Las Vegas, Nevada, USA.

Moxham EJ et al. 2017. Spatial ecology of bonefish (*Albula glossodonta*) in St Joseph Atoll, Seychelles. Oral presentation. International Conference on Fish Telemetry, Cairns, Australia.

Peel LR et al. 2017. Movement patterns and social structure of Seychelles reef manta ray population. Oral presentation. International Conference on Fish Telemetry, Cairns, Australia.

UNIVERSITY PRESENTATIONS

Elston C. 2017. Trophic and spatial ecology of a sympatric stingray community in a remote atoll. Oral presentation. Department of Ichthyology and Fisheries Seminars, Rhodes University, Grahamstown.

Gadoutsis E. 2017. Impacts of the 2016 coral bleaching event on the hard coral reefs of D'Arros Island and St Joseph Atoll, Seychelles. Oral presentation. University of York, England.

Hounslow J. 2017. Developing tools for best practice classification of shark behavior from bio-logging data. Poster presentation (first prize). Murdoch University, Australia.

Peel LR. 2017. Manta Rays: eyes on the back of their head. Oral presentation. School of Biological Sciences, University of Western Australia, Australia.

Peel LR. 2017. Movement patterns, trophic role and ecology of reef mantas in the D'Arros Area. Oral presentation. University of Seychelles, Seychelles.

Weideli OC. 2017. Resource partitioning and competition in the multi-species shark nursery at the St Joseph Atoll. Oral presentation. University of Seychelles, Seychelles.

Weideli OC. 2017. Multi-dimensional niche patterns and underlying competitive interactions in sympatric juvenile predators. Oral presentation. Doctorial CRIOBE, Moorea, French Polynesia.

Photo by Michael Scholl

Photo by Nicholas Lamberbos/SOSF Crew

SOSF SHARK EDUCATION CENTRE

ELEANOR YELD HUTCHINGS

save our seas
shark education centre

'This type of interactive education is important and will encourage young people to learn and understand more of the magic of the marine ecosystem. I thoroughly enjoyed my time with the team at the SOSF Shark Education Centre.'

Angela Warrior, visiting assistant

2017 was the year that made all the changes we have put into the Shark Education Centre really come alive. We were busier than in previous years, with more and bigger classes of learners coming through the centre, and we were able to make full use of the new facilities and exhibits and start to integrate them in a way that has elevated our educational programming and increased the experiential nature of what we can offer.

Every January, the South African Marine and Coastal Educators Network (MCEN) holds its annual conference. In 2017 it was the turn of the province of KwaZulu-Natal to host the meeting and educator Paul Millar, assistant educator Zanele Mayiya and I attended for the week. The conference took a travelling format this year, with stops at uShaka Marine World, iSimangaliso Wetland Park at Lake St Lucia and Ballito. This was wonderful as it gave us a chance to see a part of South Africa that is subtropical, with warm water, humid air and summer rainfall – quite a contrast to what we are used to in the Western Cape. KwaZulu-Natal also has a very beautiful coastline, while Lake St Lucia is a World Heritage Site.

This week at the conference is always such an inspirational time for us, as we network with other coastal and environmental educators, take on board new ideas and activities, share our own experiences and what we have learnt, and get ready for the year ahead. This year I shared an activity with the group called 'Jellyfish in a Bottle', which is a craft activity that re-uses plastic bottles and grocery store plastic bags and at the same time emphasises the conservation message about plastic pollution in the oceans. Highlights of the week included the first night, which was a sleepover in the uShaka Seaworld Aquarium – a very different experience for all of us! Another highlight was an afternoon cruise on Lake St Lucia, during which we were treated to wonderful sightings of fish eagles, hippos and crocodiles. We unfortunately did not see one of the famous St Lucia Zambezi (or bull) sharks that inhabit the lake, although we looked extremely hard!

I serve as the Western Cape representative on the MCEN's national steering committee, so every year I participate in the national meeting. This network is an extremely valuable resource and it is an honour to be able to actively contribute to the running of it. As the representative for the Western Cape, I have the responsibility of organising the annual regional meeting and this year the Shark Education Centre once again played host. Held during National Marine Week in October, the conference went very well and the quality and relevance of the invited keynote addresses (on desalination in the South African context and evaluating the impact of environmental education programmes) ensured a very appreciative reception. In fact, so popular were the talks that they were repeated at several other venues at later dates. It was a very successful day and the positive feedback on the proceedings and the venue was very satisfying.

During 2017 the Shark Education Centre played host to a large number of people in the two accommodation bedrooms located upstairs. Except for three days in January, we had guests from 1 January until 31 May without a break and after that we had people staying for a few weeks out of each month. Some of the guests who stayed with us during this past year were Dr Ruth Leeney, the leader of the Save Our Seas Foundation's project Protect Africa's Sawfishes (*https://saveourseas.com/project-leader/ruth-leeney/*) and Peter Musembi from Kenya, the leader of the project Sharks and People of Watamu MPA (*https://saveourseas.com/project-leader/peter-musembi/*). We also hosted Lisa Schroeter, the leader of the ELMO project (*https://saveourseas.com/project-leader/lisa-schroeter/*) that works with citizen scientists to monitor sharks and other elasmobranchs. At the same time we hosted ELMO's Cape Town workshops, which were geared to getting the diving public involved in the implementation of the project. We're very pleased that the accommodation facilities are being so well used.

Another highlight of 2017 was the initiation of a formal assistantship programme, during which Angela Warrior from the UK-based Shark Trust joined the Shark Education Centre team for three months. She not only assisted with the general running and programming of the centre, but also put forward a proposal for an intern programme that could be run from the centre in the upcoming year. She then went on to develop this programme. It was great having Angela here with us to give a different perspective and to input some new and exciting ideas, as well

Photos by Nicholas James Good | Fresh Air Crew

as to lend an enthusiastic hand. This is what Angela had to say about her time with us:

'Today's children are so much more interested in their environment. It is important that the tools and information are available to help them understand how they can reduce the impact of their actions on the natural world. The Save Our Seas Shark Education Centre runs a fantastic programme that covers a whole range of educational activities, including school visits, holiday clubs, environmental camps and in-water experiences for children from informal settlements. The programme aims to instil a love and respect for the ocean and its inhabitants and to teach children how to take better care of their marine environment.

'This type of interactive education is important and will encourage young people to learn and understand more of the magic of the marine ecosystem. I thoroughly enjoyed my time with the team at the SOSF Shark Education Centre. A model for community-based environmental education, this programme instils a passion, provides tools, develops skills, inspires youth to actively participate in environmental protection and promotes individual understanding of the complex and intricate relationship between humans and the marine environment.

'Environmental education is a lifelong task, but with more education centres and more dedicated teams like those in the Shark Education Centre, we will create more marine ambassadors for the future.'

Although we had largely finished the renovations at the centre the previous year, there was one element that we were not quite happy with, and that was how to ensure that visiting children (and others) really engaged with every aspect of the new exhibits and signage, and that they connected the storylines that link each area of the exhibits to one another. We also wanted a way to incorporate the floor space of the centre, with all its elements, into the formal programming that we do, rather than just have it offering free time to look around. With that in mind, we approached a company called RetroEpic with a brief to develop a 'treasure hunt' app that, utilising augmented reality, would lead players around the centre with mandatory explorations of every exhibit – from the signage to the

Photo by Ntombizanele Mayiya

Photo by Nicholas James Good | Fresh Air Crew

Photo by Nicholas James Good | Fresh Air Crew

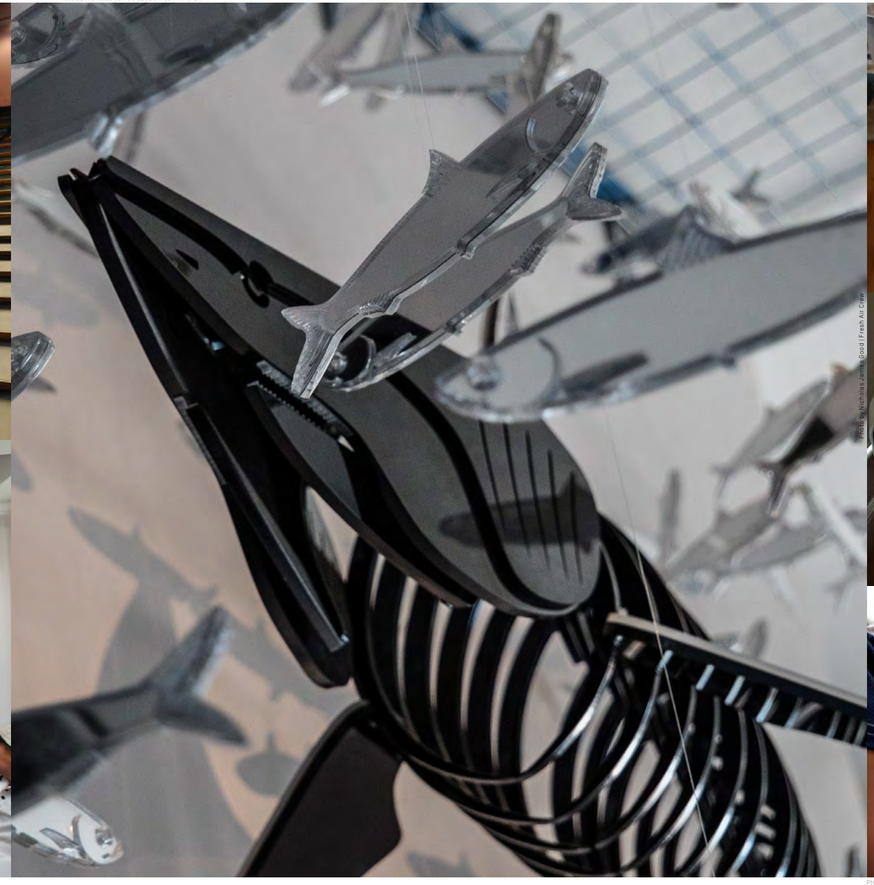


Photo by Paul Millar

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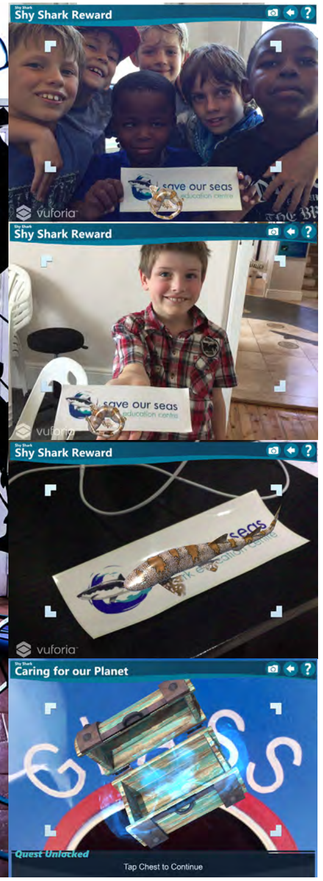


Photo by Nicholas James Good | Fresh Air Crew

detailed information within the exhibit itself – in order to earn a reward.

The development of the app took a long time and many very detailed sessions with the RetroEpic team in order to ensure that everything was perfect, from the wording of the questions to the pictures used as clues. Because of the wide range of ages and abilities that visit us here, we developed four different levels, which we call 'adventures': Shyshark (foundation phase, grades R–3), Guitar Shark (intermediate phase, grades 4–6), Great White Shark (senior phase, grades 7–9) and Whale Shark (FET phase, grades 10–12 and adults). Each adventure has an increasing level of difficulty and complexity. An adventure consists of six 'quests', which are the different areas or themes found within the centre. These are Kelp Forest, Rocky Shore, Sandy Shore, Shark Central, Sharks & People and Caring for our Planet. To unlock a quest, the user has to locate a picture with a clue prompt. This presents him or her with an augmented reality treasure chest that springs open to reveal the five or six designated tasks. After successfully completing all the quests, the user is given a Shark Education Centre bumper sticker, and this in turn unlocks an augmented reality version of that adventure's name shark, which displays a characteristic behaviour when tickled (the shyshark, for example, curls into a ball and covers its eyes with its tail).

We have finally managed to get the app functioning exactly as we want it to and have tested it on a number of our Holiday Club and teacher groups, with great success and huge enthusiasm from the testers. We have purchased five Apple iPad Air tablets for the centre, pre-loaded with the app, and have put them into extremely robust protective cases. We intend to buy a further five to 10 in the future, as the adventure really only works with a maximum of three children sharing an iPad.

The other major renovation undertaken during 2017 was the replacement of the double garage roof (the garage operates as the ship-themed large classroom). Being asbestos, it was deemed a hazard and was replaced with metal sheeting specially designed to be able to support 57 solar panels, which were installed and fixed to the new roof. These solar panels are photovoltaic and provide electricity for the centre's operations, reduce our carbon footprint, ensure that we have a

Photos by Francis Moult

steady supply of electricity and, when we generate more than we consume, enable us to feed back into the municipal electricity grid. Their performance is monitored on our SolarEdge monitoring platform and will in future be displayed in the centre as a teaching tool for sustainable living and renewable energy use.

We continued our formal education programming with school groups in 2017. This year has seen a large increase in the numbers of learners and group bookings – an encouraging trend. The number of groups has increased by roughly 30%, from about 60 in 2016 to nearly 80, and they came to visit the Shark Education Centre for a day out, explore the rock-pools, learn about sharks and discover what we can do to help conserve our oceans and marine environment. The actual number of individuals also increased, from nearly 2,000 learners in 2016 to approximately 2,700 in 2017, showing us that not only did we host more groups, but the groups themselves increased in average size. Notable for the staff has been the increase in our teaching capacity due to the inclusion of our second classroom, which has meant that we are able to double the size of the groups that we can accommodate. Formal groups hosted at the centre have ranged from Grade R through to Grade 12 and beyond to tertiary level. Talks at other venues have reached 750 people.

Our Holiday Clubs continue to be popular and in 2017 registered 156 person days. As has been the case previously, they were fully booked long in advance, with 20 children attending each day. They included such activities as shark lessons, rock-pooling, science experiments, beach hunts, coastal walks, harbour tours, arts and crafts, baking and, of course, a lot of swimming! 2017 saw the continuation of the wonderful collaboration between Shark Spotters and the Shark Education Centre that had begun the previous year, with Shark Spotters running and getting involved in several activities as part of the Holiday Clubs. Targeted direct events in which we participated reached 322 individual learners.

We also continued with our very successful Marine Explorers programme, running two six-month clubs in 2017 with Capricorn Primary School and Muizenberg Junior School, both coastal institutions within easy reach of Muizenberg beach and False Bay. We are so grateful for the wonderful

Photos by Nicholas James Good | Fresh Air Crew

collaboration of our partners in this programme, Xpression on the Beach, University of Cape Town Underwater Club and Pisces Divers, each of whom contributes significantly to its success and to the incredible experiences that the participants have. Following on from the Marine Explorers programme, we once again ran two fully sponsored Marine Awareness Camps at the Soetwater Environmental Education Centre in Kommetjie. We hosted learners from the same schools that took part in the Marine Explorers programme, but expanded the number of participants to 30 learners per camp and provided an immersive and safe three-day outdoor experience for children who might otherwise never get such an opportunity.

One highlight of the year for all staff was the first (of hopefully many!) training session that we facilitated for teachers of the Cape Town Environmental Education Trust. We ran a two-day programme for their field staff and educators, explaining about the ocean and giving them the knowledge they need to include marine elements in their existing programming, as well as ideas for activities and in-field teaching and tips for working with children near the sea and along the coast. We also played some fun team-building games that they can incorporate with their own groups. Another highlight was the 4th Southern African Sharks & Rays Symposium, held in Hermanus this year and attended by some of the staff.

Every year, the December summer holidays in Cape Town are heralded by the Wavescape Festival, a celebration of all things beach, ocean, coast, surfing and sustainability. As one of the sponsors and supporters of this festival, the Save Our Seas Foundation is committed to raising awareness of threats to our oceans and engaging with communities to create a healthy attitude towards sharks. This year, under the Wavescape Festival banner, the Save Our Seas Shark Education Centre team organised an event called 'Beach Reach' on Muizenberg beach and worked with 95 inspirational students from the social upliftment initiatives Waves for Change and 9Miles Project to introduce them to the diverse marine life found beneath the waves in False Bay. The fun and interactive activities included making sand sculptures of False Bay sea creatures, a 'feeding frenzy' plastic pollution relay race and a marine quiz game. We were joined in this initiative by Surfers' Pledge and the We Care Collective, who educated the students about plastic pollution in our oceans and how each of them can help in the war against plastic waste. The Beach Co-op also joined us, donating copies of the book *Seashore* from Creative Nature to the graduating students. It was a wonderful, windy Cape Town day and a lot of fun was had by all.

Towards the end of 2017 we ran an online survey for school teachers to find out where we could improve and what else we could include or do differently to make their experience better – and ended up receiving nothing but extremely positive feedback! Here are a few of the comments we received from teachers who brought their learners to the centre:

- It's an amazing place of learning to visit with a class of students. Well done on your excellent programme!
- We thoroughly enjoyed our visit and were blown away by your premises and lessons. We'll be back next year.
- We LOVE Save Our Seas!
- We love coming to Save Our Seas, so will probably see you again next year.
- It's really well run and the teachers and learners love it.
- Brilliant programme! Keep up the good work.
- The children enjoyed the whole programme.

There is one element of 2017 that has affected not only the Shark Education Centre and its daily operations, but the entire Western Cape of South Africa: an extreme and critical drought. This is due to very low rainfall during the region's 2015, 2016 and 2017 winter seasons and the steadily increasing demand for water from the province's rapidly growing population and economy. This, together with climate unpredictability, has placed significant additional pressure on the water supply. By the end of 2017, Cape Town was under level 6 water restrictions, whereby consumption of potable water was restricted to 87 litres per person per day (this has subsequently been reduced to 50 litres); there is a very real risk that Cape Town will run out of water before the onset of the 2018

rainy winter season. At the centre we have had to cut our water use substantially and have done so by collecting all ‘grey’ water, reducing toilet flushing (and using grey water to do this), reducing dish washing, asking visitors to take extremely short showers and to collect their shower water for toilet flushing, and catching as much rain water as possible by diverting downpipes into barrels, buckets and outside sinks. We also plan to install rain water tanks in early 2018. We are proud to say that, since September 2017, we have reduced our water use from a monthly average of 10,000 to just 4,000 litres.

In looking back on the year, I asked the rest of the Shark Education Centre’s team for their personal work highlights in 2017.

‘A highlight of the past year has been the growth in the involvement and commitment of our collaborating partners in the Marine Explorers programme, particularly Pisces Diving and the University of Cape Town’s Underwater Club. The extent to which they contribute to the quality and success of the programme cannot be overemphasised. On a personal level, it has been great to see the development of the youngsters who participate in the programme, which certainly affirms the value of all our efforts.’ – Paul Millar, education coordinator

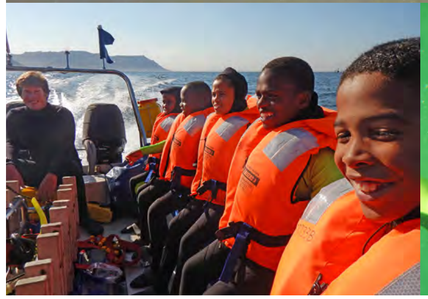
‘In 2017 a lot happened here at the centre and we have worked hard as a team. I personally gained more experience from the different activities that we’ve done, and I’ve learnt a lot of things from people like Angela Warrior while she was here. I would say my 2017 work highlight was team work.’ – Ntombizanele Mayiya, assistant educator

‘My personal work highlight of 2017 would have to be joining in on the Capricorn Primary Marine Awareness Camp in June. I would say specifically the night hike, where the children got to hike with us along a path and onto a sand dune, to look out over the sea and even see the lights of fishing boats. Being outdoors with kids who never get to do the things my family and I take for granted. Exploring the lighthouse, walking in the bush and even just getting to play on the sand on the beach – the kids really seemed to enjoy themselves. At the time I felt as though it gave me a fresh perspective on how lucky my family and I are to have access to the outdoors whenever we have free time.’ – Claire-Frances Metcalf, facilities administrator

‘I used to think that my department was the kitchen and cleaning the centre, but as time went on I discovered that we work as a team here. In 2017 I learned to help everywhere and with everything, even with school groups and Holiday Clubs, and with showing the public around the centre.’ – Nosakhele Lillian Ngotshane, housekeeper

And my own highlight? I have to say that I agree with Zanele and Lillian. 2017 was the year of team work for me. It was very rewarding to see the education team pull together into such a cohesive unit, with even Lillian, the housekeeper, and Claire, the facilities administrator, getting actively involved in all aspects of our educational work and not just sticking to their job descriptions. This has helped us become even more effective in striving towards achieving our vision. As Steve Jobs famously said, ‘Great things … are never done by one person. They’re done by a team of people.’

Photos by Nicholas James Dodd / Fresh Air Crew



Photos by Claire Metcalf

Photo by Michael Scholl

SOSF SHARK RESEARCH CENTER

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save our seas
shark research center

'A major effort was our continued research on deciphering entire genome sequences of sharks to obtain a highly detailed view of the genetic basis underlying the biological and ecological functioning of these extraordinary animals.'

The Save Our Seas Shark Research Center (SOSSRC) is located at Nova Southeastern University, Florida, and housed in the modern research facilities of the Guy Harvey Oceanographic Center. Its staff conduct research using a combination of methods obtained from the disciplines of genetics, genomics and ecology. This integrative, multi-disciplinary approach to research is based on our philosophy that a holistic understanding of shark and ray species is imperative for implementing the best conservation practices for these imperilled animals.

Given the interdisciplinary breadth of SOSSRC research, many of our projects are accomplished by combining resources and expertise from multiple sources. We work in close partnership with the Guy Harvey Research Institute on a wide variety of shark and ray studies. In addition to this key programmatic partner, we collaborate with scientists from around the world to achieve the best possible scientific outcomes.

In 2017, the SOSSRC investigated the genetics and genomics of sharks and rays to understand whether and how populations of widespread individual species are connected and the level of genetic diversity they possess, and to decipher trends in their population sizes. A key issue when trying to manage and conserve globally distributed shark species that are caught in fisheries is finding the answer to a basic question: how many genetically different populations of the 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 requirement for properly managing exploited marine species is to conserve their genetic variation. This type of variation is critical for providing the species with an ability to adapt to ongoing changes in the environment, thus providing 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 survive, find mates and reproduce, leaving offspring with their genes – the very definition of biological fitness (also known as Darwinian fitness) – and thus ensuring the survival of the species.

A major effort by the SOSSRC team and its collaborators was also our continued research on deciphering entire genome sequences of sharks to obtain a highly detailed view of the genetic basis underlying the biological and ecological functioning of these extraordinary animals.

Photo by Reinhard Dirscherl | Biosphoto

I. DECIPHERING SHARK GENOMES

The SOSSRC continued our collaboration with colleagues at Cornell University (USA) and Saint Petersburg University (Russia) and expanded our collaboration with the Monterey Bay Aquarium, California. The overall aims of this massive project are to understand how sharks function at their most fundamental level – their entire genomes and expressed genes – and to use that knowledge to enhance awareness of the biology and ecological importance of sharks.

Our goal is to obtain a high-quality DNA sequence characterisation of the whole genome (a genetic blueprint) of the white shark, one of the world's most charismatic animals and a species that is probably one of the most publically recognised in the world. Our progress on this project made large strides in 2017 in that we refined and completed the assembly and annotation of the white shark's genome and subsequently embarked on a deep-level analysis of individual genes of interest.

The results thus far are painting a very interesting biological picture of the white shark. To gain the most detailed evolutionary insight, our analyses are comparatively centred, both within the chondrichthyans – taking advantage of the availability of an elephant shark genome and the recently available draft whale shark genome – and across vertebrates more broadly.

The white shark genome represents the largest vertebrate genome yet sequenced, which made the assembly and bioinformatics analyses very challenging. After using cutting-edge computational approaches to achieve substantial bioinformatics analyses, we obtained a high-quality genome assembly. The final gene discovery (genome annotation) analysis resulted in finding about 25,000 predicted genes in the white shark, which is in line with the total number of genes found in other model vertebrate species (mouse, human, chicken, zebrafish) whose genomes have been sequenced. The question then is, what explains the much larger size of the white shark genome? It turns out that the answer lies in the amount of repeat DNA in the white shark genome, which is quite large relative to that of other species. The functional reason for this extra repeated DNA is currently unknown, but under active investigation.

A focus of 2017 research was a detailed investigation of specific white shark genes of potential biomedical interest. A key finding from our analysis of white shark genes is that more than 100 of them are under positive selection. Positive selection is the fixation of advantageous mutations driven by natural selection and is a fundamental process behind adaptive changes in genes and genomes, leading to evolutionary innovations and species differences. This high number of genes indicates that the white shark is a highly adapted lineage with a long history of evolutionary selection pressure.

A finding of particular note is the evidence for positive selection on fibrinogen genes (the fibrinogen protein plays a key role in blood clotting and wound healing in animals). Since rapid wound healing is a commonly observed phenomenon in sharks, its basis is of strong interest for understanding shark biology and also for potential downstream applications in human medicine. That key genes involved in wound healing are found to be positively selected in the white shark provides a unique discovery that may explain the rapid wound healing attributes in these animals. We are continuing to investigate the specific biological roles of the remaining genes under positive selection, including genes involved in shark smell, vision, cell division and DNA repair.

In addition to completing the assembly and annotation of the white shark genome, we began sequencing the genome of the endangered great hammerhead shark. For this genome, initially we used an approach similar to that for the white shark, with our shotgun Illumina short-read sequencing yielding about 80 times coverage for the estimated hammerhead genome of about 3.8 billion base pairs of DNA. We then added sequences obtained by a longer-read DNA sequencing technology known as PacBio to further close sequence gaps within and between the hammerhead large DNA sequence sections (scaffolds). This new assembly analysis is ongoing to obtain a high-quality genome characterisation for the great hammerhead shark.

The completed genome sequences of the great hammerhead and white sharks will subsequently be compared to look for genes that underlie the unique properties of each of these remarkable species.

II. GENETIC POPULATION STRUCTURE OF THE ANGELSHARK IN THE CANARY ISLANDS CRISTÍN KEELIN FITZPATRICK, MSC STUDENT

During 2017 Cristín Fitzpatrick completed the bulk of her Master's thesis work investigating the genetic population structure and diversity of the angelshark *Squatina squatina*. Listed as Critically Endangered on the International Union for the Conservation of Nature (IUCN) Red List, the angelshark has been extirpated from an estimated 80% of its historical range due to massive overfishing. Although low numbers of angelsharks may continue to inhabit parts of this historical range, the only place where the species is now found with any regularity is the Canary Islands, a last stronghold. Despite its precarious conservation status and long history as an important fishery target, to date almost nothing is known about the population dynamics of the angelshark. To increase basic knowledge and understanding of this species, a thorough genetic assessment of the diversity, connectivity and population demographic status of the angelshark within the Canary Islands was performed.

To investigate the population genetics of the angelshark, Cristín sequenced DNA, including a set of mitochondrial and nuclear regions from up to 300 individuals from the Canary Islands. She also sequenced the complete mitochondrial genomes of nine additional sharks to assess the genetic diversity of this species at a genomic scale. Surprisingly, very little genetic diversity was found, with almost all individuals possessing the same haplotype, or DNA sequence, across nearly all surveyed markers. Nevertheless, some evidence of population structure between the Canary Islands was uncovered, with individuals from the island of Lanzarote genetically differentiated from the sharks inhabiting the islands of Gran Canaria and Tenerife.

In addition, when DNA sequences of Canary Island individuals were compared to those of angelshark individuals collected from outside the Canary Islands (such as St George's Channel, Ireland, and the Mediterranean Sea), no haplotype sharing was found, indicating that the Canary Islands sharks are a genetically unique and probably a highly isolated population. These findings are important for advising effectively on conservation and management decisions and for providing a baseline for the genetic monitoring of the Canary Islands

Photo by Michael Scholl

angelshark population in the future. Through this work we also hope to guide the way to a more hopeful outlook for this Critically Endangered species.

Cristín presented this work at the American Elasmobranch Society meeting in Austin, Texas, in July 2017 and is working towards a journal publication in 2018.

III. GREAT HAMMERHEAD GLOBAL POPULATION GENOMICS

CASSANDRA RUCK, PHD STUDENT

During the past year, PhD student Cassandra Ruck made great strides in her work uncovering the global population dynamics of the great hammerhead shark *Sphyrna mokarran*, an IUCN Red List globally Endangered species. Management and conservation efforts for this species are made particularly difficult because estimates of species-specific declines are difficult to obtain, as fisheries logs often report landings of the three large hammerhead species as a single pooled category, *Sphyrna* (which also includes the smooth hammerhead *S. zygaena* and the scalloped hammerhead *S. lewini*). Furthermore, the great hammerhead experiences high rates of post-release mortality. Thus, there are few tracking datasets available to reveal the movements and migratory propensity of this species. To date, only one population genetic study has been conducted and that was by a former SOSSRC PhD student, Christine Bruels.

Christine's dissertation employed conventional genetic markers, including a small sequence section of the mitochondrial DNA and several nuclear microsatellite markers, to investigate the global population dynamics of this species. Her work revealed that great hammerhead sharks inhabiting separate ocean basins form genetically unique populations. However, as is often the case in science, this first analysis left the door open for more questions to be asked. Is there, for example, a fine-scale population structure in this species within ocean basins? And can we estimate how long ago these ocean basin-specific hammerhead populations diverged from one another?

To complement and extend our previous work to resolve population dynamics of the endangered hammerhead over a much more refined spatial scale,

Photo by Michael Scholl

Cassandra added more newly acquired samples and employed next generation sequencing methods, including single nucleotide polymorphism (SNP) markers and *whole* mitochondrial genome DNA sequences. To date she has generated a large dataset consisting of whole mitochondrial genomes sequenced from 183 individual sharks and 2,330 nuclear SNP loci genotyped in 163 individual sharks from around the world. Through these new, high-resolution nuclear and mitochondrial data analyses, Cassandra has identified a minimum of three global, highly differentiated genetic meta-populations, which are further divided into smaller subpopulations that are by and large genetically discrete. Both the whole mitochondrial genomes and the nuclear SNP data have demonstrated greater power (i.e. resolution) than previously used conventional markers to uncover high-resolution population dynamics of this species. These data ultimately reveal a high degree of population genetic structure in this large-bodied, coastal-pelagic species. As a fundamental aspect of species management, these population structure results will help inform policymakers to enact best-practice strategies to conserve individual populations of this endangered species.

Cassandra reported her preliminary findings at the American Elasmobranch Society meeting in Austin, Texas, in July 2017. She is currently finishing final analyses and moving on to writing a manuscript on her findings.

Photo by D. Roberts, LDO, Science Photo Library, Researchers

IV. REGIONAL MOVEMENT PATTERNS OF THE SHORTFIN MAKO

DR JEREMY VAUDO, RESEARCH SCIENTIST

The shortfin mako shark *Isurus oxyrinchus* is a long-lived, highly mobile, upper trophic-level predator in tropical and temperate seas whose habitat overlaps with that of commercially targeted tunas and swordfish. As a result, mako sharks are taken as by-catch in these fisheries and often retained to be sold because of their high-value meat. Ultimately, this has led to population declines and their listing as Vulnerable on the IUCN Red List. To manage this species adequately, its populations need to be monitored.

Since 2013, in collaboration with Nova Southeastern University's Guy Harvey Research Institute, we have tagged and been tracking 72 shortfin mako sharks in the western North Atlantic Ocean using satellite telemetry, including 14 new sharks that were tagged in 2017. Satellite-linked radio tags attached to the sharks' dorsal fins contact satellites overhead and provide an estimate of a shark's location whenever the fin breaks the surface, enabling us to track mako sharks for periods of up to 754 days.

In 2017, we published the first results of this long-term study. We found that mako shark movements were highly dependent on where a shark was caught. Sharks tagged off the tip of the Yucatán Peninsula, Mexico, near the boundary of the Gulf of Mexico and Caribbean Sea, showed relatively restricted movements. Although some sharks moved into the western Gulf and northern Caribbean, the core activity was centred over the eastern edge of the Campeche Bank in the Gulf of Mexico, year-round. Mako sharks tagged in the Mid-Atlantic Bight, USA, on the other hand were wide ranging. These sharks covered an area from as far north as Newfoundland, Canada, to Venezuela in the south. They also displayed seasonal movements, with a core distribution that centred off South Carolina, USA, in the winter and moved north over the course of the year, tracking warmer waters up to Nova Scotia, Canada, in the autumn.

Amazingly, the mako tracks crossed through the waters of 19 countries! Of particular note was that 30% of our tagged mako sharks were harvested by fishers from five countries: Canada, Cuba, Mexico, Spain and the USA. We were able to identify harvested sharks because their satellite tags began reporting from shore. Because of these captures, we had come across a fisheries-independent method of assessing fisheries mortality. Fisheries mortality has traditionally been calculated using data, such as catch rate, provided by fishers, but these data can be unreliable if catch reports are misrepresented. Using our fisheries-independent data, we calculated a fisheries mortality rate 10 times that of previously reported values, which suggested that mako sharks in the North Atlantic are overfished. Our assessment of Atlantic mako shark overfishing has recently been corroborated by the International Commission for the Conservation of Atlantic Tunas, which uses traditional methods of stock assessment.

Overall this project highlights the need for international cooperation for the successful management of pelagic fishes, such as mako sharks, and that policies may need to be tailored to specific regions based on regional movement patterns.

V. GENETIC CONNECTIVITY DYNAMICS OF CARIBBEAN REEF SHARKS

DR ANDREA BERNARD, RESEARCH SCIENTIST

In 2017 we completed the first of two planned studies aimed at resolving the population genetic dynamics of the Caribbean reef shark *Carcharhinus perezi*, an ecologically and economically important warm temperate-tropical coral reef mesopredator. Although in the past the species was highly valued by artisanal and commercial fishers for its meat and fins, more recently its primary economic value has been to the scuba-diving ecotourism industry, which generates millions of dollars annually for local Caribbean communities.

The Caribbean reef shark is a large-bodied benthic species that, according to tagging data, exhibits high site-fidelity and residency to distinct coral reef habitats. This suggests there is little genetic connectivity across its western Atlantic Ocean and Caribbean distribution. For our work, we aimed to use genetic data (DNA genotyping and sequencing) to define the population genetic structure of this species – that is, to resolve how many genetically distinct populations occur and to what extent these populations are connected by gene flow. Similarly, we used some of these same genetic markers to assess the phylogeographic history and levels of genetic diversity of this species, in the hope of understanding its recent evolutionary and biogeographic history.

Photo by Mathieu Foulquié | Biosphoto

Our work showed much higher levels of genetic connectivity than originally hypothesised, which suggests that Caribbean reef sharks are capable of dispersal across much larger geographic distances than previously recorded (hundreds of kilometres). The low levels of genetic diversity and indications of historical demographic flux we also found across populations indicate that a population contraction (decrease in population size) occurred in the past and was followed by a more recent expansion (increase in population size). Combined, these data suggest that the connectivity dynamics of the Caribbean reef shark are highly complex and that population genetic structure may be dependent on an array of factors, including habitat complexity and availability.

To complement this work we have begun a second study, in collaboration with the University of Miami, to use next generation sequencing in association with a high-throughput genotyping protocol called Genotyping by Sequencing (GBS), a Restriction site Associated DNA (RAD) Sequencing technique, to survey the genetic variation distributed across the entire Caribbean reef shark nuclear genome. The power of GBS is that it is able to identify thousands of variable nucleotide markers in a single individual, and can specifically target and survey the same markers in all other individuals tested to assess population genetic relationships.

This genomics approach will allow for a more refined, high-resolution spatial assessment of the genetic population structure of the Caribbean reef shark than our previous efforts using conventional genetic markers. Preliminary results show high levels of genetic population structure and the presence of multiple distinct breeding units that were previously undetected.

VI. THE GENETIC ISOLATION OF NORTH-EAST PACIFIC WHITE SHARKS

DR ANDREA BERNARD, RESEARCH SCIENTIST

Despite all the tracking work done on white sharks, examination of the genetic dynamics of this species on a global scale is limited. We have been working to understand the nuclear trans-Pacific genetic connectivity of white sharks *Carcharodon carcharias* with the aim of further resolving the population genetic dynamics of this large predator. Within North-east Pacific (NEP) waters, telemetry-derived movement patterns of white sharks have shown that adult and sub-adult individuals carry out regular, long-distance seasonal migrations. They move from their North American coastal aggregation sites in California, USA, and the Guadalupe Islands, Mexico, in the winter months to offshore pelagic waters where they remain until the following summer and their return to near-shore waters.

Previous work has shown that these NEP white sharks demonstrate strong matrilineal genetic differentiation from white sharks captured at other Pacific aggregation sites. As sex-specific differences in movement patterns have been noted across white shark aggregation sites, female philopatric behaviour may be the underlying mechanism that drives the high levels of matrilineal population structure observed. We at the SOSSRC worked to isolate and develop a large suite of nuclear markers from white shark transcriptome sequences, providing the first male- and female-driven gene flow perspective of the connectivity dynamics of NEP white sharks.

We have genotyped white sharks from the waters of the NEP and eastern Australia, at 40 bi-parentally inherited, nuclear microsatellite DNA markers. As three-quarters of our genetic markers were derived from our previously published transcriptome sequences, the microsatellites developed herein were isolated from both non-coding and coding (such as protein coding) regions of the genome, providing a multi-level (neutral vs. adaptive) view of the trans-Pacific connectivity of white sharks. Using these markers, we have found strong trans-Pacific genetic differentiation between white sharks inhabiting the NEP and Australia, which suggests there is little ongoing genetic mixing between these distant habitats and that male and female white sharks inhabiting the NEP are genetically isolated.

VII. A CLOSER LOOK AT THE GLOBAL POPULATION GENETICS OF TIGER SHARKS KIMBERLEY FINNEGAN

As molecular genetic tools and high-throughput sequencing capabilities continue to advance, marine scientists have more opportunities to assess the global patterns of female and male genetic connectivity of sharks at increasingly fine spatial scales. Genomic approaches, including reduced representation genome sequencing (RRGS), have allowed for the development of thousands of high-resolution DNA markers (single nucleotide polymorphism [SNPs]) for non-model taxa, including sharks and rays.

Utilising these advances in genetic technologies, we are expanding our previous research using conventional genetic markers, which explored the genetic dynamics of the global population of the highly migratory tiger shark. To test nuclear DNA for previously undetected fine-scale spatial population genetic partitioning, we developed 2,929 tiger shark specific SNPs and found subtle but significant genetic differences between tiger shark populations within ocean basins. These findings support our previous research, which suggested that long-distance migrations by tiger sharks play a key role in the unique genetic diversity patterns of this species.

Furthermore, with the support of SOSF international collaborators, we obtained an additional 64 tiger shark fin clips from previously unsampled geographic areas, which we DNA sequenced to complement our earlier mitochondrial DNA analysis research. The addition of DNA sequences from these four geographically distinct locations (Bermuda, Venezuela, the Cayman Islands and the Red Sea) greatly enhanced our current dataset, allowing for a more holistic view of female population connectivity. Mitochondrial sequencing was completed for a total of 404 globally distributed samples, resulting in 25 haplotypes, with only three genetic haplotypes (DNA sequences) being shared between the Indo-Pacific and western Atlantic Ocean basins. Mitochondrial DNA analyses indicated strong inter-basin genetic differentiation (Indo-Pacific vs. western Atlantic Ocean) with the potential for numerous isolated matrilineal genetic populations of tiger sharks within ocean basins.

The genome SNP marker work will be completed in 2018 and, together with our previous work, will provide a highly detailed, unprecedented view of the population genetic dynamics of the magnificent tiger shark.

VIII. SCIENTIFIC JOURNAL OUTPUT IN 2017

* Undergraduate student author
** Graduate student author
*** Post-doc author

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Photo by Michael Scholl

OUR PARTNERS

REPORTS FROM THE SAVE OUR SEAS FOUNDATION
PARTNERS AROUND THE WORLD

Photo by Richard Trachet | Biosphoto

SHARK SPOTTERS

ALISON KOCK & SARAH WARIES

Photo by Alison Kock

Sarah Waries

Alison Kock

Sikweyiya Monwabisi

SHARK SAFETY

Shark Spotters continued to provide a sustainable shark safety service to the water-users of Cape Town in 2017 by proactively reducing the spatial overlap between people and sharks in our area. This was achieved by assigning trained shark spotters to eight strategically chosen high-risk beaches and deploying our innovative shark exclusion barrier in Fish Hoek bay.

In 2017 we recorded 63 shark sightings at the beaches where we operate, bringing the total number of sightings recorded to 2,143 since the inception of the programme in 2014. For the second year in succession, the level of shark activity was very low compared to the annual average of 170 sightings per year. The exact reasons for this are unknown, but a number of factors could be at play, including large-scale fluctuations in environmental conditions, changes in prey availability and the presence of orcas *Orcinus orca*, which are known to have preyed on white sharks in Gansbaai, only 170 kilometres (105 miles) from Cape Town, on a number of occasions in 2017. Annual fluctuations in levels of shark activity are common and this is why the long-term monitoring conducted by Shark Spotters is so valuable, enabling us to increase our understanding of white sharks in False Bay for the purpose of not only managing shark bite risk, but also protecting this threatened species.

Although this was one of the quietest years in the programme's history in terms of shark activity, the beaches were still as busy as ever, with hundreds of thousands of local and international visitors using them throughout the year. Of the 63 shark sightings, 54% resulted in temporary beach closures while the shark was in close proximity to water-users. In this way, the spatial overlap between water-users and sharks was reduced, the risk of a negative shark encounter was lowered and beach safety for the many people visiting our coastline was improved.

The Fish Hoek shark exclusion barrier was deployed on 136 occasions over the spring and summer months and once again proved to be an effective, affordable and environmentally responsible shark safety solution. This unique shark exclusion net continues to be deployed and retrieved each day to reduce the risk of environmental impacts and potential damage caused by unfavourable weather and sea conditions. No entanglements were recorded in the net during the course of the year and thousands of bathers swam inside it on a daily basis.

This year we incorporated the use of drones in our spotting programme in order to enhance the safety service we provide. Because of their limited battery life, small field of view and inability to withstand strong winds, the drones were not used to detect sharks. Instead they were launched once a shark had been sighted by the spotter on the mountain in order to confirm which species it was and monitor its behaviour so that any risk it posed could be assessed more accurately. This turned out to be especially useful in 2017 as a number of sightings were of bronze whaler sharks *Carcharhinus brachyurus*, which pose a different level of threat to water-users and from the spotter's vantage point are difficult to distinguish from white sharks. The drones have also become a unique educational tool, enabling us to share a perspective of marine life in our bay that is rarely seen by the public.

In order to comply with the legal requirements of operating drones as part of our safety service, two of our spotters became licensed commercial drone operators by getting Remote Pilot Licences. This was a fantastic skills development opportunity for the two, who have been with the programme for more than eight years. They are now in a position to pass on their knowledge and help train their colleagues to operate the drones as well. A total of 40 people are now employed by the programme – 24 year-round and 16 seasonally – and they are trained in first aid, emergency situation management and basic marine biology. In addition, the team got a fantastic opportunity to join a behind-the-scenes tour of the Two Oceans Aquarium, where they learned more about our oceans and the threats they face.

Our mobile app, launched in 2016, has become a must-have for beach-goers in Cape Town and reached 10,000 downloads by the end of 2017. Inspired by requests from the community, this unique app provides water-users with current and accurate shark safety information in the palm of their hands so that they can make informed decisions on shark risk even before they arrive at the beach. The spotters update the app in real time with the flag status, spotting conditions, marine activity and a surf video.

'The Shark Spotters programme reduces the spatial overlap between people and sharks (...) at beaches where it operates, thereby significantly reducing the risk of shark attack.'

Shark Spotters continues to work with the South African and other governments, sharing our knowledge and experience to encourage a collaborative approach to sustainable shark bite mitigation around the world. In 2017, CEO Sarah Waries was invited to become an advisory member of the Réunion Shark Risk Management Group, an international panel of experts that assesses new shark bite mitigation technologies for trial at Réunion Island. In September Shark Spotters hosted government officials from Réunion to view our operations and provided advice and assistance with regard to shark bite mitigation. The visiting officials were particularly interested in our unique, award-winning design of an environmentally responsible shark exclusion barrier, as it overcomes a number of issues they had been encountering with their own shark exclusion enclosures.

A new study published in November 2017 by PhD student Tamlyn Engelbrecht highlights the effectiveness of shark spotting as a sustainable shark bite mitigation measure. It shows that the Shark Spotters programme reduces the spatial overlap between people and sharks through auditory (siren) and visual (flag) warnings at beaches where it operates, thereby significantly reducing the risk of shark attack. The study also emphasises the importance of the programme in protecting local business and beach tourism, as it was found that a fatal shark attack results in significantly fewer water-users at a beach for three months following the incident. This shows the value of the programme in creating safer spaces for communities and businesses to thrive in the beach environment.

We are constantly striving to improve the safety service we provide to the public and have begun investigating the possibility of using automated shark detection software to enhance our spotting ability. In October 2017 we were awarded a grant from Eurostars, an international technology funding agency, to pursue the development of the software further. In partnership with the Zurich Institute for Applied Sciences in Switzerland and the Institute for Communities and Wildlife at the University of Cape Town, we have begun a research project that assesses the effectiveness of the automated shark spotting system and quantifies the spotting ability of trained observers (spotters) in order to make a comparison between the two.

Photo by Sarah Waries

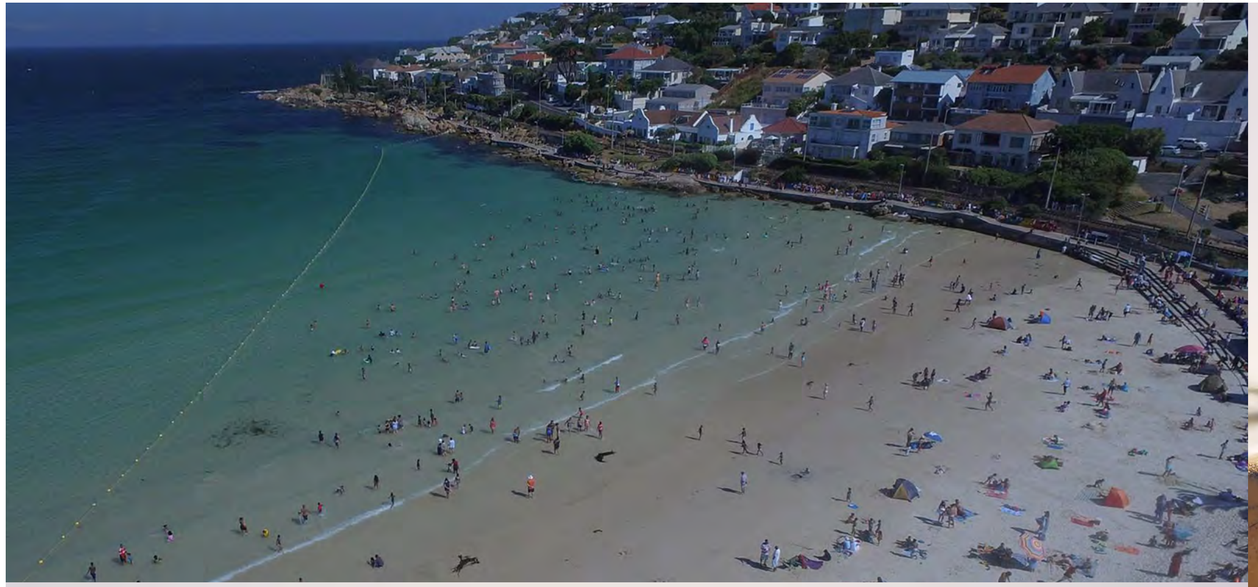


Photo by Lars Jockumsen

Photo by Lars Jockumsen

Photos by Lars Jockumsen

Photo by Alison Kock

Photo by Lars Jockumsen

Photo by Sarah Waries

RESEARCH AND CONSERVATION

Shark Spotters provides support to a number of students in order to help us meet our scientific objectives as well as build marine research capacity in South Africa. In June 2017 two of our students, Leigh de Necker and Kristina Loosen, graduated from the University of Cape Town with MSc degrees, with Leigh achieving a distinction. PhD student Tamlyn Engelbrecht continues her study on the spatial ecology of sevengill sharks in South Africa, aiming to finish in 2019.

Our applied research programme continued to investigate the behavioural ecology of the white shark *Carcharodon carcharias* around Cape Town in an attempt to better understand its impact on the structure and function of the ecosystem in False Bay. We conducted 19 white shark photo-ID and tagging trips to Seal Island and the section inshore of it, even though shark activity in both areas was extremely low. We maintained the network of our own 24 acoustic receivers around Cape Town as well as the ATAP array in False Bay.

In 2017 we gave eight scientific presentations at four symposia: the Southern African Shark & Ray Symposium, the Southern African Marine Science Symposium, the Biologging Symposium in Germany and the Gills Club Symposium in the USA. We also published three peer-reviewed papers in scientific journals, ensuring that we share the findings of our research at an international level in order to expand global knowledge of white shark conservation issues and sustainable shark safety practices.

Shark Spotters continues to foster co-existence between people and sharks, not just from the perspective of recreational water-user safety, but also in relation to other ocean uses, including consumptive and commercial. This year our research team participated in a workshop led by the Nelson Mandela Metropolitan University on tracking top predators for use in marine spatial planning initiatives such as Operation Phakisa and Ecologically or Biologically Significant Marine Areas (EBSAs). The delegates from Shark Spotters provided input on shark movements along the South African coastline.

We were sad to see our research manager Dr Alison Kock move on to a new position at South African National Parks in the middle of the year, but are pleased to report that she continues to be involved in the programme and now plays an oversight role at Shark Spotters on our executive committee. The recruitment process for a new research manager has begun and will be completed in early 2018.

EDUCATION AND AWARENESS

There have been a number of exciting developments with regard to our communication activities over the past 12 months and they have resulted in a significant increase in the impact we are making through our education and awareness campaigns.

Encouraged by the huge success of the mobile app we launched in September 2016, we decided to give our *sharkspotters.org.za* website a complete overhaul and re-design. The new and improved website went live in May 2017 and provides comprehensive information about the programme's safety, research and education activities, as well as general shark safety and conservation issues. People from all over the world now have easy access to the information, which is presented in a clear and straightforward format in order to maximise the reach of the programme.

Furthermore, our education programme expanded considerably in 2017 thanks to our new education coordinator, Nicole Locket. We have now developed a number of interactive lessons and activities for groups of all ages and have been actively seeking audiences to share our important message of sustainable shark bite mitigation and shark conservation. We directly addressed more than 2,000 people through our education interventions, which included public presentations, interactive activity programmes and an 'amazing race' event for underprivileged children. Many of these activities have taken place in partnership with the Save Our Seas Foundation Shark Education Centre in Kalk Bay. We also educated many thousands more people who passed through our information centre on Muizenberg beach, spoke to spotters at their beach locations across False Bay or attended outreach events that we participated in.

Photo by Sarah Waries

Photo by Sarah Waries

Photo by Nicholas James Good (Fresh Air Crew

Our social media presence remains strong, with more than 24,000 Twitter followers, 15,000 followers on Facebook and nearly 2,000 Instagram followers. The drone footage we share using the #EyeInTheSky tag provokes great interest and interaction from our supporters, while our ongoing #BeSharkSmart campaign on social media and on the beaches continues to make people more aware about shark safety issues when using the ocean.

In 2017 we featured in 49 news articles and participated in 20 radio interviews as well as numerous documentary interviews, and the significant attention we attract from all forms of media enables us to share our message even further. Our fact-based and non-sensational communication campaign has resulted in Shark Spotters being recognised by the community and the media as an objective source of information on shark safety and conservation issues.

CETACEA LAB
THE NORTH COAST CETACEAN SOCIETY

JANIE WRAY & HERMANN MEUTER

'In 2017 we identified 33 new arrivals in our research area, many of which were young juveniles.'

Janie Wray

Hermann Meuter

The North Coast Cetacean Society (NCCS) has been operating land-based whale research stations in the Great Bear Region of northern British Columbia, Canada, since 2001. The three stations are connected to two underwater hydrophone networks to monitor all acoustic whale activity. This monitoring, in conjunction with dedicated marine vessel surveys, is undertaken to obtain an accurate assessment of how often whales occur in the region, their seasonal use of habitat, the prey they select and their social behaviour.

This summary gives an account of the methods, effort and results of our study on humpback and fin whales and two orca populations and describes what we have learnt about common foraging areas and seasonal movements during the 2017 season.

MONITORING

Cetaceans are observed from three shore-based platforms and during the course of marine, or boat-based, surveys. Their movements are also monitored by means of hydrophone networks.

SHORE-BASED MONITORING

Shore-based observations of the cetaceans listed took place from three locations: Cetacea Lab, Wall Islets Out-camp and Fin Island Research Station.

CETACEA LAB

With the permission of the Gitga'at First Nation, Cetacea Lab was built in 2002 in Taylor Bight on Gil Island. It lies in the heart of whale territory and provides a 180-degree view of the pristine ocean. Both humpback and fin whales pass just metres from the rocky shoreline. Every year a group of interns from around the world join us at Cetacea Lab to help us carry out our research. From dawn until dusk, come rain or shine, someone is on deck on the lookout for whales.

Whales were documented by our trained land-based observers who conducted scheduled scans of the entire viewable area from Cetacea Lab from May until the end of September 2017. Four to six observers rotated in two-hour shifts to maintain a constant watch throughout daylight hours. They used a combination of naked eye, Nikon 8x40 and 7x50 hand-held binoculars and a tripod-mounted 20–60x80 Vortex Skyline ED spotting scope to search for marine mammals, generally beginning at 7 am and ending at 7 pm each day, depending on the length of daylight. When they caught sight of whales, the observers determined their direction of travel and their behaviour. Whenever possible, they also took photographs of whales that passed close enough to Cetacea Lab, focusing on the dorsal fin and dorsal saddle in the case of orcas, the dorsal fin of fin whales and the dorsal fin and fluke of humpback whales. The photos were then compared to previously compiled photo-identification catalogues to identify individuals based on the presence of distinctive natural markings.

WALL ISLETS OUT-CAMP

From May until early September 2017, lead researchers Janie Wray and Hermann Meuter, with the assistance of interns, documented whales from a remote shore-based camp on the Wall Islets, just off Rennison Island. They kept lookout from a platform nine metres (29 feet) above tide level, which offers an unobstructed viewing arc of more than 180 degrees looking north into Caamano Sound and, if conditions are perfect, enables them to see whales approximately seven nautical miles away. Using Pentax 8x40 hand-held binoculars in combination with 25x100 OberwerkTM tripod-mounted binoculars, the observers conducted a 15-minute rigorous scan every 30 minutes between about 6.30 am and 9 pm, and continued more casually until 11 pm. When whales were sighted, they would stop scanning and focus on tracking and watching the cetaceans, using the same methods as at Cetacea Lab. When possible, individuals within a group of whales would be identified from memory by an experienced observer.

For parts of the 2017 season, boat-based photo identification of whales was possible thanks to the efforts of the Gitga'at First Nation Coastal Guardian Watchmen stationed on Rennison Island. The methods used are described under 'Marine surveys'.

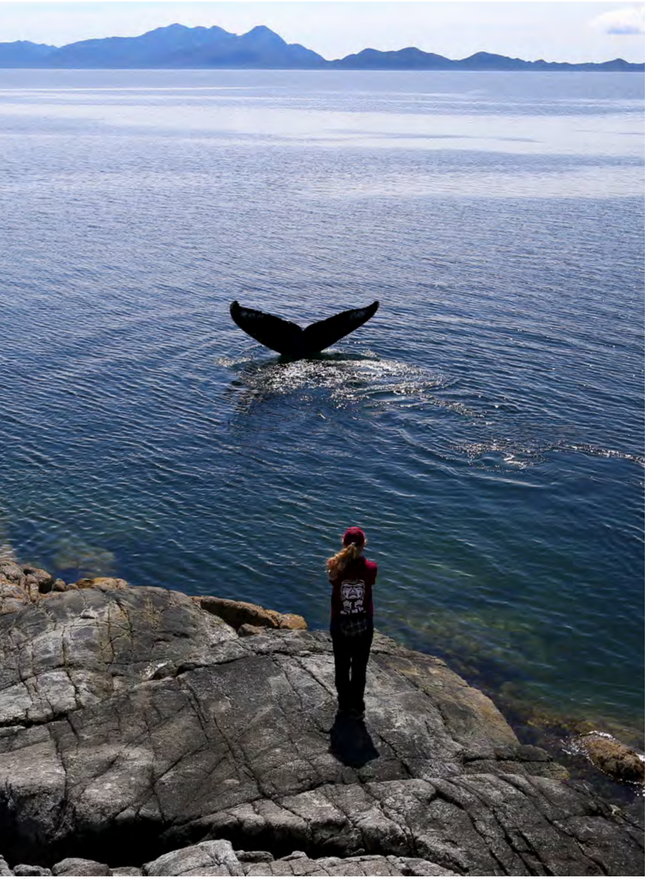


Photo by Janie Wray

FIN ISLAND RESEARCH STATION

In June 2017 a new research station was built on Fin Island, to the north-west of Gil Island. The station is located in line of sight of four hydrophones so that acoustic signals can be triangulated. It has been proposed that a shipping route for a number of liquid natural gas projects will pass through this region. The data collected from Fin Island during the 2017 season will provide information for an analysis of ship strikes on whales and will test a new land-based method to determine the GPS locations of all whales and marine vessels within the research area. The success of this project will enable the NCCS to ascertain the impact of marine vessel traffic on the acoustic and physical behaviour of whales. This topic is of great concern worldwide and the NCCS is proud to be part of a network of researchers who are working together to protect the marine environment for all cetacean species.

The Fin Island Research Station was open for 85 days in 2017, from 8 July until 27 September. A total of 2,070 hours of observation data was collected, comprising 811 systematic scans for marine mammals and marine vessel traffic and 504 scans for seabirds. During the scans, observers recorded the location and details of 1,251 small vessels and 3,633 sightings of marine mammals.

MARINE SURVEYS

Boat-based monitoring took place during daylight hours in the form of dedicated weekly surveys, as well as opportunistically if whales were detected acoustically or visually, or were reported by a third party. The vessels used in these surveys were a 20-foot aluminium-welded, centre-console boat or a 26-foot aluminium cabin cruiser.

When conducting surveys, researchers travelled in good weather and sea conditions along one of several predetermined routes of the study area, including the waters of Campania Sound, around Gil Island, in the southern part of Estevan Sound and the waters around Gribbell Island. During the survey, they periodically stopped and turned off the engine for about 15 minutes while they scanned for whales using the naked eye and Nikon 8x40 hand-held binoculars. They would also deploy a portable hydrophone to listen for whales.

The observers recorded the time and location of a whale encounter and took identification photographs if possible. To do this, the vessel operator would position the boat approximately 100 metres (325 feet) away from a whale and travel parallel to it in the same direction while another researcher would take identification photos. When possible, lead researcher Janie Wray would identify individual whales from memory. Afterwards, whales were identified by comparing their photograph with previously compiled photo-identification catalogues. In addition to collecting photo data, researchers took notes on the whales' behaviour and direction of travel and on vessel traffic around them. Scat and prey samples were collected if possible.

In 2017, in collaboration with the Department of Fisheries and Oceans, the NCCS participated in a project to detect entanglement scars from each sighting of different whale species. This was done by taking photographs during each encounter from both sides of the whale while it was at the surface. The NCCS will continue this project in the 2018 season.

HYDROPHONE NETWORKS

The NCCS maintains two strategically placed networks of hydrophones in the study area, in Caamano Sound and in Whale and Squally channels, in order to provide maximum coverage for the monitoring of cetacean vocalisations. These networks enable researchers to monitor continuously for whale activity in any environmental conditions, day or night. The depth of each hydrophone varies, ranging between 15 metres (50 feet) and 30 metres (100 feet) below the surface. The live signals from each hydrophone are continuously sent via radio transmitter to Cetacea Lab and the Fin Island station, where they are received and simultaneously recorded 24/7. From these recordings we are able to monitor the movement patterns of different orca and humpback whale populations.

From early on we have understood that if you want to study whales, you need the resources that will enable you to listen in on their world. For this reason, in 2017 we began the next phase of our research with a new hydrophone project in collaboration with the Gitga'at First Nation and WWF-Canada. The NCCS

Photo by Michael Scholl

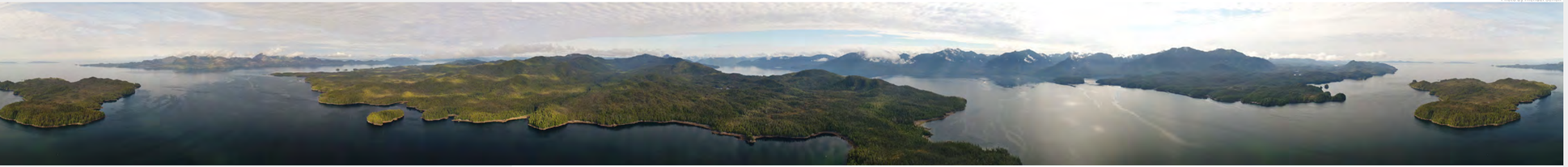
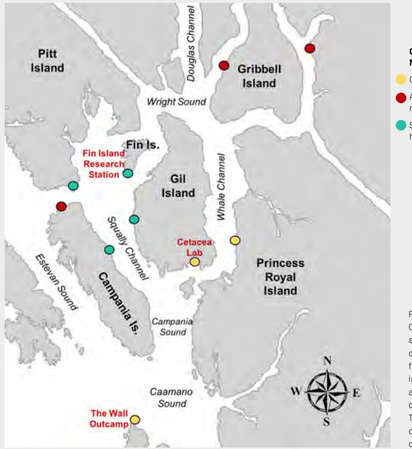


Photo by Michael Scholl



Cetacea Lab Hydrophone Network

- Cetacean monitoring
- Ambient noise & cetacean monitoring
- Squally Channel hydrophone array

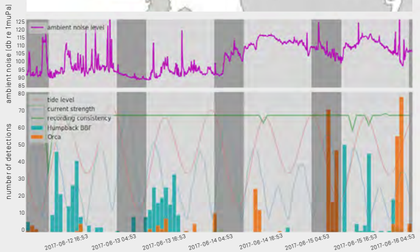


Figure 1. Results from the Squally Channel hydrophone project. Over a period of four days in June 2017, orca (orange) and humpback (blue) feeding call detections are shown in the lower panel, together with the ambient noise level recorded on one of the hydrophones (upper panel). Tidal levels (orange line), tidal currents (blue line) and the recording consistency (green line) are also shown. For visual purposes, they are not drawn to scale. Day and night are indicated as darker and lighter shaded areas in both panels. The rise in ambient noise level on days 3 and 4 of the recording sequence is caused by heavy rainfall during this period. The spikes in ambient noise indicate ships in the area. The preference of humpback whales to bubble net feed during daylight hours is visible. All orca vocalisation events with more than 10 call detections are from the same pod of northern resident orcas, which were present in the area during the time of recording.

installed a state-of-the-art long-baseline hydrophone array in the coastal waters of Squally Channel, west of Gil Island. This array consists of four hydrophones that provide a wide bandwidth of 10 hertz up to 100 kilohertz. Each hydrophone is equipped with a GPS clock that ensures microsecond time accuracy between each station. It acoustically monitors a terrain of about 200 square kilometres (77 square miles) in an area that needs to manage the balance between high cultural and high commercial use, including proposed shipping routes for liquefied natural gas projects. This area has been identified as potential critical habitat for several at-risk marine mammals, including two distinct populations of orca as well as both humpback and fin whales. The hydrophones in Squally Channel will enable us to localise in 3D and subsequently track a vocalising whale as soon as a signal has been detected on all four of them.

This hydrophone project is being developed by Ben Henricks through a Mitacs Elevate postdoctoral fellowship. Ben completed his PhD in 2015 with a focus on observational astrophysics and has a strong skill set in the statistical analysis of large data samples, data processing and image manipulation, programming and project planning and management.

Ben's role in this project is to develop the software that allows the automated detection, classification, localisation and tracking of transient signals of marine mammals from long-baseline array data, such as that generated by the Squally Channel hydrophone network. The software aims to provide the following information to the user in real-time: detect if a whale vocalised, determine when the vocalisation took place, classify which whale species vocalised and compute where it happened.

The primary goal is to use the acoustic data to analyse the presence, activity and movement patterns of the different whale species in the area. Furthermore, acoustic recordings from the hydrophone array will be analysed to monitor the ambient noise level in Squally Channel, as well as additional noise such as that of ship traffic. This hydrophone project and the Fin Island Research Station will work hand in hand to provide both acoustic and visual data for studying the impact of ambient noise on whales in the area. In this way, marine management will be improved and research into the habitat use of cetaceans and their interactions with marine vessels will be facilitated.

STUDY SPECIES

The cetaceans we monitor are two baleen whale species – humpback and fin – and orca, of which there are three populations: northern resident, transient and offshore. Both baleen species demonstrate strong site fidelity to this region, but the humpback has made the stronger return to the entire coast of British Columbia. The humpback and the fin were listed as Threatened under the Species at Risk Act, but the former has recently been downlisted to Special Concern.

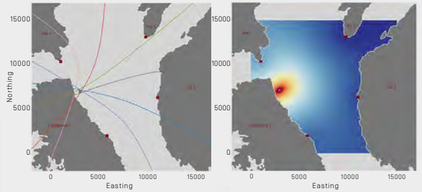
ORCA

The three orca populations in our research area are culturally different from one another in terms of social structure, diet and behaviour. The majority of our sightings are of transients and northern residents. Members of the third group, the offshores, have only been sighted four times in the past 15 years, and three of those times were in 2015.

RESIDENT ORCA

Resident orca exhibit extremely strong and complex family bonds. The bond between mother and son is particularly resilient and is broken only by death. A daughter stays with her mother until she feels the urge to become the matriarch of her own family, at which point she begins to break away for periods of time. It is because of this separation into new groups that every family has a distinct dialect, enabling us to follow and identify them by means of our network of hydrophones. Our observations indicate that the primary food source for resident orca is Chinook salmon. During a feeding event we have seen older females share a catch with calves and juveniles. Males have often been observed feeding at a distance, although they would often share their catch with their mother.

The northern resident population is divided into three clans, each of which has its own set of call types that are different from those of other clans. In



Figures 2.1 (left) and 2.2 (right). The localisation process with simulated acoustic data from all four hydrophones. Each pair of hydrophones creates a hyperbola on which the acoustic source (whale call) can lie. When all pairs are combined, the location is found. For the figures, we added an uncertainty to the time delay to simulate real data. Figure 2.2 shows the probability of where a whale will surface after a call is heard on all four hydrophones (red is highly probable, yellow is mid-range).

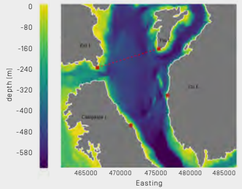
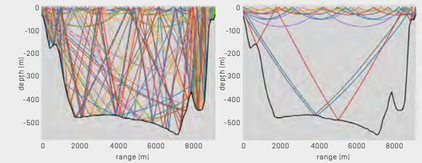


Figure 3. The bathymetry in Squally Channel and a hypothetical connection between a source located at the Otter Pass hydrophone and received by the Fin Island Research Station.



Figures 4.1 (left) and 4.2 (right). Figure 4.1 shows the bathymetry profile between the Otter Pass and Fin Island hydrophones and the acoustic rays traced through the water. For this we used sound speed profiles. From the rays we can determine the travel time of the sound and thus the time of arrival at the next hydrophone. Figure 4.2 shows the same as Figure 4.1, but only the travel path of each signal that will actually reach the Fin Island hydrophone from Otter Pass. These are the signals that matter for analysis.

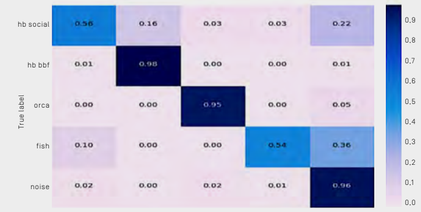


Figure 5. The percentage of call types, such as humpback feeding or orca, that have been correctly classified and how often they have been classified as a different call type. For example, 98% of humpback feeding calls (BBF) have been correctly classified, while 1% have been misclassified as social calls and 1% have been misclassified as noise.

Whale Point field research station on Gil Island

Photos by Michael Scholl

CETACEAN SIGHTINGS

CETACEANS SIGHTED FROM EACH PLATFORM

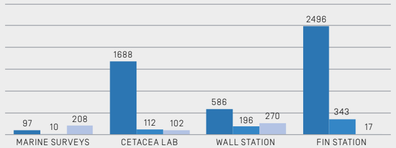


Figure 6. The number of cetaceans observed from each platform during the 2017 season.

TOTAL CETACEAN SIGHTINGS COMBINED

Figure 7

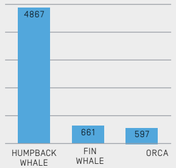


Figure 8

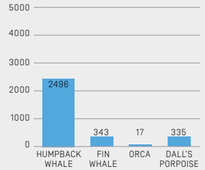


Figure 7. The number of cetaceans seen from all platforms during the 2017 season.

Figure 8. The number of cetaceans observed from Fin Island between 29 June and 30 September. Orcas are most common in this area from April until the end of June, which may have influenced these results. Observers also completed 33 land-based focal follow protocols of individual humpback and fin whales from this land-based platform in an attempt to develop and refine methods for subsequent research seasons. For the first 60 days of field work, large ships (ranging from barges to cruise liners) were seen 30 times, with an average of one day-time transit every two days.

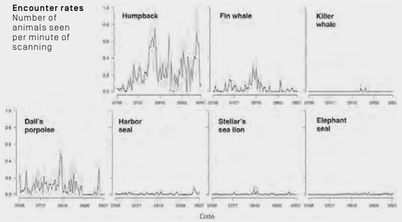


Figure 9. The encounter rates of cetaceans seen from the Fin Island Research Station during the first season of its operation.

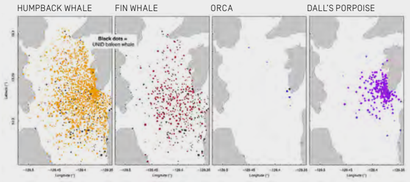


Figure 10. The locations of cetaceans seen from the Fin Island Research Station during the 2017 season.

other words, each has its own language. Within each clan there are a number of pods that will share certain call types but use different dialects when vocalising these calls. During social events, when more than one clan is present, the orca become extremely excited and very vocal. It is during these 'all clan' meetings that mating may occur. Members of the same clan will never mate, always choosing a partner from a different clan. We believe that during these social events they are searching for a mate that does not speak the same language they do and therefore is not related to them.

Most of the resident orca observed in the 2017 season appeared healthy except for one male, A46. In the past decade the mother of this male has died, followed by his two brothers. We think that he has now also died. To the research community of British Columbia this is a great loss as his family and the dialect they shared for more than 50 years will never be heard again. Dialects are usually passed down from mother to daughter, but in this case this did not occur.

TRANSIENT ORCA

Often referred to as the 'wolves of the seas', transient orca hunt marine mammals, including other whales, which has led to the term 'killer whale' being coined for them. This population travels mostly in silence to avoid detection by other species, so there is little opportunity for a specific dialect to be passed on to family members. Thus, when we detect transient orca call types over the hydrophone we know which population we are recording, but cannot determine the family group. Our recordings have revealed that transient orca are very vocal when they have completed a successful hunt. In our research area they prey mostly on Dall's porpoises, followed by seals and sea lions. In 2016 we witnessed three attacks by a family of transients on a young humpback whale, none of which was successful. No such attacks were observed in 2017.

The family structure of transient orca is much more fluid than that of residents, with members leaving the group and joining others for a period of time. The one relationship that remains consistent, however, is between a mother and her oldest son. As in the residents' family structure, this bond lasts a lifetime.

Photos by Janie Wray

Photo by Jane Wray

In 2015 a young female transient orca became stranded during a seal hunt with her family. With the help of the Gitga'at Guardians and Eric Keen, we were able to rescue the juvenile, keeping her cold and wet for the entire day until she could free herself at the tide's flood. This orca was not seen again in 2016, but in May 2017 she was finally spotted, healthy and back with her family. This was a great relief to the team of people who had participated in the rescue, as we didn't know whether she would survive the experience, having been stranded on the rocks all day with pressure on her organs. This emotional encounter can be seen at *https://www.youtube.com/watch?v=GPCjr2AJj8M*.

HUMPBACK WHALE

The return of humpbacks to our research area has been dramatic. Of the three whale species that we study, it is the humpback that we see on a daily basis during the field season. Thanks to this high abundance, we have been able to gain great insights into the social behaviour and habitat use of this robust cetacean.

For identification purposes, humpbacks are divided into three categories. Each fluke is assigned a number in conjunction with the letters BC (British Columbia) and a letter that reflects the amount of pigment seen on the fluke: X for black, Y for white and black and Z for almost all white.

The humpback whale is a migratory species that feeds in high-latitude, nutrient-rich waters from spring until fall. In early winter these whales migrate to low-latitude, subtropical to tropical waters to calve and breed. They do not feed during this winter migration.

The resident population of humpback whales in our region now stands at more than 463. There has been a steady increase since 2004, when this population comprised only 42 whales. During a single survey day in September 2016 no fewer than 75 individuals were identified – almost double the entire population in 2004! Moreover, the dedicated lead researchers and interns of the NCCS have compiled the largest catalogue of the seasonal resident humpback whale population in British Columbia. We are now in the process of collaborating with other researchers to develop a humpback catalogue for the entire British Columbia

Photo by Michael Scholl

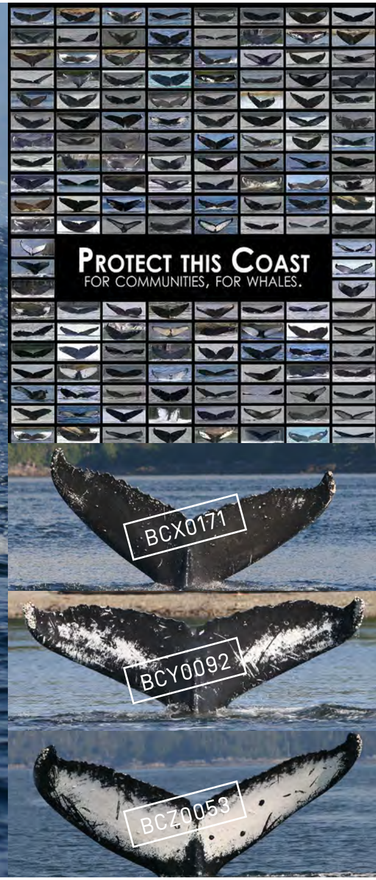


Photo by Janie Wray

Photo by Michaël Scholl

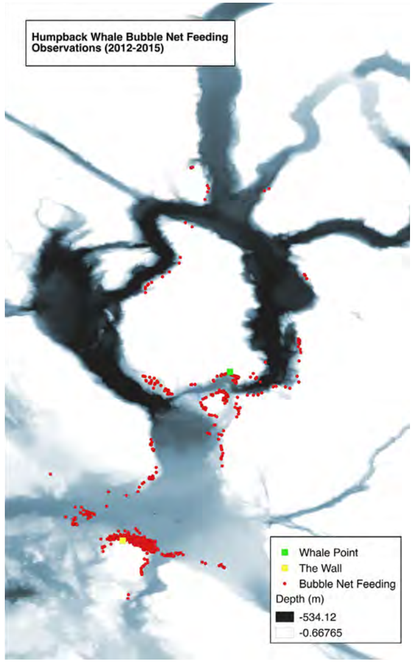
coast. Through this collaboration we will also gain valuable insights into humpback whale society, how relationships develop and the importance of habitat use along this coast.

In 2017, 222 (to be confirmed) individual humpback whales were identified, of which 33 were documented as new arrivals to the area. Only six mother-and-calf groups were sighted, which is fewer than in previous years – an observation that is of great concern. However, all the calves appeared to be healthy and energetic. Over the past two years we have noted an increase in the number of calves that displayed rake marks from attacks by transient killer whales, and for the first time we are seeing multiple mother-and-calf groups interacting and travelling together. An increase in female escorts staying with a mother humpback's calf at the surface while she feeds at depth was also observed. This is the first time this behaviour has been documented in the feeding grounds of northern British Columbia and it may have arisen due to the need to protect calves from attack by transient orcas, as well as the larger population of whales available to do so. The indication that humpback calves may now be targeted by orca needs further study and will be a project for the 2018 season.

Historically, humpback whales were hunted commercially from the late 1800s until 1965, during which time an estimated 28,000 were caught in the North Pacific. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) proposed that the population be listed as Threatened, based on the low observed density of the species in British Columbia. COSEWIC has recently reassessed this Threatened status and downlisted the population to Special Concern based on its increased numbers. This reassessment is being challenged by a number of researchers.

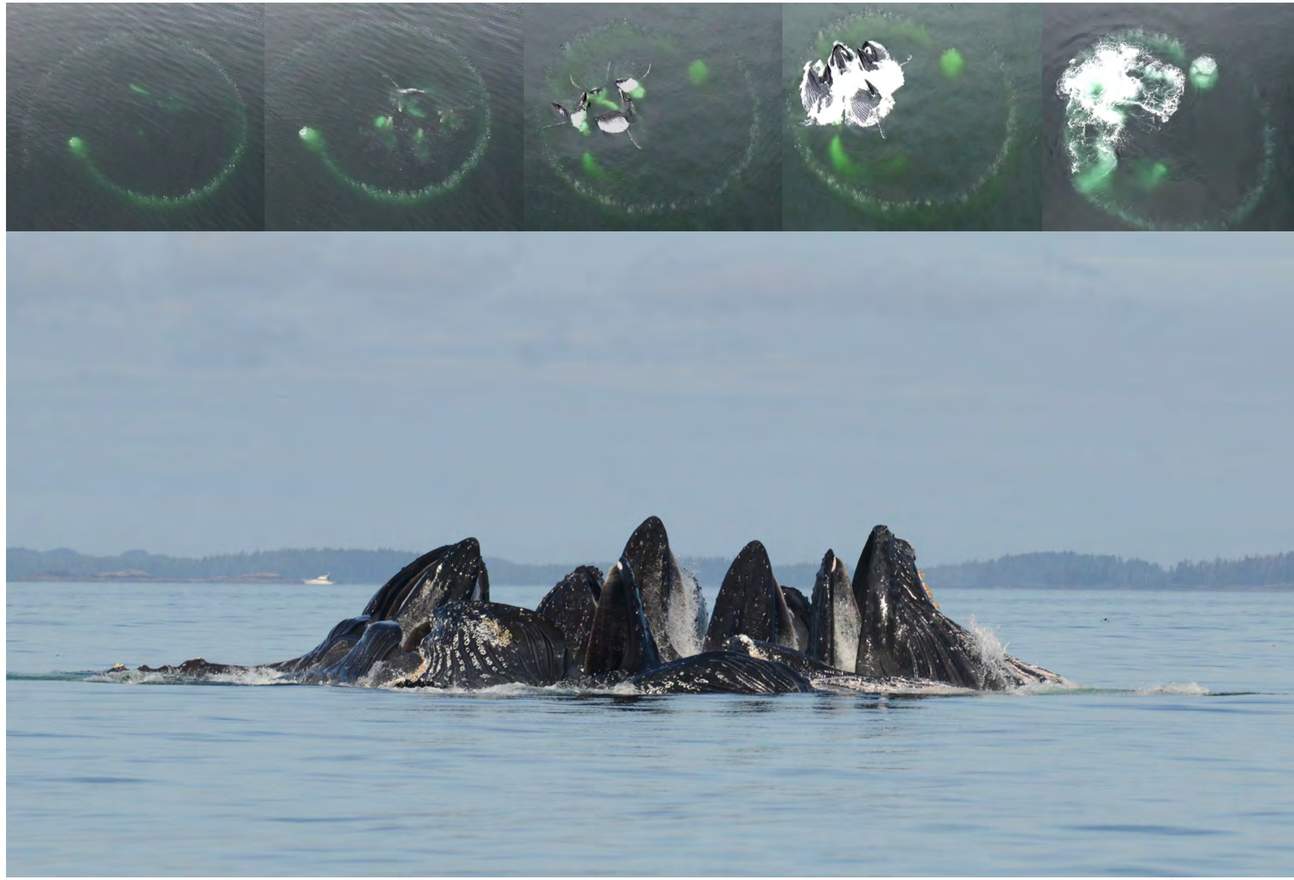
FORAGING

Over the study period we opportunistically collected prey samples while observing humpback feeding events to determine the composition of the whales' diet. The samples indicate that the cetaceans were feeding primarily on herring and krill. All scale samples collected during bubble net feeding events were from



herring. Humpback whales within our research area are often observed bubble net feeding in groups of up to 14 individuals. During these events we identify each member of the feeding group and record the GPS location of each feed. This information has enabled us to understand the importance of location with regard to bubble net feeding: the whales show a definite preference for the slopes of the deep fjord systems of this area. They often follow the shoreline and have specific 'hotspots' where they regularly feed.

From our photo-identification work we have been able to establish that the same nine individuals have been practising this feeding behaviour together for



Photos by Michael Scholl

Photo by Janie Wray

the past decade or longer. We have observed other humpbacks trying to join the group; some have been accepted, others not. We are not sure what the criteria are to join, but it is obvious when a humpback fails the test as the entire group will react with tonal blows and robust behaviour until the would-be recruit departs. Interestingly, the bubble net feeding technique appears to be a behaviour that is learnt and passed on.

Some individuals are now separating from the main group and developing new bubble net feeding groups. They use a distinct call type only heard during the bubble net foraging display and by analysing how this call type is changing over time from group to group we are able to allocate a specific dialect to particular whales and groups. We record all the calls using a hydrophone and a portable recorder and add them to a database with the identification of each individual whale. This library of call types and individual humpback identifications will eventually give the NCCS an acoustic fingerprint for each whale that participates in bubble net feeding. The number of individuals observed to bubble net feed has increased from nine in 2006 to 57 in 2017.

Humpback whales that do not participate in bubble net feeding use other foraging techniques such as lunge feeding, tail flicking and feeding at depth.

RESTING

Humpback whales have been observed floating on the surface, or 'resting', and they do so day or night and close to shore or in the middle of channels or bays. Mothers and calves are often seen resting side by side for up to six hours at a time. When resting whales were observed, we would document the size and composition of the group and the time it spent resting, as well as the whales' reaction to any acoustic or physical disturbance. It is during this time that they are vulnerable to ship strikes.

SOCIAL DYNAMICS AND ROBUST BEHAVIOUR

In early fall we witness a change from cooperative feeding to more robust types of behaviour, such as breaching and tail or pectoral slaps. Males form

Photo by Michaela Schedl

Photo by Janie Wray

Photo by Michael Scholl

Photo by Janie Wray

posturing groups and compete to escort a female, sometimes becoming quite aggressive towards one another. On many occasions we have seen a group dive together, then reappear at the surface moments later to the sound of tonal blows echoing through the channels and with fresh bloody scratches along their bodies after having fought each other underwater. On the surface they perform tail and pectoral slaps and breach very close to one another.

While observing these social events we document the size of the group and the gender and life stage (adult, juvenile or calf) of each whale taking part. When the whales resurface after a long dive, we take photographs to check for any fresh scratch marks that would suggest posturing behaviour underwater and look for old scars that may be the result of injury from a net entanglement or boat strike. We also document and photograph all surface behaviour, such as pectoral slaps, breaching, tail lobbing or tonal blows. If we encounter a lone whale and there are skin samples on the surface, we collect them for analysis to determine the animal's gender. It is also at this time of year that the males sing their beautiful songs at night.

MOTHERS AND CALVES

A humpback mother has one year to teach her calf all that it will need to know to survive. At the beginning of the season a calf does not venture far from its mother's side, but as winter approaches and the whales prepare to migrate south the calf leaves its mother and begins life as a juvenile searching for companionship and food. This is a very vulnerable time in the young whale's life. In recent seasons we have noticed a decline in the number of mothers and calves in our region, which is cause for great concern.

NEW ARRIVALS AND SEASONAL RESIDENTS

When a humpback whale is identified for the first time in our region it is referred to as a new arrival (NA). If the same whale is identified the following year it is designated a possible resident (PR), and if it is seen three years in a row we call it a seasonal resident (SR). In 2017 we identified 33 new arrivals in our research area, many of which were young juveniles. The seasonal resident population has climbed to more than 463 humpbacks, reflecting a steady increase since 2004, when the population was only 42. It is the females within this population that demonstrate the strongest site fidelity.

SEASONAL ABUNDANCE PATTERNS

Humpback whales are found in all oceans and follow the same migration pattern from cold-water feeding grounds in summer to warmer waters in winter for calving. Every fall we know that, one by one, the humpback whales that have filled our days will begin their annual migration south. The first to leave are the mothers and calves, followed by the sub-adults and then the adult males. The last whales to quit the feeding grounds are the pregnant females. They will need every ounce of nutrition to sustain them through the rigours of the long migration, giving birth and then nursing their calves. There is no food available for a mother in the calving grounds and she will not be able to forage until she arrives back in the next season, with her new calf by her side.

Some of our resident humpback whales travel to a group of islands east of Japan; others make the long journey to the Baja and Hawaii. The migration will take them between four and eight weeks to complete and the estimated distance each way is 4,800 kilometres (3,000 miles), making it one of the longest known migrations of any mammal. However, a change in this pattern has occurred and we are now getting reports of humpback whales that do not migrate at all, but remain resident in this area for the entire year.

SOCIAL LIFE

Humpback whales are extremely social and are often seen in the company of other whales, although there are a few exceptions that have chosen a more solitary lifestyle. Curious about these social bonds, we have begun a 10-year project to research these diverse relationships and have learnt so far that humpback relationships evolve through a series of events that lead to certain whales choosing companions based on gender, the time of year, behaviour and

Photos by Janie Wray

location. These social connections do not necessarily relate to a family bond. In the coming years we hope to obtain a better understanding of the complicated and intimate relationships that the North Pacific population of humpback whales share.

HUMPBACKS AND SEA LIONS

During our research we have become aware of an extraordinary bond between humpback whales and sea lions. Often groups of young sea lions will follow and interact with juvenile humpbacks and mother-and-calf pairs. Obvious play is observed when this happens, especially between the sea lions and the calves. Sea lions also interact with feeding whales, benefiting from any fish scraps. Interestingly, when transient orca have been observed attacking sea lions, humpback whales have been seen charging aggressively into the hunt while it is in progress or afterwards, to disrupt the orca while they are feeding. We are not the only ones to have witnessed such events and we wonder whether sea lions have an ulterior motive – safety – when they interact with humpbacks.

FIN WHALE

Next to the blue whale, the fin whale is the second largest mammal on the planet. It feeds on euphausiids (krill-like crustaceans), herring, capelin and other shoaling fish, along with squid and copepods. Like other baleen whales, it strains its food from the water through baleen plates.

Large numbers of fin whales were hunted in British Columbia, with more than 7,600 taken by coastal whaling stations between 1905 and 1967, and thousands more caught by pelagic whalers until the 1970s. In British Columbia, the species is typically found in exposed waters off western Vancouver Island and in Queen Charlotte Sound, Hecate Strait and Dixon Entrance. From sightings in summer and winter and acoustic detections at least from February until August, the current population in the north-eastern Pacific is estimated at less than 50% of the numbers of 60–90 years ago. The fin whale has consequently been designated as Threatened by both COSEWIC (2005) and the Species at Risk Act.

Photo by Janie Wray

Photos by Michael Scholl

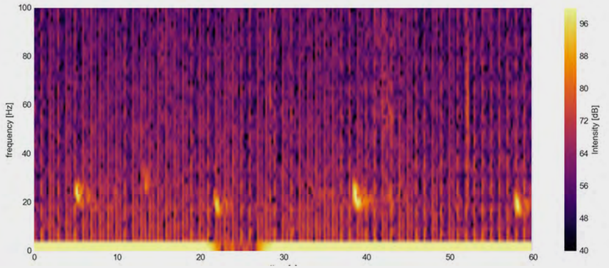


Figure 11. Fin whale pulses from the Squally Channel hydrophone network.

Photo by Janie Wray

Fin whales were first documented by the NCCS in 2006. Since then, increasingly frequent sightings suggest that the species is beginning to re-occupy our study area, which has been highlighted as an important location for it by the Pacific North Coast Integrated Management Area (PNCIMA) process through interviews with experts, documented observations and historical whaling records. Indeed, the area probably represents unique near-shore fin whale habitat on Canada's Pacific Coast. The whales' return raises questions about the current and past importance of coastal fjords for a species that historically was believed to prefer an offshore habitat. As fin whale populations continue to recover from 20th-century whaling, we will determine how and to what extent they have come to rely on this habitat and will examine how important they may be to the ecological function of the north coast.

At between 16 and 40 hertz, fin whale pulse calls are the lowest frequency sounds made by any animal on the planet – way below the hearing ability of humans. Thanks to the quality of the IC Listen hydrophones of the new network in Squally Channel, we were able to detect fin whale vocalisations for the first time in 2017. Now the NCCS will finally be able to document the acoustic activity and seasonal use of vocalisations by fin whales within our research area. To date it has been recognised that most call displays by fin whales are seasonal and may be directly related to mating. We are keen to investigate this theory for ourselves. If this is the case, the increase in ambient noise in our oceans may impact the ability of males and females to communicate over long distances. The call of a fin whale can travel hundreds of miles across the ocean (see figure 11).

FUTURE PROJECTS

For the 2018 season, the focus of the NCCS will be to work with other NGOs and researchers along this coast to determine the effects of ambient noise and industry on the habitat and daily lives of whales. This will be accomplished by comparing acoustic data from the Squally Channel hydrophone array with all visual data collected from the Fin Island Research Station. Our goal by the end of 2018 is to set up a relay station from the Fin Island station to the nearby First Nation community of Hartley Bay so that the entire community will have the opportunity to listen to whales live within its territory. The NCCS has also been given permission to deploy a new hydrophone station near the remote First Nation community of Klemtu, which will enable us to increase the range of our acoustic research about whales and ambient noise deep into the fjord system of northern

Photo by Janie Wray

Photo by Michael Scholl

British Columbia. The signals from this station will also be transmitted to the community so that it too can listen to the whales.

The NCCS will continue to work with the Department of Fisheries and Oceans on the Entanglement Scar Project, taking the lead to ensure that as many cetaceans as possible are photographed during the 2018 season. Signs of scar damage seen in these photographs will enable us to determine whether a whale has been entangled in fishing gear. We believe that these results will influence measures taken to protect whales from the prolonged suffering and death caused by entanglement. The abundance of humpback whales has increased radically along the coast of British Columbia, and so too has the likelihood of entanglement. Humpbacks whales have the ability to go for months without food, an evolutionary adaption that, when a whale is entangled, only prolongs the suffering of this majestic mammal.

Continuing to support the Cetacea Lab internship programme is another priority for the NCCS, as is the collection of cetacean sightings data from the land-based platforms. Increased effort will go into the collection and analysis of call types relating to bubble net feeding and research into the social dynamics of this behaviour will be conducted with the assistance of the hydrophone, drone and identification methods already in place.

As far as outreach is concerned, the NCCS will maintain its open-door policy at Cetacea Lab and the Fin Island station whereby it welcomes boaters ashore for an interpretive talk about whales and what role we can all play to ensure that this coast remains a safe and quiet region for cetaceans.

In the 2018–2019 season we will begin a study using drone technology with the assistance of Dr Lance Barrett-Lennard to determine the physical health of different whale species. This will be accomplished with high-resolution images known as photogrammetry to measure length and girth. This technology will also assist in a project to determine the mortality rate of calves and it can be used when a whale is in distress due to entanglement in fishing gear.

We would like to thank the Save Our Seas Foundation for its generous support for the North Coast Cetacean Society to protect this coast for whales.

Photo by Janie Wray

Photo by Guy Stevens

THE MANTA TRUST

ISABEL ENDER & GUY STEVENS

Guy Stevens

THE YEAR OF THE DEVILS

We never cease to be amazed at how science can unravel nature's mysteries – and at how much more there is to learn about the species around us. In 2017 a new study not only revealed that manta rays belong to the same genus as mobula rays, but proposed taxonomic changes for several of the mobula ray species as well. It was only a decade ago that manta rays were split into the two recognised species that exist today and it is highly likely that this latest revelation is not the end of taxonomic reshuffling. All these steps will hopefully lead us closer to the 'truth' of how these majestic rays are related to each other, which in turn will provide insights into their vulnerability and inform conservation priorities. It is exciting to see scientists working so hard to unravel the rays' taxonomy and we are thrilled at the prospect of soon being able to contribute more insights from our Manta Trust genetics project.

Understanding the taxonomy of mobulids is important as it will have implications for national and regional protection measures. Countries with regulations for species-specific fisheries management need to know whether their policies are still appropriate and fishers need to understand which species they can catch. Managers, meanwhile, rely on species-specific population studies to develop conservation actions. Thanks to the efforts of multiple organisations and scientists on an international scale, in 2016 all mobulid species were listed on the Convention on International Trade in Endangered Species (CITES) Appendix II (they have been receiving the same level of protection through the Convention on Migratory Species (CMS) Appendices I and II listings since 2014). While this was a great achievement, it is important that these measures are implemented effectively. This has been one of the priorities for the Manta Trust throughout 2017 and into 2018.

The Manta Trust, in conjunction with the Wildlife Conservation Society, developed a Concerted Action proposal for mobulid rays for the CMS Convention of the Parties (CoP12) held in the Philippines in October 2017. We also participated in several CITES implementation workshops in Indonesia and Sri Lanka throughout the year. Countries that are Range State Parties to species listed on the CMS Appendix I are required to endeavour to strictly protect those species by 'prohibiting the taking of such species'. They should also endeavour to 'conserve, and where appropriate restore, the species' habitats; preventing, removing or mitigating obstacles to their migration and controlling other factors that might endanger them'. This can be a challenge, particularly in locations where communities depend on fishing for these species for their livelihoods. The Concerted Action aims to assist Parties in the implementation of their obligations under the CMS. It also serves as an opportunity for Parties to collaborate, share and propagate conservation knowledge, monitor the progress of their efforts and generate coordinated actions to conserve these species. The Concerted Action was successfully adopted at the CMS CoP12.

In 2017 the Manta Trust completed and launched a best-practice guide for shark and ray tourism in collaboration with Project AWARE and WWF, as well as a team of scientific experts and industry professionals. The guide, *Responsible Shark and Ray Tourism: A Guide to Best Practice*, provides a suite of free, practical, downloadable tools that can be used by operators, NGOs, local communities and resource managers. Shark and ray tourism is becoming increasingly popular worldwide, but there is limited guidance on aspects of best practice. Guidelines are needed to ensure that sites are established and operated in a manner that benefits both the mobulids and the local communities, while also inspiring among tourists awe and respect for sharks and rays and a greater appreciation of the need to conserve them. Shark and ray tourism, when properly designed and managed, can provide alternative direct and indirect benefits to local communities and economies.

The Manta Trust developed a 360VR film of feeding reef manta rays in the Maldives that, used as part of the Dubai Aquarium's VR Zoo exhibit, allows people of any age and physical ability to experience an underwater encounter with mantas. We also supported BBC cameraman and Manta Trust patron Roger Munns with his project to film manta rays for the documentary series *Blue Planet II*. The Manta Trust's main research site in the Maldives, Hanifaru Bay, featured in the 'Coral Reefs' episode of *Blue Planet II*, which aired in November and December 2017.

Photo by Isabel Ender

Photo by Isabel Ender

Photo by Guy Stevens

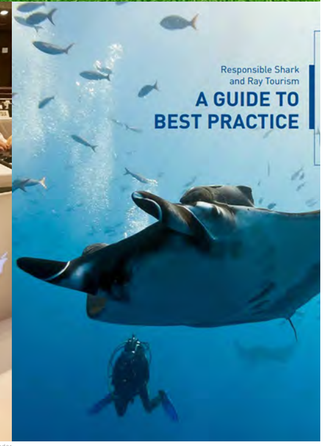


Photo by Isabel Ender

'Having starting in 2011 with a handful of projects, the Manta Trust has (...) established research collaborations, partnerships and affiliated projects in more than 20 countries worldwide.'

In October 2017, the Manta Trust launched *www.swimwithmantas.org*, an online resource hub for tourists and manta tour operators around the world. On this micro-site, members of the public can watch the film *How to Swim with Manta Rays*. They can also learn about the importance of global manta tourism, browse a Wall of Fame dedicated to tourism operators who have committed to sustainable practices, and become acquainted with the new 10-step guide to swimming with mantas. This guide is a revised version of the Manta Trust's Tourism Code of Conduct, with illustrations and simple captions that explain how to interact responsibly with a manta during an encounter.

The first book on the natural history of manta rays, *Manta: Secret Life of Devil Rays* by Guy Stevens and Tom Peschak, was officially launched in November 2017 (*www.mantabook.com*). Among the tributes for it received so far are testimonials from Sir Richard Branson and renowned underwater photographer Doug Perrine:

'*Guy and Thomas have brought together their knowledge and expertise to create a book that perfectly captures the essence of manta rays. It stirred within me a desire to do more to help conserve our oceans, and I hope that it does the same for you!*' – Sir Richard Branson

'Manta: Secret Life of Devil Rays *is one of those rare volumes that is both gorgeous to look at and fascinating to read. Although the author and most of the contributors are scientists, they write in a style that is easily accessible to the average reader.*' – Doug Perrine

The sales of this book have been excellent. A second Manta Trust book, *Guide to the Manta and Devil Rays of the World*, is close to completion and will be published in March 2018 by Wild Nature Press. The 144-page book provides an overview of this family of rays, detailing species identification, ecology, threats and behaviour.

We secured a partnership agreement with Carl F. Bucherer for a limited-edition Manta Trust watch, which was released in July 2017 (*www.watchmymanta.com*). Donations from the sale of the watch fund research in the Maldives that investigates the diet of mantas. By using stable isotope techniques,

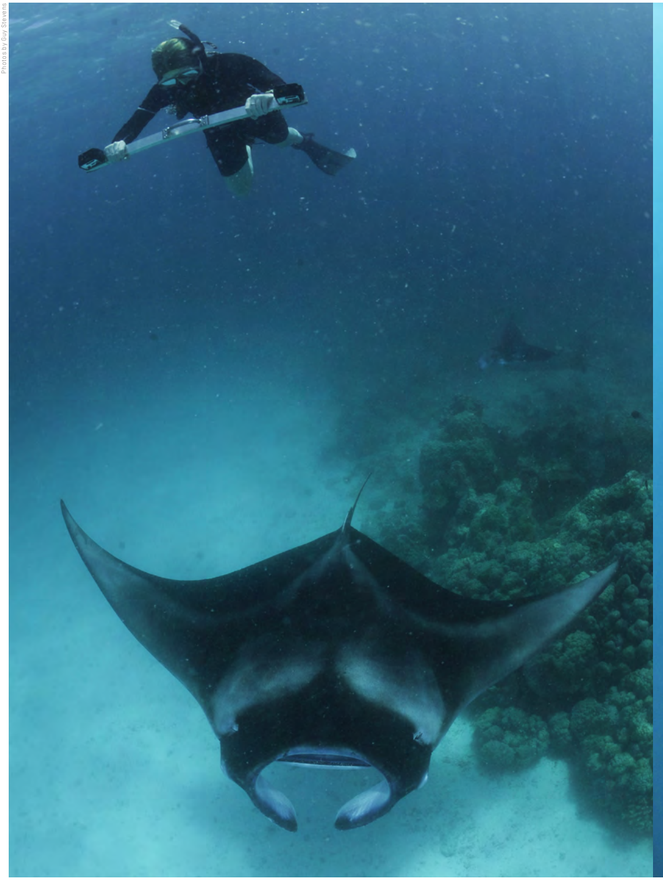
'Shark and ray tourism, when properly designed and managed, can provide alternative direct and indirect benefits to local communities and economies.'

we aim to define the zooplankton community of the manta ray's prey. We also started a collaborative project with PhD students of Project Manta, University of Queensland, which aims to investigate movement patterns of manta rays across jurisdictional regions within South-East Asia and the south-western Pacific Ocean; manta patterns and morph variations globally; and sub-lethal manta injuries. Satellite-tagging research conducted in Indonesia, Mexico, New Caledonia, the Seychelles and Hawaii has provided further insights into the foraging ecology, diving and migration behaviour of these species.

In 2017 the Manta Trust celebrated its sixth year in operation. Having starting in 2011 with a handful of projects, it has grown substantially as a charity that has established research collaborations, partnerships and affiliated projects in more than 20 countries worldwide. This year provided a good opportunity to review what we have achieved. In August we brought together the core operations team in the UK to review the trust's conservation strategy, enabling us to update and refine our charitable mission and goals for the next five years. We also welcomed a new fundraising manager. With such a great team and dedicated affiliate partner projects, the next five years promise to be as successful as the first.

The charity continues to have a significant social media following, with more than 12,000 followers on Twitter, 23,000 on Facebook and 21,000 on Instagram. The first quarter of 2018 will see the launch of the new Manta Trust website, which we hope will better engage the public with current information on mobulid research, threats and conservation and will help to secure increased support for campaigns, events and fundraising. The new site will be easier to navigate and update and will be better linked to our social media platforms.

The Manta Trust secured funding from the Global Partnership of Sharks and Rays and the Save Our Seas Foundation to continue its Global Mobulid Conservation Programme (GMCP) in 2017. The GMCP was launched in 2014 to coordinate and carry out a strategic, long-term conservation plan for manta and mobula rays. With objectives intricately linked to the IUCN Shark Specialist Group's Global Conservation Strategy for Manta and Devil Rays, the programme has driven numerous advances in our understanding of mobulids and has secured



Photos by Guy Stevens

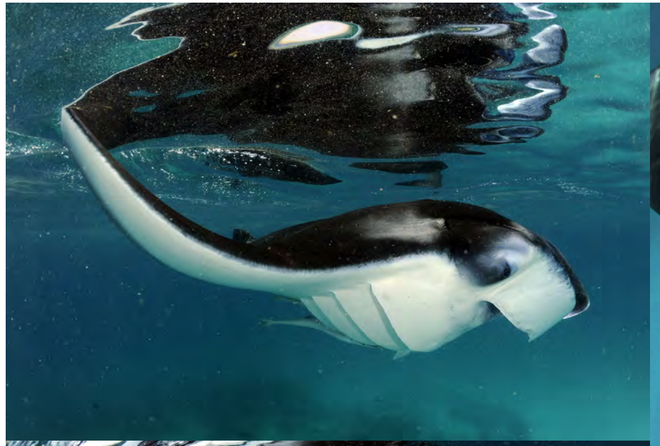
'The aim [of the educational project] would be to develop a Manta Trust curriculum that can be used by schools and projects all over the world.'

several critical achievements, including the CITES and CMS listings, that have improved the conservation status of these animals. By taking a multi-faceted and collaborative approach, the GMCP is an example of turning a 'paper' strategy into coordinated activities and conservation outcomes.

Going forward, we will be focusing on three key mobulid fishing countries: Indonesia, Sri Lanka and Peru. We will make sure that the governments of these nations possess the data necessary to quantify their targeted and by-catch mobulid fisheries and that they receive the external support needed to develop protective policies. Additionally, our work will ensure that these governments have the skills, knowledge and tools to enforce effectively the protective measures they implement. Finally, we will engage with communities that currently rely upon mobulid fishing. Our efforts will help them to switch to alternative livelihoods and a more sustainable, non-consumptive use of their mobulid populations.

2017 saw a big jump in the total percentage of the world's oceans that now fall within marine protected areas, from just 5% a few years ago to more than 13% by the end of the year. One of the most significant areas of key manta ray habitat that gained greater protection in 2017 was Mexico's Revillagigedo Archipelago. This group of four volcanic islands in the Pacific Ocean is known for its unique ecosystem and Dr Robert Rubin, a director of the Pacific Manta Research Group and a member of the Manta Trust Scientific Advisory Board, has been studying the mantas there for more than 30 years. Designated a marine reserve by the Mexican government last year, this reserve is now the largest protected area of its kind in North America. The no-take sector of the reserve encompasses 148,000 square kilometres (57,000 square miles). Sightings of oceanic manta rays at this remote location are still relatively common when compared to other areas along the mainland coast of Mexico, where intensive fishing pressure in the past has dramatically reduced the manta population.

During 2017, the Manta Trust attended dive shows in Italy and France and participated in the Green is the New Black Festival in Singapore. The Maldives Educational Programme has been working with schools in Baa Atoll to engage children with their native marine ecosystems, and plans for expanding



Photos by Guy Stevens

Photo by Stefanie Brose

the programme to other atolls are under way. The trust has also attended marine education festivals for children in the Maldives and Peru, running stands and manta-themed games. Our project in Yap is working closely with a local high school, giving presentations during school holidays and setting up a summer class on marine biology. As our partnership with Carl F. Bucherer continues into the new year, and following on from the success of the 2017 project, the luxury watch manufacturer has expressed a desire to fund an educational project in 2018. The aim would be to develop a Manta Trust curriculum that can be used by schools and projects all over the world to provide children with a greater understanding and appreciation of manta rays and the marine environment.

Finally, the Manta Trust made new contacts in New Zealand and we are expecting Manta Watch New Zealand to become an affiliated partner soon. We formally established a collaboration with Conservation International for our project in New Caledonia and began a study to investigate the spatial ecology and movement of the local manta population by deploying seven satellite tags. We also produced a short movie on this project with conservation filmmaker Shawn Heinrichs, which is expected to be released in 2018. We consolidated our relationship with our collaborators in French Polynesia to drive forward the research on manta rays in the South Pacific. A manuscript providing insights into the population size and distribution of French Polynesia's manta rays is in the making.

Spanning a wide variety of topics, half a dozen new scientific papers by Manta Trust staff or affiliated partners were published in 2017, or are under review, and several dozen more collaborative publications are in preparation. With Sharks International occurring in mid-2018, an increased number of new mobulid scientific publications and presentations are anticipated, advancing our knowledge of these species. We are excited to see what new insights and developments the year will bring.

Thank you as always to our wonderful funders for supporting our work!

Photo by Andrei Dodu

Photo by Daniel Fernando

Photo by Chase Bias

BIMINI BIOLOGICAL FIELD STATION FOUNDATION

TRISTAN GUTTRIDGE & SAMUEL GRUBER

Tristan Guttridge

Samuel Gruber

The Bimini Biological Field Station Foundation (BBFSF) was established in 1990 to advance our knowledge of shark biology, improve shark conservation and educate young scientists and the public. The field station itself is a small research facility located on the island of South Bimini in The Bahamas, 85 kilometres (53 miles) east of Miami, Florida. Its environs provide access to a diverse and abundant elasmobranch fauna that occupies marine habitats ranging from fringing mangroves, sand and sea-grass flats and shallow-water lagoons to coral reefs and a shelf sloping into deeper waters.

Since its inception, the BBFSF has contributed significantly to scientific knowledge and education about sharks and their conservation. This can be seen from our wide range of peer-reviewed publications, our outreach to the local community, and the accommodation and training of large numbers of national and international interns at both undergraduate and graduate level. Through many of our publications, we have provided new information to improve, manage and protect shark stocks in The Bahamas and the USA.

Given its 27-year history, first-rate research reputation and diverse accomplishments, the BBFSF is uniquely positioned to develop and carry out innovative projects that will continue to contribute to a basic understanding of the behaviour and ecology of a variety of elasmobranch species. One overarching goal the BBFSF focuses on is the recovery of shark populations worldwide and managing them effectively and sustainably for future generations. Through our educational outreach, we aim to improve marine science education as well as public perception and understanding of these compelling predators.

We are extremely grateful to have completed our 27th year of operation. In 2017 our activities ranged from determining pregnancy in great hammerhead, tiger and lemon sharks to the acoustic tracking of southern stingrays and the collection of genetic samples from newborn lemon sharks – a continuation of our 23-year annual neonate-tagging programme. In this report we describe scientific and conservation milestones and outreach and media activities and provide a short summary of goals and plans for 2018.

Photo by Michael Scholl

SCIENTIFIC RESEARCH
LONG-TERM PROJECTS

MOVEMENT AND HABITAT PREFERENCES OF NINE ELASMOBRANCH SPECIES

Over the past four years we have installed an array of bottom-mounted acoustic receivers (VR2W, Vemco) in Bimini's waters to monitor the movements of a variety of sharks and rays. Our team's long-term goals are threefold: to build a theoretical framework that can predict the spatio-temporal distribution of habitats used by sharks in Bimini; to determine the physical and biological drivers of movement and migration; and to identify hotspots of habitat use so that the management and conservation of local elasmobranch populations can be improved. We aim to accomplish these objectives by addressing potential underlying mechanisms such as competition, intra-guild predation and species-specific habitat preferences.

This year, through a collaboration with the Ocean Tracking Network (OTN) and continued support from the Save Our Seas Foundation (SOSF), we expanded our acoustic array to 68 receivers. We are now able to monitor areas to the north of Bimini at North Rock, Moselle Bank and Great Isaacs Cay (32 kilometres, or 20 miles, distant) and south to Cat Cay (16 kilometres, or 10 miles, distant). The habitats currently being monitored are shallow sand flats with interspersed macro-vegetation; mangrove-bordered sea-grass beds; and shallow- and deep-water rocky and coral reefs. These new locations are posing a variety of research questions regarding habitat connectivity and ecosystem dynamics.

Using the extensive BBFSF acoustic array in collaboration with Florida International University and Florida State University, we are monitoring 178 individual elasmobranchs representing nine species: 23 lemon *Negaprion brevirostris*,14 bull *Carcharhinus leucas*, 18 blacktip C. *limbatus*, 13 Caribbean reef *C. perezi*, 16 nurse *Ginglymostoma cirratum*, 37 great hammerhead *Sphyrna mokarran* and 42 tiger sharks *Galeocerdo cuvier*, as well as 16 southern stingrays *Hypanus americanus* and 55 green sea turtles *Chelonia mydas*. After collecting data for nearly three years we have accumulated more than 1.4 million detections from these individuals as they range over Bimini and the north-western Atlantic Ocean.

Within these predator guilds, dominant predators elicit strong consumptive and non-consumptive risk effects on smaller, subordinate predators. Subordinate predators probably partition space and/or time to avoid competitive and lethal encounters with the main predators and are thus able to coexist with them. How coexistence is achieved within guilds of large marine predators remains poorly understood. Past studies of elasmobranchs generally covered one or at most a few species, but to our knowledge no study has attempted to understand coexistence mechanisms and their spatial outcomes among several sympatric elasmobranch species.

Bimini is the only island in the chain of cays and rocks on the western edge of the Great Bahama Bank that supports extensive mangroves. Its high productivity and complexity of habitats promote the coexistence of at least 13 elasmobranch species. Thus, this ecosystem provides an opportunity to examine the mechanisms that facilitate coexistence among bull, blacktip, Caribbean reef, great hammerhead, lemon, nurse and tiger sharks as well as the southern stingray. Acoustic telemetry and dynamic Brownian Bridge movement models were used to quantify patterns of space use among these eight focal elasmobranchs. The results show different patterns of space use, depending on size. Understanding guild-level coexistence of sympatric elasmobranchs has important implications for an understanding of ecologically based conservation. For instance, elasmobranchs are declining at an alarming rate due to fishing pressure and this alone may alter the strength of intra-guild interactions.

Preliminary spatial analyses have revealed that many of the nine elasmobranch species we are monitoring use diverse habitats throughout North and South Bimini. Some of the larger sharks, like bull, great hammerhead and nurse, concentrate their use of space in the waters off south-western and western Bimini, which suggests that these areas are important corridors for shark movements (see figure 1). In contrast, smaller species such as blacktip shark and southern stingray concentrate their activity to the south and east of Bimini, as well as the central lagoon (see figure 2). Lemon sharks use most of Bimini's habitats, whereas the activity space of Caribbean reef sharks was highly constrained (see figure 3).

We also detected individual subjects each day over long periods (for example, a lemon shark for 551 days, a nurse shark for 608 days and a reef shark

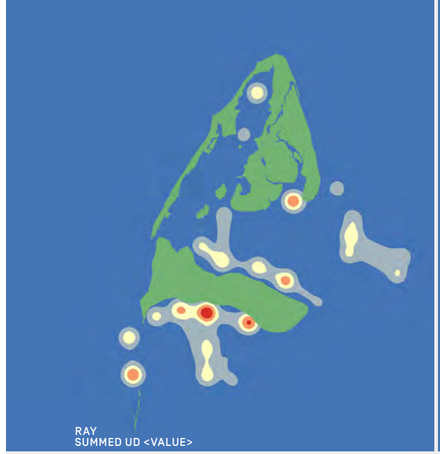


Figure 1
Average probability estimates of utilisation density (UD) calculated using Dynamic Brownian Bridge movement analysis for the bull shark at Bimini, 2016–2018.

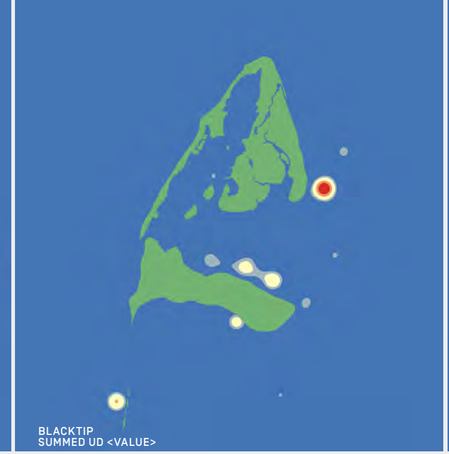


Figure 2
Average probability estimates of utilisation density (UD) calculated using Dynamic Brownian Bridge movement analysis for the blacktip shark at Bimini, 2016–2018.

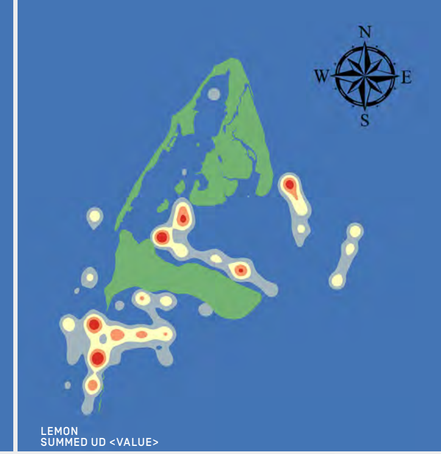


Figure 3
Average probability estimates of utilisation density (UD) calculated using Dynamic Brownian Bridge movement analysis for the Caribbean reef shark at Bimini, 2016–2018.

Photo by Michael Scholl

Photos by Chelle Blais

for 740 days). We calculated a residency index (RI = the number of days detected in the array divided by the number of possible days detected) and found that the RI ranged between 0.01 and 0.98 (RI = 1 indicates that an individual is always present). We also found that different species have widely varying RI scores, indicating that some individuals are resident whereas others are transient. For example, one nurse shark had an RI of 0.76 for 722 of 951 days studied. This was similar to a lemon shark that had an RI of 0.73 for 599 of 822 days. The residency of these species differed greatly from a Caribbean reef shark with an RI of 0.98 for 926 of 945 days. Data collected from 18 tiger sharks suggested that these individuals are primarily transient in Bimini as they displayed an average RI of 0.03.

Based on more than three years of acoustic detections, we found that many individuals moved far beyond the Bimini array into the north-western Atlantic Ocean (see figure 4). For example, a blacktip shark tagged off Bimini was acoustically detected at Grand Bahama Island 127 kilometres (79 miles) to the north, while another was detected near Melbourne, Florida, 389 kilometres (242 miles) to the west. Ten of 12 adult bull sharks travelled some 156 kilometres (97 miles), crossing the Gulf Stream, to mainland Florida; five of them returned to Bimini. Of 18 adult lemon sharks tracked, at least one crossed the Gulf Stream and was detected in the Florida Keys, 78 kilometres (48 miles) south-west of Bimini; another two adult lemon sharks were detected at Grand Bahama Island and Cape Eleuthera respectively. Seven of 15 adult nurse sharks we tagged were acoustically detected on other receiver arrays at Bahamian and Floridian locations. Five of our tagged nurse sharks returned to Bimini. Six of 22 tiger sharks were detected in distant arrays, of which one female travelled more than 1,560 kilometres (970 miles) to the coast of Texas. Finally, three of our tagged great hammerhead sharks were detected, two having travelled approximately 1,000 kilometres (620 miles) in a north-westerly direction to South Carolina. One of these hammerheads made its way along the Georgia coastline, a distance of about 880 kilometres (545 miles).

In 2018, our team plans to use spatial mapping software to identify key areas at Bimini for all the tracked elasmobranch species. The resulting data will be

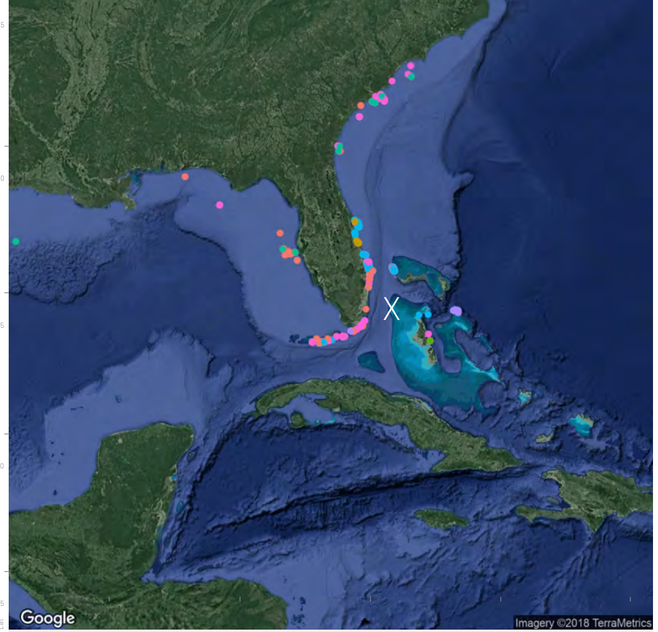


Figure 4
Regional movements and migrations of seven shark species tagged with 10-year ultrasonic devices at Bimini. Detections were primarily acquired by the FACT and ACT arrays. The white X represents the location where the sharks were tagged.

Figure 5
Newborn and juvenile lemon sharks captured during the PIT-tagging campaign in the North Sound (NS) and Sharkland (SL) between 2015 and 2017.

able to be used to define the boundaries of the planned Bimini marine protected area, as well as areas of conservation concern.

QUANTITATIVE GENETIC STUDY OF THE MATING SYSTEM AND SURVIVAL OF THE LEMON SHARK

2017 marked our 23rd annual PIT (passive integrated transponder) tagging campaign. A PIT tag, also called an RFID tag, is an implantable transreceiver the size of a grain of rice. This study is the longest census of any juvenile/neonate shark we are aware of.

Over a period of 12 fishing nights, gill nets are set in two mangrove-fringed nurseries we call the North Sound and Sharkland, both of which are located in North Bimini. The nets are left in place for 12 hours and checked every 15 minutes. Our goal is to explore the mating system, population dynamics and life history of the lemon shark, primarily using genetic information from neonates captured in the gill nets. On capture, each shark is weighed, measured and sexed and a PIT tag is implanted in it. Small pieces of fin containing critical genetic material are collected from the shark and shipped to Dr Kevin Feldheim, director of the Field Museum's Pritzker Genetics Laboratory in Chicago.

All samples are genotyped at 11 lemon shark microsatellite alleles. By analysing these alleles, we are able to infer parent/offspring and sibling relationships between sampled individuals, which allows us to reconstruct the adults that sired each individual. Indeed, we have never seen or captured the vast majority sires and dams. In this way, each year we add new members to our existing pedigree of lemon sharks, which presently comprises more than 4,000 individuals.

Using the genetic data and the lemon shark family tree, we are able to investigate questions such as how many females had pupped at Bimini in 2017; how large were their litters; whether any particular sire or dam had visited Bimini in previous years and if so, how many times the dam had produced pups; whether dams give birth on a biennial cycle; whether the adult females giving birth at Bimini in 2017 were themselves born at Bimini decades earlier (if this is so, it

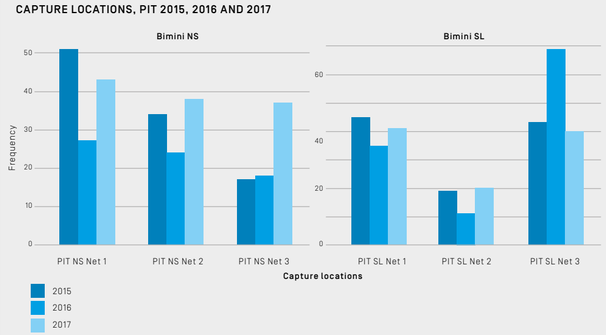


Photo by Michael Scholl

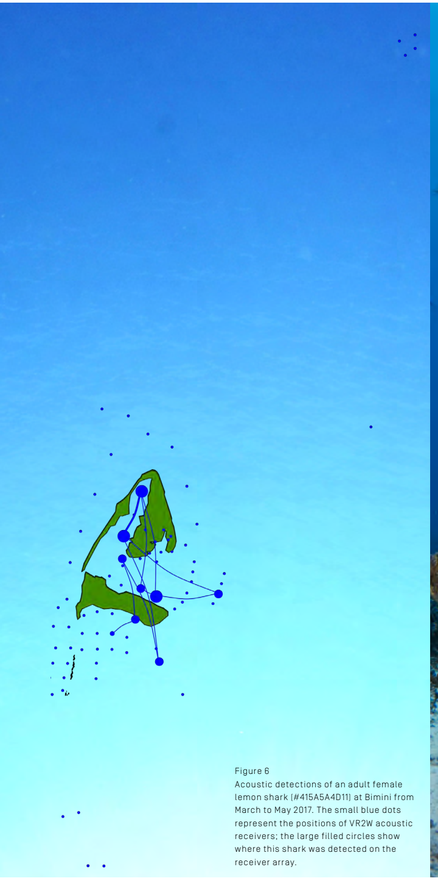


Figure 6
Acoustic detections of an adult female lemon shark (#415A5A4D11) at Bimini from March to May 2017. The small blue dots represent the positions of VR2W acoustic receivers; the large filled circles show where this shark was detected on the receiver array.

Photo by Chelle Blais

is absolute proof of natal philopatry similar to that in sea turtles, salmon and pinnipeds); and finally, if natal philopatry is present, how common is this breeding system in the lemon shark population at Bimini?

PIT SUMMARY 2017

During our 2017 tagging campaign we captured 218 juvenile sharks. Historically, we capture greater numbers of lemon sharks in Sharkland than in the North Sound. Between 1996 and 2017, the mean number of sharks caught in Sharkland was 115 compared to 80 in the North Sound. Capture rates in 2017 compare favourably with those of previous years (see figure 5). As usual, most sharks were captured in nets closest to the mangrove edge, which emphasises the importance of mangroves to the early life history and development of juvenile lemon sharks at Bimini.

ADULT LEMON SHARK RETURNEES

In the spring of 2017, eight adult females originally tagged between 2014 and 2016 were detected on receivers in Bimini's lagoon and nursery areas. Two of the eight sharks arrived in early March and were detected intermittently until August. A third individual was detected over an eight-day period between 23 and 31 May. One adult female (tag #415A5A4D11) was detected on 261 occasions from March to May on nine different receivers (see figure 6). Through genetic analysis of five of her pups, we found that this mother previously gave birth at Bimini. Two of her newborns were caught in the North Sound and three in Sharkland. This female was first captured in 1997 as a 252-centimetre (99-inch) adult and her offspring have been detected at Bimini for more than 10 years of a 20-year period, which demonstrates extremely faithful reproductive philopatry. Based on the number of occasions she gave birth at Bimini and the highly accurate estimate of her age at maturity (12 years), this shark was at least 34 years old in 2017. In addition, she was detected in Bimini's lagoon for short periods during April and May in each of the past four years. These findings suggest to us that many females may return faithfully to Bimini to both mate and give birth.

Photo by Michael Scholl

Photo by Michael Scholl

Photo by Chelle Blais

Photo by Michael Scholl

Photo by Michael Scholl

Figure 7
A transverse ultrasound image of a female great hammerhead. The arrows indicate cross-sections of two embryos, showing their vertebral columns.

GREAT HAMMERHEADS: A CRITICAL NEED FOR LIFE HISTORY DATA

Over the next few years, the BBFSF team aims to improve our understanding of the ecology, movements and behaviour of the globally Endangered great hammerhead shark *Sphyrna mokarran* by tracking individuals acoustically and via satellite in The Bahamas and the USA. Through collaboration with the US National Marine Fisheries Service (NMFS), we intend to provide critical spatio-temporal data that will help to improve the management of this IUCN-listed species, leading to the recovery of its populations.

This year saw the publication of our first hammerhead paper in *Frontiers in Marine Science* (Guttridge et al., 2017). The article provided NOAA/NMFS with data for updating an important habitat of particular concern (HAPC) in the north-western Atlantic. Bringing this research to the public, our team featured on Discovery Channel's *Shark Week* in an episode entitled 'Hammerhead Invasion'. This programme led directly to a collaboration with elasmobranch veterinary expert Dr Natalie Mylniczenko of the Walt Disney Company, who instructed us on the use of ultrasound to determine pregnancy in hammerheads.

Following the airing of the hammerhead programme, E.I. Medical Imaging generously provided us with a portable, waterproof ultrasound unit to continue our work with Natalie and Dr Yannis Papastamatiou of Florida International University. We were thus able to confirm the near-term pregnancy of one of two great hammerheads that were scanned (see figure 7). A pop-off satellite archival tag (PSAT) was deployed on this gravid female, which released from her 80 days later, in mid-July, about 100 kilometres (62 miles) east of Georgia. These data provided the first direct evidence that great hammerheads overwinter in Bimini and then in spring migrate north to the US eastern seaboard for parturition.

In collaboration with William Winram, founder and director of the Waterman Project, our team deployed seven PSATs on great hammerhead sharks. In addition, Dr Bryan Frazier, of the Department of Natural Resources, South Carolina, tagged a gravid female with a PSAT in August, which released on 25 December with a full dataset.

Photo by Michael Scholl

'Since its inception, the BBFSF has contributed significantly to scientific knowledge and education about sharks and their conservation (...) Through many of our publications, we have provided new information to improve, manage and protect shark stocks in The Bahamas and the USA.'

Our satellite-tagged hammerheads continuously recorded depth and temperature for between four and 270 days at intervals varying from two to 15 minutes. MSc student Lukas Moller of Wageningen University, The Netherlands, is currently analysing these data to examine how hammerheads deal with temperature and depth over time. The data are useful, for example, to inform commercial fishers where to place long-line fishing gear to reduce hammerhead by-catch. We have also used PSAT data to reconstruct migratory routes of this species after individuals leave Bimini in April. This year we hope to deploy Smart Position and Temperature Tags (SPOT, Wildlife Computers) to shed light on the efficacy of the Bahamas Shark Sanctuary and to provide us with improved location resolution for delineating migratory pathways and possible parturition sites for great hammerheads.

CAUSES AND CONSEQUENCES OF LEMON SHARK PERSONALITY

Doctoral candidate Félicie Dhellemmes, of the Humboldt Institute, Germany, was at Bimini from February 2015 until 2018, continuing and expanding our previous doctoral student's research into the ecological consequences of personality in sharks. Félicie is investigating the connection between behaviour and personality in free-ranging juvenile lemon sharks. The longitudinal nature of this project will enable us to examine, by means of genetic analyses, whether traits are inherited and to explore foraging specialisation in juvenile lemon sharks. Our aim is to reveal lemon shark life-history traits and movements within the context of cognition and personality research.

In connection with our annual PIT-tagging census in June 2017, 49 juvenile lemon sharks were transferred to specially designed holding pens and tested for behavioural traits of sociality. For example, one question asked whether some sharks were more social than others; another queried how lemon sharks explore a novel environment. For the trials, each of the 49 sharks was tested twice for repeatability of behaviour by scoring correlations between the two tests.

It is particularly problematic to monitor behavioural traits of free-ranging aquatic vertebrates across the span of several years. Most individuals use a large home range that increases in size as the vertebrate grows and they therefore become difficult to recapture. However, Félicie has progressed in recording and understanding how these behavioural traits express themselves through ontogeny as the sharks learn about their environment. Part of the study involved taking blood samples from 22 individuals at regular intervals in April, May and June 2017. Analyses of stable isotopes in the blood are representative of foraging habitat and type of food as well as energy storage. In addition, skin samples were collected throughout the study and are being analysed to look for correlations between isotopic signatures and personality. These studies initiated new collaborations with Dr Nigel Hussey of Windsor University in Canada and Dr Austin Gallagher, the CEO and chief scientist of Beneath the Waves Foundation. Preliminary findings suggest that the energy stores of young lemon sharks depend not on personality but on location and season.

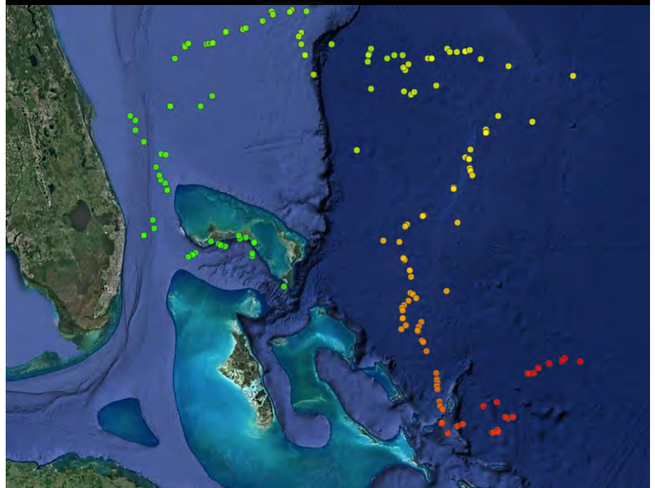
Do personality measures in captivity reflect those of free-ranging lemon sharks?

One of our long-term objectives is to examine whether personality affects life-history traits. Is rapid growth, for example, linked to sharks with exploratory personalities? In August 2017 we surgically implanted acoustic transmitters in 19 juvenile lemon sharks that had previously been tested for personality traits. These 19 individuals will be followed through summer 2018 with a combination of manual tracking from a moving boat and automated tracking via bottom-mounted acoustic receivers.

Over nearly three years of tracking we have found correlations between the home ranges of sharks using traditional movement analyses, such as maximum convex polygons and kernel distribution. We have also evaluated the number of 'zones' a shark moves through during personality trials and recorded the mean distance of each shark from shore as estimated during active tracking. In addition, we have looked for correlations between the individual tracked shark and its 'exploration score' in captivity trials. The preliminary results strongly suggest that behavioural traits of lemon sharks in captivity are a good proxy for behaviour

Figure 8
A transverse ultrasonic image of a full-term tiger shark foetus, showing the cranium, orbit, jaw and rostrum.

Figure 9
The satellite track of a female tiger shark SPOT-tagged at Bimini. The green dots are SPOT locations at the start of the track; the red dots are the most recent locations recorded.



in the wild. If confirmed, this finding will greatly aid our interpretations of personality and behaviour in free-ranging lemon sharks.

ECOLOGY OF THE TIGER SHARK

Tiger sharks play an important role as apex predators in many tropical and temperate ecosystems worldwide. At maturity, they can reach a length of more than five metres (16.4 feet), are able to consume large individuals and exert top-down control over a wide variety of prey. However, this control changes during ontogeny as the shark's size and habitat change. As tiger sharks are highly mobile predators capable of inhabiting diverse marine habitats, it is clear that their prey will vary greatly. We believe it is critical to use field research to improve our understanding of the movement patterns of tiger sharks and to find out how they transition through ontogeny to apex predators and how their role in the various ecosystems changes with age and in space.

Each year, we routinely and systematically set long-line fishing gear and capture tiger sharks that range in size from neonates to large, pregnant females. Due to the presence of gravid females and a high abundance of juveniles in the shallow-water sea-grass flats of the Grand Bahama Bank, we suggest that habitats around Bimini may be important pupping grounds for tiger sharks. It has, however, been difficult to confirm pregnancy or determine sites of parturition. This year, on 9 May, two female tiger sharks (one measuring 3.53 metres, or 11.6 feet, and the other 3.79 metres, or 12.4 feet, total length) were captured on monthly long-line surveys on the shallow sand flats south-east of Bimini. Biological samples were collected from them and 10-year acoustic tags were implanted. Using our donated ultrasound system, we were able to identify a number of full-term pups in both tiger sharks (see figure 8).

For years, our team has presumed that large, rotund females captured on our long-lines were pregnant. Ultrasonic confirmation of pregnancy removes the guesswork and enables us to equip females that we know are pregnant with fin-mounted satellite transmitters. We are thus now in a position to determine where these sharks give birth and whether Bimini is indeed a tiger shark nursery.

Additional questions we aim to investigate include whether gravid tiger sharks display atypical use of habitat and if there is a diet shift that might compensate for their reproductive status and metabolic requirements.

We will use ultrasonography to determine the reproductive status of captured female tiger sharks as well as the number and approximate size of any foetuses. We will also estimate the season of parturition, if there is one. In addition, tracks from the satellite transmitters will be analysed to determine likely pupping locations. In early December 2017, the first SPOT tag was deployed as part of this reproduction research. The tagged female, three metres (10 feet) long and not pregnant, travelled throughout the northern Bahamas and into pelagic water to the east (see figure 9). She has frequently left the safety of the Bahamas Shark Sanctuary, which is an important consideration for the management and conservation of this species.

PUBLISHED RESEARCH PROJECTS

LOCAL INDICATORS OF ABUNDANCE AND DEMOGRAPHICS FOR THE COASTAL SHARK ASSEMBLAGE OF BIMINI, BAHAMAS

Hansell AC, Kessel ST, Brewster LR, Gruber SH, Cadrin SX, Skomal G, Guttridge TL. 2017. Local indicators of abundance trends and demographics for the coastal shark assemblage of Bimini, The Bahamas. *Fisheries Research. https://dx.doi.org/10.1016/J.FishRes.2017.09.016*

Understanding population dynamics is essential for implementing effective management and conservation of shark populations. In this paper we analysed our 12-year (2004–2015) standardised long-line survey. Monthly sets comprised five long-lines totalling 75 hooks with a soak time of 24 hours. A total of 770 individuals representing nine shark species have been caught so far over the course of the study. The majority were tiger (87% immature), lemon (82% immature), nurse (62% immature) and blacktip sharks (67% immature). Females dominated the catch of tiger and blacktip sharks, whereas males were more prevalent in the capture of nurse and lemon sharks. Statistical models were used to tease out abundance and how catch rates were influenced by year, month, location, tide, hour of capture and lunar cycle. Trends indicated that more nurse, blacktip and lemon sharks were caught in summer. Results from this study improve our understanding of the coastal shark assemblage at Bimini and provide important local abundance estimates that will be beneficial for regional assessments and the conservation of these populations.

EFFECTS OF PREDATION RISK ON HABITAT USE IN JUVENILE LEMON SHARKS

Stump K, Crooks CJ, Fitchett MD, Gruber SH, Guttridge TL. 2017. Hunted hunters: an experimental test of the effects of predation risk on juvenile lemon shark habitat use. *Marine Ecology Progress Series. doi.org/10.3354/meps12187.*

Predation can affect prey populations either through direct consumption or as responses to risk, such as alterations in prey behaviour to decrease detection by or encounters with the predator. Effects of predation risk can be significant at

Photos by Michael Scholl

'One overarching goal the BBFSF focuses on is the recovery of shark populations worldwide and managing them effectively and sustainably for future generations.'

the population level. At Bimini, juvenile lemon sharks occupy mangrove-fringed shorelines as nursery areas. We investigated the use by young lemon sharks of an artificial mangrove structure as an anti-predatory device. Trials were conducted to discover which sharks used the protection of the artificial mangrove structure when a single, larger conspecific (known to prey on smaller conspecifics) was placed in the shark pen. We found a negative relation between body size and refuge use in the presence of a larger potential predator, suggesting to us that size is an important factor influencing anti-predatory behaviour. Test sharks exhibited a high degree of social swimming with other size-matched conspecifics, but the presence of a large conspecific predator usually elicited fright responses. This study is apparently the first experimental evidence of how intraspecific predator–prey interactions influence habitat use by juvenile sharks and it demonstrates the importance of finding refuge among mangrove roots as an escape tactic.

TESTING THE INFLUENCE OF FORAGING STRATEGIES AND NATURAL SELECTION ON SIZE AND GROWTH RATE IN JUVENILE LEMON SHARKS

Hussey N, DiBattista JD, Moore JW, Ward EJ, Fisk AT, Kessel ST, Guttridge TL, Feldheim KA, Franks BR, Gruber SH, Weideli OC, Chapman DD. 2017. Risky business for juvenile marine predator? An indirect test of the influence of foraging strategies and natural selection on size and growth rate in the wild. *Proceedings of Royal Society* 284: 20170166. *http://dx.doi.org/10.1098/rspb.2017.0166*

The mechanisms that influence the selection of body size and growth rate in free-ranging marine vertebrates are poorly understood. We tested whether there is selection for size-related traits of nursery-bound juvenile sharks that occupy two very different habitats: protected mangroves with low predation risk and exposed sea-grass beds with high predation risk. The juvenile sharks displayed a continuum of foraging strategies between mangrove and sea-grass areas, with some individuals preferring to feed in one habitat. We found that small, slow-growing lemon sharks foraged predominantly in sheltered mangroves, whereas larger, faster-growing lemon sharks fed over exposed sea grass. These data provide support for the hypothesis that selection favouring smaller size and slower growth rate – both heritable traits – may be driven by variability in foraging behaviour and predation risk. Such evolutionary pathways may be critical to adaptation within predator-driven marine ecosystems.

Photos by Michael Scholl

SCIENTIFIC OUTPUT

PUBLICATIONS

Six papers were accepted in peer-reviewed journals such as *Frontiers in Marine Science* and *Proceedings of the Royal Society*. Topics were varied and included social, foraging and refuge behaviour by lemon sharks; local indicators of abundance and demographics for nine of Bimini's coastal shark assemblage; and philopatry and regional connectivity of the great hammerhead shark.

PRESENTATIONS

BBFSF scientists, principal investigators and students presented at three conferences this year, including the American Elasmobranch Society (Texas, USA) and the 35th annual ethological conference (Lisbon, Portugal).

CONSERVATION

We are revealing migratory pathways of the Endangered great hammerhead shark. Approximately 30 individuals overwinter at Bimini and our preliminary findings indicate that females migrate to South Carolina, a movement we suggest is linked to parturition. Neonates have previously been documented in this region. In 2017 we ultrasonically scanned the reproductive status of two females at Bimini, finding that one was gravid. She was fitted with a satellite tag, which was subsequently released off South Carolina, providing support for our hypothesis that female great hammerheads migrate north for parturition. Continued tagging, coupled with genetic analyses and ultrasonic evaluation, will contribute new and important data on this highly mobile predator. Our movement data were recently shown to corroborate NOAA and Mote Marine Laboratory's bottom long-line fishery results, which are used to create Essential Fish Habitat (EFH) for great hammerhead sharks in the Western Atlantic and Gulf of Mexico. In 2018, our team will use MARXAN software to identify areas used by all tracked elasmobranchs at Bimini. The resulting data will also be valuable for drawing up the boundaries of the newly resurrected North Bimini Marine Protected Area.

EDUCATION & OUTREACH

STUDENTS

In 2017, BBFSF scholarships supported three doctoral candidates: Matt Smukall of the University of Alaska, USA; Félicie Dhellemmes of Humboldt University, Germany; and Maurits Van Zinnicq Bergmann of Florida International University, USA. We also hosted and supported field study by PhD candidate Dennis Heinrich, of Flinders University, Australia, on his project investigating time–place learning in lemon sharks. Two MSc students completed their field research for their degrees: Vital Heim, of the University of Basel, Switzerland, and Lukas Moller of the University of Wageningen, The Netherlands. Finally, one undergraduate student, Harry Gray of Cardiff University, UK, completed his senior thesis at Bimini.

INTERNS

For between one and six months in 2017, 38 interns representing countries throughout Europe and North and South America resided at the research station. They gained skills in marine research techniques, handling boats and field station operations, and assisted in the dynamic field research conducted at the BBFSF throughout the year.

UNIVERSITY COURSES IN SHARK AND MARINE BIOLOGY

University courses were completed at the BBFSF by 78 students from the following US academic institutions:

- Eckerd University (Florida): two undergraduate naturalist courses in shark conservation;
- Coastal Carolina University (South Carolina): undergraduate elasmobranch biology course;
- University of Minnesota (Minnesota): undergraduate tropical marine biology course;
- Florida Southern College (Florida): undergraduate tropical marine biology course.

RESEARCH EXPERIENCE

Thirty members of the public were hosted at the BBFSF over nine five-day intensive courses, during which they were exposed to hands-on field research and techniques applicable to sharks and rays.

HIGH SCHOOL STUDENT EXPERIENCES

Approximately 70 high school students from Camp Live Oak and Shedd Aquarium were hosted at the BBFSF and were given classes in marine and shark biology.

EDUCATIONAL OPEN DAYS

Thirty-five students from McDonald High School, North Bimini, were hosted at the BBFSF in March to educate young Bahamian people about marine biology and the importance of healthy marine ecosystems. On 10 November our outreach coordinator gave a lecture to 50 students at the local high school.

PUBLIC TOURS

Approximately 750 members of the public were given tours of our facility and offered lectures on current research, techniques and shark conservation. Public tours culminate with a visit to our temporarily captive sharks and rays.

BAHAMAS SCHOLARSHIPS

One-month scholarships were supported for two Bahamian college students in partnership with Bahamas Marine EcoCentre.

VET CLINIC

In 2017, four spay and neuter clinics were held at the BBFSF, providing important *pro bono* support for the ongoing control of Bimini's feral cats and dogs.

BEACH CLEAN-UP

The BBFSF organised and took part in seven local beach cleanups where approximately 500 kilograms (1,100 pounds) of trash was collected and removed.

Photo by Michael Scholl

Photo by Eugene Kitsios

Photo by Eugene Kitsios

Photo by Eugene Kitsios

Photo by Michael Scholl

Photo by Chelle Blais

Photo by Chelle Blais

MEDIA

FILM TEAMS

The BBFSF has hosted six film teams from the USA and The Netherlands, including four *Shark Week* specials: 'Hammerhead Invasion', 'Shark Storm', 'Phelps vs. Shark' and 'Shark School with Michael Phelps.' *Nature Zone*, with Dutch naturalist Dr Freek Vonk, was also filmed twice at the BBFSF. At the end of 2017, our team hosted Dr Zeb Hogan for filming of National Geographic's *Monster Fish*.

SOCIAL MEDIA

Through our online media platforms, we often provide 'live' updates in the field about our various research projects to 55,200 followers on Instagram, 8,566 on Twitter, 14,340 likes on Facebook and 47,000 unique visitors in the past 12 months to our website.

SHARK DOC, SHARK LAB

In partnership with the SOSF and author Jeremy Stafford-Deitsch in 2016, Dr Samuel Gruber helped to produce a compelling autobiography, which includes the early days of his work on sharks and how the BBFSF, also known as Shark Lab, was created. We were extremely gratified to see this book published and in 2017 proceeds from the sale of it, as well as donations, continued to generate funds, bringing the total to $183,000. These funds will go directly into the construction of a hurricane-proof, solar-operated facility in the near future.

FUTURE PLANS

SHARK LAB

In 2018 we expect to finalise architectural plans and government caveats and begin construction of a new facility to replace the ageing wooden duplex that is so vulnerable to fire and storm. We plan to build a fully functional 'green' and solar-operated structure that will withstand a category 4 storm and a three-metre (10-foot) storm surge. It will accommodate 22 to 24 staff and volunteers and we will add on a small 'president and visiting faculty' space with cooking, bath and private facilities. Pending agreements with The Bahamas' government and Cubbico Corp, Amsterdam, we anticipate breaking ground in late 2019.

HAMMERHEAD SHARKS

We are preparing for submission the manuscripts of our second and third papers on hammerheads, which will examine the movement and migration patterns of the great and scalloped hammerheads, with a focus on thermal and vertical use of the waters throughout the western North Atlantic Ocean.

NEW PROJECTS

We were pleased to welcome Dr Greg Skomal of the Massachusetts Division of Marine Fisheries and engineers from the Woods Hole Oceanographic Institution in February 2018 to deploy the Remus 100 'Sharkcam', a remote autonomous vehicle that followed two bull sharks for about 20 hours in total. The resulting programme will take the lead in a series of shark films for *Shark Week*'s 30th anniversary.

The BBFSF is officially recognised as a charitable organisation in The Bahamas as well as a 501(3)c US non-profit. It purchased the land occupied by the station and is currently coordinating planning to replace the existing facility.

THE ACOUSTIC TRACKING ARRAY PLATFORM

PAUL COWLEY

Photo by Paul Cowley

Paul Cowley

'A sustainable marine science platform that monitors the movements and migrations of marine animals tagged off the coast of southern Africa.'

BACKGROUND

South Africa's Acoustic Tracking Array Platform (ATAP), managed by the South African Institute for Aquatic Biodiversity (SAIAB), is one of several large-scale acoustic receiver arrays or networks around the globe. It was established to facilitate the large-scale and long-term monitoring of acoustically tagged marine animals, whereby SAIAB and its collaborating partners maintain the nationwide network of receivers. SAIAB manages the data downloaded from the receivers and sends researchers the information relating to their tagged animals. In this way, the ATAP provides a sustainable and cost-effective means for local researchers to gather data about the movement of the animals they are following. At the same time it fosters broader collaboration at an international level. To date, more than 25 researchers from 14 different organisations have benefited from the data collected by the ATAP.

THE SCIENCE

With 14 monitoring sites situated between False Bay (Cape Town) and Ponta do Ouro on the Mozambique border, the ATAP array spans some 2,200 kilometres (1,370 miles) of the southern African coastline. In addition, 20 estuaries throughout the region are equipped with moored receivers. In its current format, the array's design enables researchers to address a number of key questions pertaining to animal movement, including estuarine–marine connectivity, inter-estuary connectivity, bay-scale movements, movements in relation to MPA boundaries, large-scale annual migrations and trans-boundary movements. It also allows them to look at a host of ecological aspects, such as spawning aggregation dynamics and predator–prey interactions.

Since its inception in 2011, the ATAP has witnessed steady growth in terms of the number of species and individuals tagged. To date more than 750 individuals from more than 35 species have been tagged, with considerable focus on large sharks such as white, bull (Zambezi) and broadnose sevengill and, more recently, on batoids (guitarfish and stingrays). Many of the deployed tags have a battery life of up to 10 years and over this period will yield unprecedented insights into the habits of the tagged animals, which can be used to improve how they are managed and conserved.

2017 PROGRESS AND HIGHLIGHTS

Since its humble beginning as a project involving a few scientists sharing data, the ATAP has developed into a formal national research platform under the auspices of SAIAB's African Coelacanth Ecosystem Programme (ACEP), a flagship undertaking supported by the Department of Science and Technology. The success and continued growth of the ATAP meant that dedicated staff needed to be taken on board and at the beginning of 2017 two appointments were made: Dr Taryn Murray as the scientist responsible for data management and reporting; and Matt Parkinson as the marine instrument technician in charge of refurbishing and deploying the equipment to ensure that it operates successfully in the field. Dr Paul Cowley remains the principal scientist and ATAP

'To date, more than 25 researchers from 14 different organisations have benefited from the data collected by the ATAP.'

manager. The ATAP is a partner of the global Ocean Tracking Network (OTN) and Taryn was appointed to OTN's Data Management Committee. During 2017 she attended meetings in Germany and Canada. Paul also works closely with the OTN and is a member of its International Scientific Advisory Committee.

2017 was a year of integrating new technology. Firstly, capital equipment was secured with the help of the OTN and the National Research Foundation, resulting in the deployment of Vemco's new VR2AR receivers with a built-in acoustic release mechanism. With several additional features, such as a temperature logger and a sentinel tag, these new units have performed very well. Secondly, the ATAP partnered with 'Gliders in the Agulhas' (GINA), a multi-institutional project led by Dr Marjolaine Krug of the Council for Scientific and Industrial Research (CSIR) and Dr Juliet Hermes of the South African Environmental Observation Network (SAEON). An acoustic receiver was fitted to a remotely operated ocean glider that undertook a two-month maiden trip from Richards Bay to Port Elizabeth. Although only two detections of tagged animals were recorded during this experiment, the GINA project holds promise for the future integration of a mobile platform to the ATAP's existing static (moored) receiver network. Some modifications relating to how the receiver is attached to the glider need to be made and range testing will be required to assess the reception potential of the mobile receiver. In addition, a collaborative project with Oceans Research in Mossel Bay is evaluating the performance of a receiver attached to a vessel that undertakes daily sea trips. The results look promising and ATAP will be investigating ways to expand this approach to collect additional data on tagged animals.

As part of the funding received from the Save Our Seas Foundation, the ATAP releases an annual call for proposals to tag elasmobranchs in South Africa. In 2017, the award of 20 V16 transmitters went to Tamlyn Engelbrecht, a PhD candidate working on broadnose sevengill sharks under the supervision of Dr Alison Kock (of Shark Spotters and South African National Parks). Final reports have also been received from the two recipients of the 2016 tag awards, who each received 10 tags. The project on giant guitarfish under the leadership of Stuart

Photo by Paul Cowley

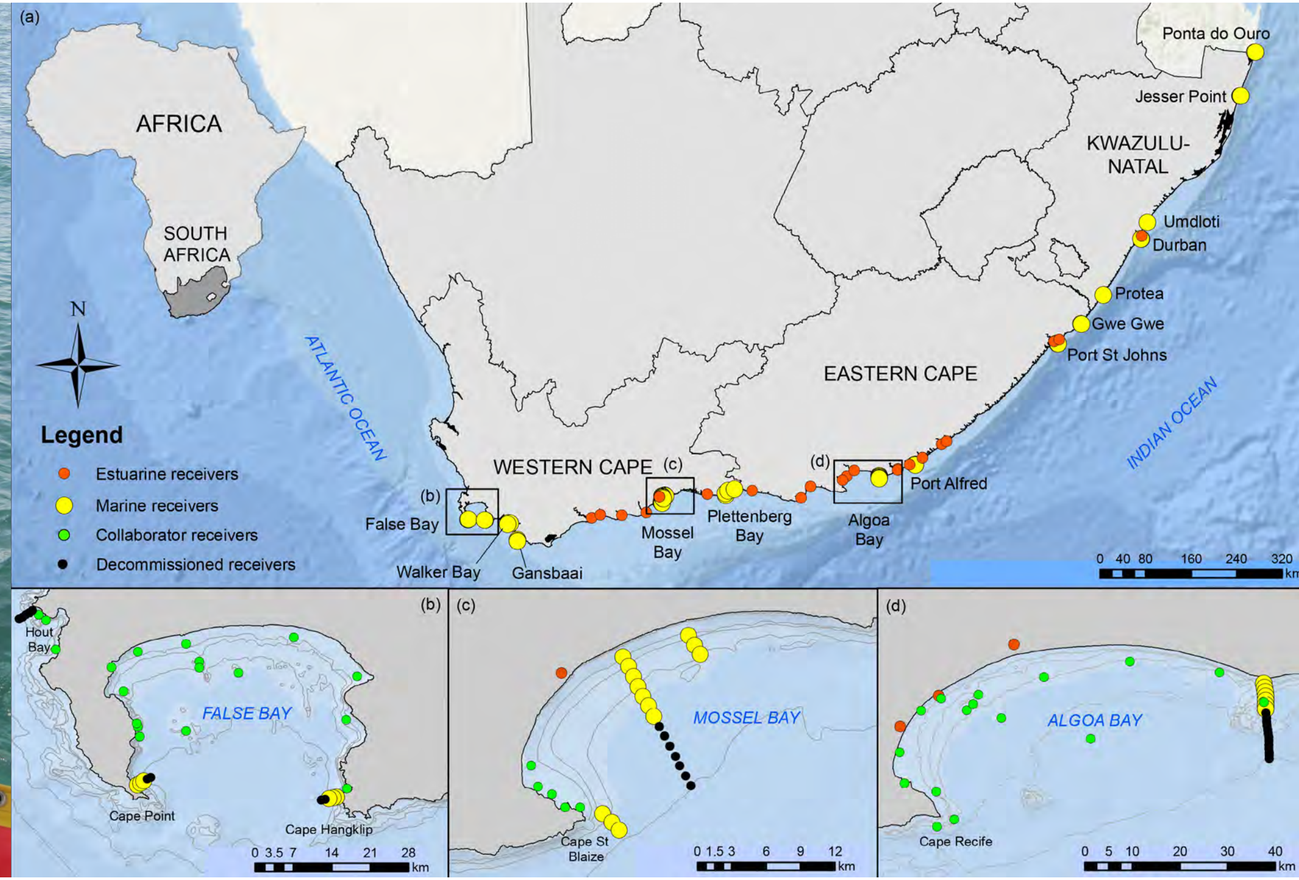


Photo by Bruce Mann

Photo by Kwan Dilly

Dunlop (Oceanographic Research Institute, Durban) achieved early success and the ATAP sponsored an additional 10 transmitters for this project in 2017.

The ACEP's open call for research proposals (on a three-year funding cycle) went out again in 2017 and three of the supported projects will be making use of the ATAP to achieve their research objectives. These projects will investigate: how large sharks use the deep-water canyons off the northern KwaZulu-Natal coast; the movement patterns of threatened rockcod species (groupers) and how effectively two marine protected areas are managed; and localised inshore movements in response to cold water upwelling by an important commercial fishery species.

Over the reporting period, ATAP researchers attended a number of fishing competitions that provided a great opportunity to not only tag additional animals, but also engage with anglers and inform them about our research activities and preliminary findings. The ATAP team managed to tag 21 blue stingrays in Algoa Bay and plans to tag another 20 individuals in Mossel Bay in 2018. Other elasmobranchs tagged at the competitions included five diamond rays, one duckbill ray, one spotted gulley shark, one smooth-hound shark and two bronze whaler sharks. Overall, 49 new animals were tagged in 2017.

Research resulting from data collected by the ATAP was presented at a number of conferences, including the 4th International Conference on Fish Telemetry (Cairns, Australia), the South African Marine Science Symposium (Port Elizabeth, South Africa), the Southern African Shark & Ray Symposium (Hermanus, South Africa) and the South Africa/Norway Programme of Research Cooperation (SANCOOP) Concluding Conference (Pretoria, South Africa). The presentations delivered were:

Bennett RH, Cowley PD, Murray TS, Childs A-R. 2017. Residency, migrations and mortality: the ups and downs of managing South Africa's national acoustic telemetry array. 4th International Conference on Fish Telemetry. 19–23 June 2017, Cairns, Australia.

Bennett RH, Cowley PD, Childs A-R, Murray TS, Naesje TF. 2017. Management considerations for estuarine fishery species in South Africa, based on a decade of acoustic telemetry research. South African Marine Science Symposium. 4–7 July 2017, Port Elizabeth, South Africa.

Cowley PD, Cliff G, Von Blerk P, McCord M, Filmalter JD. 2017. Movement patterns and residency of juvenile Zambezi sharks *Carcharhinus leucas* in the Mzimvubu Estuary, Port St Johns, South Africa. Southern African Shark & Ray Symposium. 10–13 September 2017, Hermanus, South Africa.

Photos by Paul Cowley

Cowley PD, Naesje TF. 2017. Migration ecology of fishes for improved fisheries management in South Africa. SANCOOP Concluding Conference. 4–5 December 2017, Pretoria, South Africa.

Engelbrecht T, Kock AA, Barnett A, Gennari E, O'Riain MJ. 2017. Site fidelity and sexual segregation of broadnose sevengill sharks (*Notorynchus cepedianus*) in False Bay, South Africa. South African Marine Science Symposium, 4–7 July 2017, Port Elizabeth, South Africa.

Filmalter JD, Day R, Daly C, Dagorn L, Cowley PD. 2017. Vertical behaviour of adult Zambezi sharks in coastal waters off southern Africa. Southern African Shark & Ray Symposium. 10–13 September 2017, Hermanus, South Africa.

Gennari E, Irion D. 2017. How stressful is internal tagging? Sub-lethal effects of tonic immobility and surgical implantation on the post-release behaviour of a ram-ventilating elasmobranch, the broadnose sevengill shark (*Notorynchus cepedianus*). 4th International Conference on Fish Telemetry. 19–23 June 2017, Cairns, Australia.

Murray TS, Smale MJ, Cowley PD, Childs A-R, Dicken ML, Goschen WS. 2017. Movement ranges and time scales in marine predators: acute and seasonal environmental drivers. 4th International Conference on Fish Telemetry. 19–23 June 2017, Cairns, Australia.

Murray TS, Smale MJ, Cowley PD, Childs A-R, Dicken ML, Goschen WS. 2017. Movement ranges and time scales in marine predators: acute and seasonal environmental drivers. South African Marine Science Symposium, 4–7 July 2017, Port Elizabeth, South Africa.

Murray TS, Cowley PD. 2017. Filling in the gaps: assessing movement behaviour of data deficient stingrays in South Africa using acoustic telemetry. Southern African Shark & Ray Symposium. 10–13 September 2017, Hermanus, South Africa.

Scarponi V, Gennari E, Hughes W. 2017. Bringing shark stress into perspective. Southern African Shark & Ray Symposium. 10–13 September 2017, Hermanus, South Africa.

Watson R, Gennari E, Cowley PD. 2017. Contrasting movement behaviour of *Poroderma* spp. in Mossel Bay, South Africa. Southern African Shark & Ray Symposium. 10–13 September 2017, Hermanus, South Africa.

In addition to these presentations, the ATAP hosted a stakeholder workshop at the Southern African Shark & Ray Symposium.

During 2017, the ATAP received 11 requests for data reports from its stakeholders and beneficiaries. The increasing trend in these requests provides testimony of data maturity and we anticipate that in the near future a number of publications will result from the data currently being collected.

In terms of scientific output, we published a paper highlighting the first five years of the ATAP in the *African Journal of Marine Science*.

Cowley PD, Bennett RH, Childs A-R, Murray TS. 2017. Reflection on the first five years of South Africa's Acoustic Tracking Array Platform (ATAP): status, challenges and opportunities. *African Journal of Marine Science* 39(3): 363–372.

The front cover of this journal issue, showing a photograph taken by Dr Ryan Daly, highlighted the ATAP. We also featured in the tagging newsletter of the Oceanographic Research Institute (ORI) with a popular article describing the ATAP's research on the giant trevally.

'The GINA project holds promise for the future integration of a mobile platform to the ATAP's existing static (moored) receiver network.'

EDUCATION AND OUTREACH

The ATAP engages with the public in many different ways. Once again we hosted a live exhibition during the annual SciFest Expo in Grahamstown in 2017, which was attended by thousands of young school learners. Towards the end of the year the ATAP management team hosted 11 students from around South Africa at a Summer School in Port Alfred, Eastern Cape. The students were primarily from historically black universities. The aim of the Summer School was to provide the students with hands-on experience in acoustic telemetry field techniques and introduce them to the research methodology. During the Summer School students witnessed a mock acoustic tag implantation in an anaesthetised mullet, were shown how we deploy acoustic receivers for estuaries, took part in manual tracking, were introduced to different transmitter types and were shown examples of acoustic telemetry datasets.

FUNDING

The ATAP's acoustic telemetry hardware has been secured from the Ocean Tracking Network project and the National Research Foundation. Running expenses and costs linked to servicing the hardware are provided by the Save Our Seas Foundation and the ACEP. Collectively, the support from these organisations has enabled us to establish a significant marine science platform off the coast of southern Africa.

Photos by Paul Cowley

PROJECT LEADER PROFILES

AN INTRODUCTION TO OUR NEW PROJECT LEADERS WHOSE PROJECTS WERE FUNDED DURING 2017

Photo by Michael Schmit

KYE ADAMS

Photo by Arturo Rioli

'Regardless of what many people may think, the most dangerous thing in the ocean is water, not sharks. In Australia, the ocean claims close to 100 people a year due to drowning, whereas shark incidents claim fewer than five.'

WHO I AM

I'm a professional ocean lifeguard and marine ecologist from Australia. I live on a street called Beach Road, which I suppose is a nice metaphor for my obsession with the sea. This obsession probably stems from my father, also a great ocean lover, who named me after the Hawaiian word for ocean. Pretty much all aspects of my life have an obvious connection with the sea and I find myself getting anxious when separated from the salt water for more than a few days. I grew up surfing and diving in the small coastal town of Kiama, on the south coast of New South Wales. I started lifeguarding straight out of school, a job that has taught me great respect for the ocean. When I'm not lifeguarding, I film, catch and tag sharks and rays as part of a collaborative project with the Department of Primary Industries that looks to conserve coastal shark and ray species.

WHERE I WORK

I spend most of my time in or on the Pacific Ocean, along the south-eastern coast of Australia. I work with the seasons and spend a fair chunk of summer staring out to sea, keeping track of the tides, waves and currents and the people who enter the ocean for enjoyment. I love that the ocean is so wild and that despite our best efforts we are yet to tame or even fully understand her. Regardless of what many people may think, the most dangerous thing in the ocean is water, not sharks. In Australia, the ocean claims close to 100 people a year due to drowning, whereas shark incidents claim fewer than five. There is a growing movement towards sustainably managing shark populations, given the inherent vulnerability of most sharks (dangerous or not) to exploitation. As lifeguards, my colleagues and I can proactively prevent drowning by providing safe swimming areas, yet it is frustrating that at present we are unable to adequately prevent shark incidents. The effectiveness of the current strategy of mesh netting to catch and kill sharks remains highly contentious: it is indisputable that shark nets have high levels of by-catch and the level of safety they provide is unknown.

WHAT I DO

Our main focus at the moment is to find a sustainable alternative to shark netting, which is primarily designed to catch and kill sharks (by drowning them). Based in the small coastal township of Kiama, we run a grass-roots shark spotting programme designed to provide continuous coverage of an area used for swimming or surfing. Our blimp-mounted camera system provides a high-definition aerial view to observers. In partnership with Kiama

Photos by Tom Keyes

Photos by Paul Jones | UOW

Council, we aim to provide adequate warning to beach users when sharks and other hazards are present in their vicinity. The advantages of a blimp are that there is no by-catch and that it can stay up all day to provide a continuous watch for sharks. Traditional drones may also prove useful for shark spotting, but they tend to have a short battery life that may restrict them to responding when a shark is spotted rather than providing continuous coverage. We are testing what environmental conditions the blimp could prove useful in for shark spotting, and by deploying shark analogues we are developing a shark spotting rate. This spotting rate can directly translate into an increase in swimmer and surfer safety, rather than providing a false sense of security. With further testing, and support from the Save Our Seas Foundation, we hope to conserve sharks by providing a zero by-catch alternative to mesh netting and still prevent shark incidents.

PROJECT AIRSHIP – A NOVEL, NON-INVASIVE AND CONTINUOUS APPROACH TO DETECTING SHARKS AT OUR BEACHES

AERIAL INFLATABLE REMOTE SHARK HUMAN INTERACTION PREVENTION

2017

AUSTRALIA

RESEARCH, CONSERVATION, EDUCATION

SHARKS

RIGERS BAKIU

Photo by Silvia Dumitrita

'It consists of collecting data from fishermen and marine-aquaculture workers about their catch and at the same time training them about the conservation of sharks and rays.'

WHO I AM

As a fairly level-headed person and a scientist, I am interested not so much in having my work published or becoming famous as in doing everything I can to protect the marine species off the wild coast of Albania. I am a biologist and while working as a researcher in Italy, which I did until 2012, I used to spend a lot of time in a lab. When I returned to Albania to work for my own country and every day I saw instances of marine species being killed, I decided to give up my previous career and instead get involved in projects to protect the Mediterranean monk seal, sharks and other marine organisms.

WHERE I WORK

I work at the Agricultural University of Tirana, specifically in the Department of Aquaculture and Fisheries. What is the daily motto in my department? Help and promote the best students, those who show passion for what they learn and do. I have therefore involved several students in my project and they have helped me to establish good communication with fishermen. They have also helped fishermen to understand and practise a sustainable approach to fishing. When I am not doing this, I plan and organise meetings and field trips, especially to coastal areas. I am always ready to help fishermen when they need it, and they help me by telling me when they encounter irregular fishing practices or come across unusual species. Thus, I have colleagues at the university and I have colleagues in the field on the Ionian and the Adriatic coasts, and I work with both groups.

WHAT I DO

I regard my work as a starting point for the conservation of sharks, skates and rays in Albanian territorial waters, and it focuses not only on pelagic species, but on all of them – and particularly on small benthic species taken in trawls. It consists of collecting data from fishermen and marine-

Photo by Kristian Begiri

Photo by Orik Durmishaj

Photo by Kristian Begiri

Photo by Marilyse Guima

aquaculture workers about their catch and at the same time training them about the conservation of sharks and rays. The sensitising process encompasses the coastal communities of Albania from the Drin Delta at Shkoder-Lezhe in the north to Saranda in the south. As a leader of this project, I think that it differs from others in Albania and neighbouring countries in that the fishermen, aquaculture workers and businessmen who take part are not just completing the questionnaires, but will also train other interested people. Furthermore, in each of the ports of Albania (Shengjin, Durres, Vlore and Saranda) my colleagues and I are conducting a survey of fisheries landings that involves mainly commercial fishermen, the actors of this theatre – or let's say, 'dramatic situation'.

BEGINNING OF SHARKS CONSERVATION IN ALBANIAN TERRITORIAL WATERS BY PERFORMING FISHERIES SURVEY AND SENSITISING COMMUNITIES
ALBANIAN CENTER FOR ENVIRONMENTAL PROTECTION AND SUSTAINABLE DEVELOPMENT
2017
ALBANIA
RESEARCH, CONSERVATION
SHARKS AND RAYS

RAMÓN BONFIL

Photo by Ramón Bonfil

'We need to gather more accurate scientific information about the life cycle and movements of devil rays and to identify hotspots of interaction with fisheries in order to inform better implementation of conservation regulations.'

WHO I AM

According to my mother, the first time I saw the sea I froze in awe and cried 'Too much water, Mom! Too much water!' I was two years old, city-born, and we were on the shore of the Gulf of Mexico, in that country's Veracruz state. As she took me into the waves I began to cry. But all that changed when I was eight and had the opportunity to live by the same sea for a whole year. I fell in love with the ocean and used to daydream about being a scuba diver while my cousin Juan and I played by the sea with toy submarines, divers and sea creatures. Sharks were always the biggest thrill: majestic, mysterious and, in a child's mind, mortally dangerous. It wasn't until I was about 11 that I saw my first real shark in an aquarium in San Diego. Sharks remained fascinating to me throughout my studies in marine biology at the Autonomous University of Baja California in Ensenada. However, I never thought it would be possible to become a shark scientist.

But life is full of surprises. For my first job after graduation I was charged with generating the basic information needed for the sustainable management of the shark fishery of Yucatán – the defining moment of my career! Although I knew basically nothing about sharks, I immediately fell in love with them and spent nearly five years teaching myself all I could about shark biology, ecology and fisheries.

Now, 30 years, an MSc and a PhD later, I have become an internationally recognised shark expert. My passion for sharks and rays has taken me around the globe conducting field research projects, attending science, management and conservation meetings, acting as a consultant and providing training courses. Perhaps most rewarding of all was working with live great white sharks. I was responsible for initiating research into the migrations and movements of great white sharks in South Africa and New Zealand, in collaboration with local scientists and government organisations, and in this way pioneering the study of great white sharks with different kinds of satellite tags. During this time I made the greatest discovery of my career: we tagged 'Nicole', a female great white shark that travelled from South Africa to Australia in the first recorded transoceanic return migration for any shark species. Interestingly, that's when I met my friend and the Save Our Seas Foundation's (SOSF) current CEO Michael Scholl, who collaborated with us on the project and whose own research was instrumental in completing the cycle of Nicole's return migration.

Although learning about this misunderstood, threatened and fantastically imposing fish was the highlight of my career, I have also worked in elasmobranch taxonomy and identification, fisheries data and assessment training, ecology and fisheries modelling, conservation and management.

WHERE I WORK

I have been lucky enough to work with sharks and rays while living in nine different countries (talk about a gypsy lifestyle!). However, I am currently leading two projects that have me dividing my time between Brazil and my native Mexico.

The first is a study on the spatial dynamics of devil rays in both countries. Our main study site in Brazil is an amazing, remote and inhospitable place of great beauty. The Archipelago of St Paul and St Peter sits right on top of the Mid-Atlantic Ridge, almost halfway between the easternmost tip of Brazil and West Africa – literally in the middle of nowhere! This equatorial rocky outcrop hosts a great diversity of marine life: dolphins, whales, tunas and jacks, billfishes, sharks and at least two, if not three, species of devil rays (*Mobula tarapacana* and *M. thurstoni*) and one of manta ray (*Manta birostris*).

The islets' barely 15,000-square-metre (3.7-acre) jagged surface of pure volcanic rock offers no easy footing for walking around and no protection from wind or sun. There is no fresh water and we have to bring every single piece of life-support and research equipment and all our food and water on a gruelling three-day boat trip from the Brazilian port of Natal. But the research station and accommodation built here by the navy has incredible facilities, including electricity, satellite phone and of course Internet (slow and iffy, but Internet nonetheless!).

With its abundant and pristine marine wildlife, this is a unique place for research – and adventure. Just a few metres from the shoreline, the sea floor drops to a depth of more than 4,000 metres (13,000 feet). There are numerous pelagic species, including marine turtles, which are a common sight around the islets and in the inlet, the archipelago's only shallow section. Working here and studying the majestic devil rays is truly a thrill and a privilege!

Our Mexican field site for the devil ray project is another fabulous place: the Whale Shark Biosphere Reserve at the edge of the Gulf of Mexico/Caribbean transition zone, just off the north-eastern coast of the Yucatán Peninsula. Every summer, this very special place hosts the largest known aggregation of whale sharks in the world. Because of this it also attracts large numbers of ecotourists – and they in turn bring additional threats to the ecosystem. The area is known too for its great biodiversity, which includes marine mammals, manta rays, devil rays, spotted eagle rays, various shark species, rock lobster, shrimp, four marine turtle species, many seabird species and large schools of sardines and anchovies, as well as hundreds of species of reef, pelagic and bottom fishes, and echinoderms, polychaetes and other marine invertebrates.

My second and latest project is on smalltooth and largetooth sawfishes, both of which are Critically Endangered, and it has me working all over Mexico. This exciting and challenging endeavour saw me and my team travel along the entire eastern coast and half of the Pacific coast of Mexico in 2015. In addition, I have recently surveyed some amazing sites, such as the large bays of Chetumal and Ascensión in Quintana Roo, most of the course of the Usumacinta River in Tabasco, the coastal lagoons of Tabasco and a couple of estuaries in Veracruz – all in search of the last living sawfishes in Mexico.

WHAT I DO

Both projects combine ecological and biological research with conservation efforts. Emphasis in the first is on unveiling the mysteries of devil rays: how they use different parts of the ocean and where they migrate to. We also compare the behaviour of ray species in each site and contribute to a global study led by the Manta Trust into the number of species, the relationships between different populations of devil and manta rays, and how these are exploited to supply the trade in their gill plates.

In recent years, the belief has arisen in China and eastern Asian countries that manta and devil ray gill plates possess magical powers to cure all kinds of human ailments. The trade driven by this dubious 'traditional Chinese medicine' is fuelling a huge increase in the fishing of these beautiful marine giants around the world. Brazil and Mexico have passed legislation protecting all manta and devil rays from fishing, but these measures are often poorly implemented. There are also many other countries that have not established similar legislation. We need to gather more accurate scientific information about the life cycle and movements of devil rays and to identify hotspots of interaction with fisheries in order to inform better implementation of conservation

Photos by Ramón Bonfil

Photos by Ramón Bonfil

regulations. We also need to convince other countries that all manta and devil rays should be protected with as many types of legislation as are needed, especially now that devil rays have recently been added to Appendix II of CITES. This is why it is crucially important for their conservation that we discover where the rays go during each phase of their life cycle; how many species there are and how to recognise them; and where and which populations of each species are being overexploited.

During our field trips we deploy cutting-edge electronic satellite tags that measure depth, water temperature and light levels every few seconds. The information from the tags is relayed to us via satellites, enabling us to follow the movements of each individual ray for several months at a time. Both difficult and exhilarating, tagging the devil rays involves free diving with them in order to attach the tags to their backs by means of small darts. The tags detach automatically after a pre-programmed period and relay the information to our laptops at home. During our field trips we also try to measure and sex each individual and obtain small samples of its muscle and skin. These samples will enable us to conduct population genetic and taxonomic studies that are

CONSERVATION AND ECOLOGICAL RESEARCH OF SMALLTOOTH AND LARGETOOTH SAWFISHES IN MEXICO

OCÉANOS VIVIENTES AC

2017

MEXICO

RESEARCH, CONSERVATION

SAWFISH

essential for mapping how many different species exist, their physical differences and which populations are being exploited for the gill-plate trade.

As I go to sea for each expedition, I am always filled with joy and awe at the prospect of swimming alongside these beautiful 'flying' sea creatures. I truly hope that with the combined efforts of everyone, we will preserve them for future generations to admire.

In my second and more recent project, I have focused my attention and hard work on saving sawfishes in Mexico – and hopefully also in countries of Central America in the near future. From a review I did in 2014 on the conservation status of sharks and rays in Mexico, I discovered that nobody had ever studied any aspect of sawfishes in my native country, even though these fishes are widely known to be on the verge of extinction globally. Therefore, since 2015 and shortly after my return to Mexico after living abroad for 25 years, I have been using various disciplines to try to save the smalltooth sawfish *Pristis pectinata* and largetooth sawfish *P. pristis* here.

We use sociological, ecological and conservation approaches in this project. The first stage, now nearly complete, has been to interview coastal and fishing communities along the entire coast of Mexico where we know sawfishes existed and where we suspect they may have existed. The information we have gathered helps us to understand the abundance and distribution of sawfishes in the past and, most importantly, their current status. This has also given us valuable insight into how important sawfishes were to Mexican fishers and what they were used for.

The second stage, which I launched last year, involves surveying coastal waters and rivers using non-lethal methods to search for the last remaining sawfishes in Mexico. For this, we are using traditional methods alongside cutting-edge technology: fishing nets and long-lines to try to capture live sawfishes, aerial transects with drones in areas with good water transparency, and innovative environmental DNA (eDNA) techniques. The last involves taking samples of water, filtering them on site and then sending the filtered material to a lab. There, geneticists extract the DNA that was floating in the water and, using special primers, look for sawfish DNA. Positive samples are then sequenced to find out if the DNA belongs to the smalltooth or to the largetooth sawfish.

We are currently planning field work to apply these combined methods and complete our survey of the entire former range of both species in Mexico. In this way we will be able to map which sites still host aggregations of sawfishes. As these areas are identified, we will launch strong environmental education and conservation campaigns in them in order to involve the local communities in the protection and recovery of these sawfishes. I strongly believe that the future of conservation lies in our power to educate, involve and empower local communities in the appreciation and protection of the habitats around them, as well as the flora and fauna those habitats contain. Most definitely, the enthusiastic support of the SOSF will go a long way towards helping us to contribute to the conservation of smalltooth and largetooth sawfishes in Mexico!

'By pairing 'fitbits' for sharks with tags that track their movements, we can tell how and where sharks are using or gaining energy.'

WHO I AM

I am often asked, 'What made you interested in sharks?' but I have never been able to nail down a specific time or event that sparked the obsession. As far back as I can remember, and as all of my childhood family stories go, there was never a time when I was not infatuated with sharks and dreaming of becoming a marine biologist.

However, growing up in landlocked Pennsylvania, USA, I had little contact with sharks outside of television and books. I made up for it by roaming local creeks and ponds and keeping home aquaria to get my fill of time with fish. By the age of 13, I had opted to replace my bed with a large saltwater aquarium so that I could watch fish endlessly and learn about how they interact with each other. But this was still not enough to satisfy me, and when it was time for college I jumped at the opportunity to pursue my lifelong dream of becoming a marine biologist.

I moved to Florida to attend the University of Miami and it was during an internship in a shark research lab that I found my calling. When I got back from my very first field research trip, I knew I was going to be a researcher for the rest of my life. Not only could I finally spend every waking moment learning about sharks, but I could use what I learn to help inspire the same passion in others and contribute to conserving shark populations for future generations to appreciate as I have.

From that point on, all my life and job decisions revolved around staying involved with shark research and conservation. One thing led to another and I now find myself lucky enough to be working on my PhD at Murdoch University, Australia, focusing on research using innovative tools to provide insight into the physiology and behaviour of sicklefin lemon sharks.

WHERE I WORK

St Joseph is a remote atoll ecosystem located in the Amirante Islands of the Republic of the Seychelles, which boasts a rich abundance of life. From the schools of yellowfin tuna outside the fringing reefs to the islands covered in hermit crabs and nesting shearwaters and terns and to the turquoise lagoon and flats swarming with rays, sea turtles and juvenile sharks, St Joseph is truly spectacular. As a research site, its remoteness limits human impact, allowing us to study how sharks function in undisturbed ecosystems – a rare opportunity in the age of global travel. Unlike in most atolls, St Joseph's young age is manifested as a

EVAN BYRNES

Photo by Ryan Daly

Photo by Ryan Daly

Photo by Jenna Hauptfleur

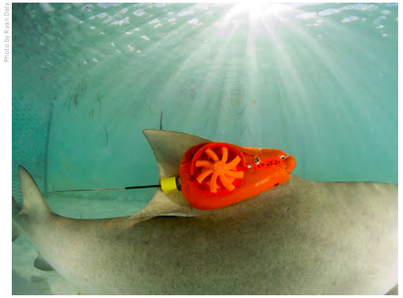


Photo by Ryan Daly

Photo by Ryan Daly

completely enclosed lagoon that excludes most large predators and provides a unique nursery habitat for juvenile sharks to flourish in. This access to sharks at all life stages is quite rare and offers the valuable opportunity to study how a shark's physiology and ecology change over the course of its lifetime.

WHAT I DO

Knowing how much space different animals need to survive is central to conservation planning. When it comes to marine animals such as sharks, however, we have a poor understanding of the factors that determine their home range. This is especially true for sharks, where reversing the decline of many species requires spatial management. This project aims to explore how the energetic demands of sharks govern the size of their home range, by using accelerometers to study how sharks use energy throughout different habitats. Accelerometers share the same technology used in popular fitness trackers, such as Fitbits, that measure the activity of people; when calibrated, they can determine the energy demand of individual animals, or sharks in this case. By pairing these 'fitbits' for sharks with tags that track their movements, we can tell how and where sharks are using or gaining energy. Additionally, we are using stable isotope analysis and prey surveys to investigate how sharks' diet and the availability of prey influence shark home ranges. Assessing how these factors govern the size of shark home ranges will help to forecast how environmental change may affect these animals and determine what measures can be taken to improve the design of marine protected areas to better conserve sharks.

HOME RANGE SCALING IN SICKLEFIN LEMON SHARKS THROUGH ONTOGENY – TESTS OF BIOENERGETICS MECHANISMS
MURDOCH UNIVERSITY
2017
SEYCHELLES
RESEARCH
LEMON SHARK (*NEGAPRION BREVIROSTRIS*)

Tony Dejean

Luca Fumagali

WHO I AM

I'm an ecological engineer and have a PhD in molecular ecology. My specialisation is the monitoring of aquatic biodiversity using environmental DNA (eDNA) and I actively participate in research and conservation projects in this field. I'm the founder, the scientific director and the chairman of SPYGEN, a French biotechnology company that focuses on molecular ecology and has become proficient in the monitoring of aquatic and terrestrial biodiversity using eDNA. In 2016 I also founded VigiLIFE, an NGO for the protection of the environment and sustainable development that works for nature and man and to maintain the close links that unite them.

WHERE I WORK

My work is based mainly in Europe (France, the Netherlands, Belgium, Germany and Norway), but I also contribute to several projects involved in the use of eDNA for biodiversity assessment. These are located in French Guyana (in collaboration with Université de Toulouse), New Caledonia (in collaboration with BioeKo), Vietnam (in collaboration with WWF Laos), Peru (in collaboration with WWF Peru) and Canada (in collaboration with Fisheries and Oceans Canada). Our expertise has contributed to the study of giant Mekong catfish in Vietnam, Arctic polar bears in Alaska and Sumatran rhinos from footprints. Using eDNA, we have described fish biodiversity along the lengths of the Rhône and Meuse rivers in Europe and the Maroni River in northern South America. In 2017, in collaboration with Monaco Explorations, the University of Montpellier, CNRS, EPHE, IFREMER, IRD and ETH Zurich, SPYGEN started a research programme to validate our technologies for monitoring marine biodiversity during a three-year expedition around the world aboard the oceanographic vessel *Yersin*.

WHAT I DO

For several years, SPYGEN has conducted numerous scientific studies in order to develop eDNA technologies and to evaluate their performance for the monitoring of biodiversity, especially in aquatic environments. I'm also at the origin of the development of new sampling technologies. These include SPYBOAT, an aquatic drone that allows DNA samples to be taken without any risk of contamination, and specific filtration capsules for the realisation of aquatic eDNA samples.

In 2018, with its ALIVe project (All Life InVentory using eDNA), SPYGEN won the 'Concours d'innovation' organised by the French government and ADEME as part of the programme 'Investing for the Future'. The ALIVe project aims to develop and standardise biodiversity inventory methods based on environmental DNA and to create a web-mapping platform to promote the sharing and processing of these genetic data. It also seeks to develop new biodiversity indicators to assess effectively the health status of ecosystems globally and track their evolution over time.

DETECTION OF SHARKS USING ENVIRONMENTAL DNA FROM SEAWATER SAMPLES
UNIVERSITY OF LAUSANNE, SPYGEN
2017
SEYCHELLES
RESEARCH
SHARKS, RAYS, TURTLES

Photo by Alyn Darby

TONY DEJEAN & LUCA FUMAGALLI

'The impacts of global climate change, habitat degradation, pollution, the introduction of non-native species and commercial exploitation all contribute to the high level of threat that could result in the extinction of sawfishes.'

WHO I AM

Twenty years ago I became involved in elasmobranch research by accident. I realised my passion when I saw the top predator of the ocean becoming the prey of human beings. Knowing that education was key, I believed that trust should be built between conservationists and communities so that we can communicate the importance of protecting species and habitats and explain that conservation offers a better future by ensuring the sustainability of community livelihoods by prioritising ecosystem services.

WHERE I WORK

Indonesia is known to have the highest diversity of rays in the world, including sawfishes. Between 1969 and 1971 more than 150 sawfishes were caught in gill nets in the waters of Lake Sentani–Papua. There is, however, no record of sawfishes having been caught since 1974. In 2016 the Indonesian government stopped the illegal trade of 53 sawfish rostrums, which indicates that sawfishes may still survive in Indonesian waters. While this is good news, the shortage of science-based information about sawfishes remains a challenge. Because of this, and because these species are vulnerable to becoming extinct, I decided to investigate the current status of sawfishes in Indonesia. In general, sawfishes have been caught incidentally in gill nets, and reports of their capture by traditional fishers have come from central Indonesia, such as Kalimantan Island and the eastern part of Papua province. Both these locations support habitat suitable for sawfishes, such as healthy mangrove forests and water of good quality.

WHAT I DO

The impacts of global climate change, habitat degradation, pollution, the introduction of non-native species and commercial exploitation all contribute to the high level of threat that could result in the extinction of sawfishes. These diverse factors are also likely to play a role in the decline of sawfish populations in Indonesian waters. At the same time, the species' biological characteristics, such as slow growth rate, long lifespan and low fecundity, make the situation worse. Because of this, the Convention

DHARMADI

Photo by Dharmadi

Photo by Armelle Jung

Photos by Armelle Jung

on International Trade in Endangered Species of Wild Flora and Fauna (CITES) has listed sawfishes on Appendix I, which means that the species can be caught only for research purposes and cannot be traded. They are also categorised on the IUCN Red List of Threatened Species as Critically Endangered.

In Indonesia, all the sawfish species are protected under state laws and regulations through Ministerial Decrees 'SK Mentan No.716 / Kpts / Um / 10/80 1999', which relate to the preservation of plant and animal species. There is, however, no science-based information that confirms the existence of sawfishes in Indonesia. This study has five primary aims: to conduct field surveys based on recent and historical sawfish catches; to raise public awareness of local and regional partners in sawfish conservation; to collect genetic samples of marine sawfish rostrums; to implement a network of allies for sawfishes; and to develop awareness of the plight of sawfishes and build capacity to counter it at different community levels. The study will also collect data about sawfish by-catch and feed them into national and regional statistics. Secondary data, such as traditional knowledge, will be collected by using questionnaires to interview all stakeholders, including local people and fishers in Muara Kintap–West Kalimantan and Merauke–Jayapura–Papua province.

SAWFISH STATUS IN INDONESIA
KEMENTERIAN KELAUTAN DAN PERIKANAN/ MINISTRY OF MARINE AFFAIRS AND FISHERIES
2017
INDONESIA
RESEARCH, CONSERVATION
SAWFISH

NIGEL DOWNING

Photo by Nigel Downing

'If the smalltooth sawfish, the most endangered of all the sharks and rays, is still [in the Casamance], it will be a massive find.'

WHO I AM

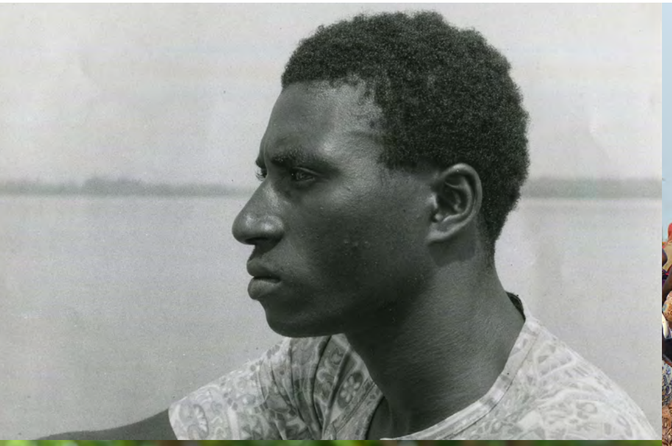
I suspect that I am somewhat of a curiosity compared to the normal recipient of an SOSF grant. Firstly, at the age of 65 I am probably older than most, although hopefully not the oldest! Secondly, I am no longer a full-time research scientist. And thirdly, I am resurrecting aspects of a project that consumed me more than 40 years ago when I was a young PhD student. Working at the Durban Aquarium between school and university, I quickly cottoned on to the fact that I liked sharks, and that to become a field biologist was my thing. I also knew quite a lot about the bull shark *Carcharhinus leucas*, which was the main culprit for a spate of shark encounters off Durban's beaches in the 1960s. What fascinated me was that this shark could enter fresh water. So, when at university the head of department said that sharks and rays were intolerant of fresh water, I happily pointed out the error of his ways. Thus the idea of a PhD was born – how do cartilaginous fish species such as the bull shark and sawfish adapt to fresh water?

WHERE I WORK

In my day job I work around the world, but it has nothing to do with where I am going with the SOSF award. That place is Senegal, and specifically the Casamance region. The Casamance is a river right in the south of the country. It flows from east to west and empties into the eastern Atlantic just a few miles north of the Guinea Bissau border. My base in the 1970s, it was where I discovered a treasure trove of sharks and rays using the estuary as a nursery ground. Bull sharks were in abundance in that area, but I needed live animals and it is not easy to keep this shark in confined spaces. However, smalltooth sawfishes were also very common there, but only at certain times of the year and in very specific locations. Luckily, I was able to discover both.

WHAT I DO

What I do now is probably dull to most scientists, so let me tell you what I *did do* for the PhD and what I am *going to do* with the SOSF award. They are linked. I took for granted the abundance of the sawfishes when I found them. I learned to catch them, keep them alive in the river and even transport them by air right up to the north of Senegal to proper holding facilities. More than 40 years on and every indication is that the smalltooth sawfish is all but extinct in the



Photos by Nigel Downing

STATUS OF SAWFISH IN THE CASAMANCE RIVER, SENEGAL, WEST AFRICA

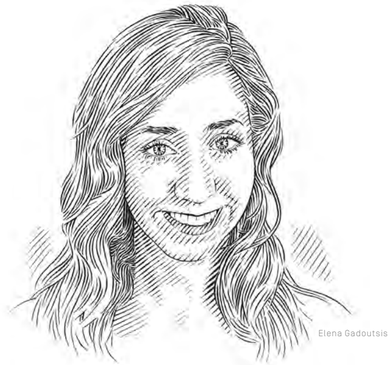
2017

SENEGAL

RESEARCH, CONSERVATION

SAWFISH

region. The big question is, does it still exist in the Casamance? I intend to do a short feasibility study to see if we can find out. If the smalltooth sawfish, the most endangered of all the sharks and rays, is still there, it will be a massive find and the implications for its preservation on the eastern Atlantic seaboard very challenging.



Elena Gadoutsis

WHO I AM

Most of my childhood was spent exploring the forests, rivers and lakes in rural Ontario, Canada, where I developed a great respect for nature and a fascination for the many species of birds, mammals and fish around me. Often my family went on camping trips to the beach, even journeying from the Atlantic coast to the Pacific. The ocean captivated me and I was constantly swimming, boating or snorkelling. I developed a deep empathy for all living creatures and was determined to rescue or adopt any animal, whether it was a stranded piglet in the middle of highway traffic or the prized fish my brother had caught. My passion for environmental protection led me to volunteer and I helped to rescue and rehabilitate a range of wildlife in my community.

Since I had an aptitude for science, particularly biology, I obtained my BSc in nursing and began a career as a registered nurse. I worked in the intensive care unit in a downtown hospital, helping critically ill people to stay alive. This is not the most typical path of a marine biologist, but it was this career that gave me the means to eventually pursue what I loved. I was able to travel, which I did as much as I could and always to the ocean. It was inspiring to learn that the ocean is largely (95%) unexplored, yet as humans we are completely dependent on it. Scuba diving became my window to the unknown underwater world. Although the ocean appeared pristine from above, below the surface I witnessed the interference from humans in the form of pollution and habitat degradation. Eager to go beyond saving people as a nurse or rescuing wildlife by volunteering, I understood that I could ultimately assist the world at a higher level. At this point, I decided to change my path to a career in marine conservation.

WHERE I WORK

I am currently completing an MSc in marine environmental management at the University of York in England. Along with a multitude of other projects, my main research involves examining the effects of light intensity on marine algae. As part of my MSc I have also undertaken a research dissertation with an external organisation. For this dissertation, I am lucky to be working with the Save Our Seas Foundation at the D'Arros Research Centre in the Seychelles. Having never been to the Seychelles before, I can only imagine the tropical beauty of the islands and the diversity of marine life. I look forward to learning what lies beneath the crystal waters of the Indian Ocean and the extent of anthropogenic impacts.

WHAT I DO

My research involves monitoring trends in the health of coral reefs at D'Arros and St Joseph. I will survey the reefs in the area while scuba diving and compare my findings with the data that have been collected since 2012. Worldwide, coral health is declining due to climate change and human impacts, which have accelerated over the past two decades. Any change in sea surface temperature can cause coral to expel energy-providing algae, which are vital for the survival of the coral. This

Photo by Ryan Daly

ELENA GADOUTSIS & JULIE HAWKINS

Photos by Ryan Daly

exposes the coral's white skeleton and is termed 'coral bleaching'. Unfortunately, coral bleaching is becoming more frequent and intense and can bring about devastating ramifications for places like the Seychelles. The destruction of coral reefs would remove an important habitat for multiple species and result in the loss of the valuable services the reefs provide. The study of coral reef health and the impacts of bleaching will guide the future management of the reefs and promote the development of long-term solutions in a changing climate.

ANALYSIS OF CORAL REEF MONITORING SURVEYS 2011–2017 AT D'ARROS ISLAND AND ST JOSEPH ATOLL

UNIVERSITY OF YORK, ENGLAND

2017

SEYCHELLES

RESEARCH

CORAL

'I believe it is important to identify which elasmobranch species are being commercialised the most and to determine whether endangered or protected species are being traded in Guatemala.'

WHO I AM

When I was a little girl I was always either in a swimming pool or in a lake during our family vacations. I have always loved being in the water and by the time I was 13 years old I already knew I wanted to study something related to the ocean. So at the age of 17 I left my home country of Guatemala and moved to Baja California Sur in Mexico to study marine biology. While studying for my Bachelor's degree, I was introduced to sharks and rays on a fateful field trip. Seeing so many sharks on the beach left an impression on me and prompted a decision to dedicate my professional life to studying sharks. For the next 12 years I lived in Baja California Sur. After completing my PhD I returned to Guatemala, where studies relating to marine biology – and especially elasmobranchs – are few and far between. Now, after several years of scientific training in Mexico, I am excited to be working in Guatemala and contributing to scientific efforts relating to conservation and management, principally of sharks and rays.

WHERE I WORK

For the past year and a half I have been conducting field work off the Caribbean coast of Guatemala, which forms part of the Mesoamerican Reef System. The field work has been carried out mostly in two fishing communities, El Quetzalito and Livingston, where shark fishing is one of the main sources of income for many families. Additionally, El Quetzalito is located inside the Refugio de Vida Silvestre Punta Manabique, a natural protected area that has a high diversity of flora and fauna.

WHAT I DO

The team I work with and I are trying to understand the local shark and ray fishery. We have been monitoring the elasmobranchs and gathering information about shark landings in Guatemala. The monitoring is vital to update scientific information about the status of sharks and rays in the country and provide a baseline of biological data for management purposes. Also, the data on the abundance and diversity of elasmobranch species in Guatemala will provide crucial information about the exploitation of these important resources.

ANA HACOHEN

Photo by Ana Hacohen

Photo by Cristopher Avalos

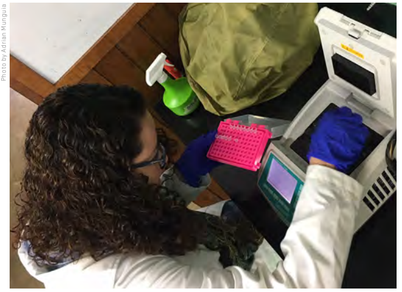


Photo by Adrian Munguia

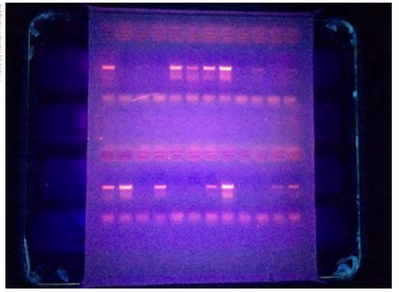


Photo by Adrian Munguia

Photo by Ana Haechen

In addition, there has been very little research into seafood labelling in Guatemala, much less any studies on which shark species are being sold and/or consumed. Sharks and rays are exploited by both artisanal and industrial fisheries, yet products derived from shark and ray fishing in Guatemala cannot be traced back to the species they come from. It is not known which species are commercialised and whether vulnerable species are being sold or bought.

In Guatemala, there is a strong tradition of consuming seafood during the weeks prior to Easter and dried fish (mostly dried fillets of shark) is one of the main products consumed during this time. The demand for shark products is thus particularly high between October and March. I believe it is important to identify which elasmobranch species are being commercialised the most and to determine whether endangered or protected species are being traded in Guatemala. By conducting this research we also aim to generate information that will help to create an awareness of the seafood products being sold and consumed in the country.

DNA TESTING TO IDENTIFY MISLABELLING OF SEAFOOD IN GUATEMALA
FUNDACION MUNDO AZUL
2017
GUATEMALA
RESEARCH, CONSERVATION
SHARKS AND RAYS

Jenna Hounslow

WHO I AM

The wild and all its treasures have fascinated me from an early age. My life began surrounded by the glorious karri forests and stunning beaches of the south-west of Western Australia before my family moved to rural England. I am lucky to have grown up on the River Test, an iconic chalk stream of outstanding natural beauty, and I used to tag along with my father, who was a fishery manager. I would camp out, fly fish and swim in the crystal-clear river to my heart's content. But it was always near the ocean that this water baby felt most at home, and many a family road trip was spent in eager anticipation of the moment I could finally shout out, 'I can see the sea!'

Having never outgrown the curious child in me, I have always been eager to travel, especially to wild places, and in Australia this led me to exploring the goldfields of the Outback, swimming in gorges in the Tropical Far North and marvelling at the fragile beauty of the Ningaloo Reef. In fact, I decided to move back to Australia permanently so that I could be near the ocean every day. I subsequently completed my undergraduate degree at Murdoch University, Perth, where I majored in environmental science. In my final year, I became inspired by an impassioned guest lecturer, Dr Adrian Gleiss, and discovered my own passion for aquatic ecology (unsurprisingly), and specifically shark science. By then there was no doubt that I would pursue a career in research so that I too could inspire those around me to protect and conserve.

WHERE I WORK

I am an Honours student based at the Fish Health Unit, Centre for Fish and Fisheries Research, Murdoch University. I am incredibly lucky to have received the opportunity to conduct my field work at the D'Arros Research Centre in conjunction with the Save Our Seas Foundation. I am so excited to learn as much as possible during my time on D'Arros and in the nearby St Joseph Atoll, which lie some 1,500 kilometres (930 miles) off the east coast of Africa in the Indian Ocean. It is amazing that my first real post-graduate experience of field work and collecting and analysing data will be at such a remote, pristine and special place that has such incredible biodiversity. The sandy beaches fringed with coconut palms, undisturbed interior forests, incredible coral reefs and shallow lagoons host an amazing array of creatures, from lemon and blacktip reef sharks to hawksbill and green turtles, manta and eagle rays, giant tortoises, hermit crabs, fairy terns and the infamous shearwaters with their ghostly calls!

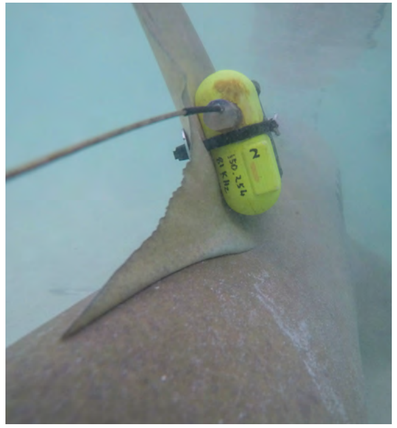
WHAT I DO

Understanding how, where and why animals behave in certain ways is essential for the development of marine conservation and management strategies. My study aims to classify the behaviour of sicklefin lemon sharks *Negaprion acutidens* using bio-logging

JENNA HOUNSLOW & ADRIAN GLEISS

Photo by Ryan Daly

Photos by Ryan Daly



DEVELOPING TOOLS FOR CLASSIFYING SHARK BEHAVIOUR FROM BIO-LOGGING DATA
MURDOCH UNIVERSITY, WESTERN AUSTRALIA
2017
SEYCHELLES
RESEARCH
LEMON SHARK (*NEGAPRION BREVIROSTRIS*)

tags called Accelerometer Data Loggers (ADLs). ADL technology is already found in smart phones and fit-bits, and custom-built tags can now be attached to a shark (or any animal) to measure its movement in three dimensions. This is especially useful where direct observation is limited. Observing the natural behaviour of sharks is very difficult, as they lead cryptic lives underwater and many species are nocturnal or highly migratory.

Although classified as globally Vulnerable on the IUCN Red List, sicklefin lemon sharks are abundant in the pristine and sheltered natural lagoon of St Joseph Atoll. The lagoon acts as a valuable nursery area and these sharks play a vital role in the ecosystem. Yet even though they are a common sight, relatively little is known about their behaviour.

Movement data from the ADL tags will be 'ground truthed' by conducting captive trials. An observation pen will be built in the lagoon so that the behaviour of a tagged shark can be directly observed from an exposed sand bank, in conjunction with drone video footage. Observed behaviours such as resting, swimming and fast-start swimming can then be time-synchronised to different patterns in the ADL data. Other sensors that will be incorporated to complement the acceleration data include a magnetometer and a gyroscope, which help measure rotational body movements. Furthermore, ADLs can be combined with other sensors (such as those recording depth, light and temperature) to give us insight into how environmental conditions, including tidal and lunar cycles, affect shark behaviours such as resting, foraging and mating.

Ultimately, the behaviour of tagged wild sharks can then be inferred from logged data alone without the need for captive trials or direct observation. This will contribute to the protection of this species and its habitat.

WHO I AM

I would be lying if I were to say that I knew from an early age what I wanted to be when I grew up. Like most people of my age, I was raised with constant affirmations that I could be whatever I wanted to be. But if you've ever been to a restaurant with an encyclopaedia for a menu, you know how difficult it can be to decide what you're eating. My parents encouraged a calling that was noble, suited my talents and came with an attractive salary. So I was to become a doctor. It didn't take long at university for me to realise that this wasn't my calling. A discouraging period of confusion, hopelessness and rebellion soon followed and after picking up what few pieces I could salvage, I managed to graduate with a degree in general biology. An opportunity to travel to a new continent and participate in a marine research programme seemed like the perfect change of pace. It was an experience that would leave me gobsmacked, awakening a latent curiosity and fascination for the ocean that had been right in front of me my entire life, yet had somehow escaped notice.

WHERE I WORK

South Africa has always been at the heart of the white shark conversation. In 1991 the country was the first to afford precautionary legislative protection to the species, a booming ecotourism industry brings in millions of dollars every year, and video footage filmed here graces television screens around the globe annually. Still, despite all the attention, very little is known about the population status of these animals. More and more, this missing information is dominating the conversation as legislators and stakeholders in South Africa and around the world attempt to balance the safety of humans with the protection of an animal that has an infamous reputation.

A fundamental step in determining the necessity and quality of conservation measures is a comprehensive population assessment. White sharks in South Africa are known to aggregate around accessible seal colonies in False Bay, Gansbaai, Mossel Bay and Algoa Bay; all close to large cities and popular beaches. This makes the sharks easy to study – and ripe for persecution. In fact, several attempts have been made to estimate the abundance of this species from photographic identification records. Each study, however, was based at just one of these aggregation sites. Preliminary results from tracking studies reveal movement between these sites that would preclude conducting a population estimate at just one location.

WHAT I DO

Traditional methods for estimating population demographics for elusive species rely on capturing individual animals, marking them so that they can be uniquely identified, and counting how many are recaptured at a later occasion. This capture-mark-recapture framework enables us to estimate the probability of capturing an individual and the probability of its survival. Extending this model further also enables us to estimate the size of that species' population. Capturing a white shark is a tricky endeavour so in the past abundance estimates

Photo by Dylan Richards

DYLAN IRION

Photo by Dylan Irwin

Photo by Dylan Irwin

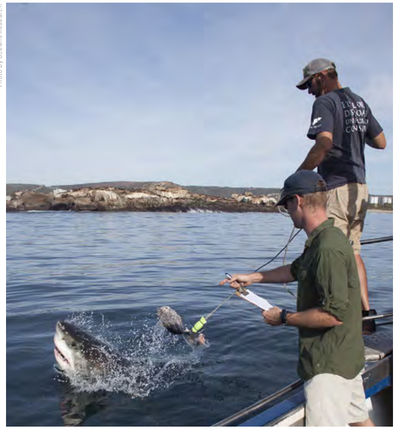


Photo by Oceans Research

for white sharks have utilised less invasive methods, capturing instead a photograph of the dorsal fin and using the unique patterns and notches on the fin to identify individuals.

Years of collecting these data have revealed several things. First, that other researchers are very protective of their photographs – but this is changing! Second, not every shark approaches our research vessels with equal chance, which is particularly problematic for this type of population model. Our project aims to overcome these limitations by first bringing together several large photographic datasets in a massive collaborative effort between researchers at each of the major white shark aggregation sites in South Africa. The project then aims to reduce the limitations of photo-based mark-recapture by using internally implanted acoustic tags as our 'mark'. These tags can then be detected (or 'captured') at a number of acoustic receivers that span the entire southern African coastline. But rather than abandon photo-based methods altogether, we will be incorporating both datasets into an integrated model to arrive at the first robust estimate of abundance for the white shark in southern Africa. At the same time we will be developing methods that can be applied globally.

ESTIMATING THE ABUNDANCE OF THE WHITE SHARK IN SOUTHERN AFRICA WITH AN INTEGRATED POPULATION MODEL

OCEANS RESEARCH

2017

SOUTH AFRICA

RESEARCH

GREAT WHITE SHARK (*CARCHARODON CARCHARIAS*)

Photo by Sergey Uryadnikov | Shutterstock

WHO I AM

I am a lover of the sea. I imagine that this kind of love is normal for someone like me, who was born and raised in the marvellous environment of the Canary Islands. Growing up near the sea, I have always felt a strange attraction to the ocean. Experiencing this allure – and the peace that it brings – every day makes me forget all my problems, whatever they may be.

My first contact with the sea came when I was only a child and every weekend I visited the beach with my family. I remember my first explorations of rock pools and my encounters with small species such as beautiful shrimps, with their incredible leaps out of the water, and different fish species, each one more strikingly coloured than the last. The appeal of the sea continued to grow and in my case I think led me to feel the same passion for the species that live in it.

For this reason I have spent more than two thirds of my life observing and learning about the different species that inhabit the entire archipelago of the Canary Islands. To begin with I observed them from the surface, during my first snorkelling sessions, but as I gained experience as a diver I gradually went deeper and learned more. I think that's why I decided at some point to study marine biology. For me it's incredible to see all these animals in their own environment and to watch how calmly they move when they swim, how they float up and down using the currents and how they have total control of everything around them.

WHERE I WORK

I am fortunate to be able to work in this lovely archipelago. If you look up the Canary Islands in Wikipedia, they are defined as 'A group of islands in the Atlantic Ocean, off the north-western coast of Africa, forming an autonomous region of Spain; capital, Las Palmas; population 2,098,593. The group includes the islands of Tenerife, La Gomera, La Palma, El Hierro, Gran Canaria, Fuerteventura and Lanzarote.'

Obviously, there is more to the Canary Islands than this description. Surrounded by the sea and with an incredible coastline, they have amazing beaches, mountains and views, as well as great weather all year round. A massive number of marine species are found in these waters, including pelagic and benthic species with extraordinary colours and forms, and they range in size from the enormous whale shark to tiny nudibranchs and frogfishes. In summary, the Canary Islands are a paradise to live in.

Unfortunately, they're not the best place for the survival of marine species. There are no data about activities such as recreational fishing in the archipelago, and management of the environment is poor, with weak laws and a high degree of ignorance about the biology, ecology and abundance of its species.

WHAT I DO

Our group is dedicated to studying elasmobranchs in the Canary Islands and increasing their chances of survival. One of the marvellous species we are studying is the spiny butterfly ray

DAVID JIMÉNEZ

Photo by Pedro Sarmiento

Photo by Pedro Sarmiento

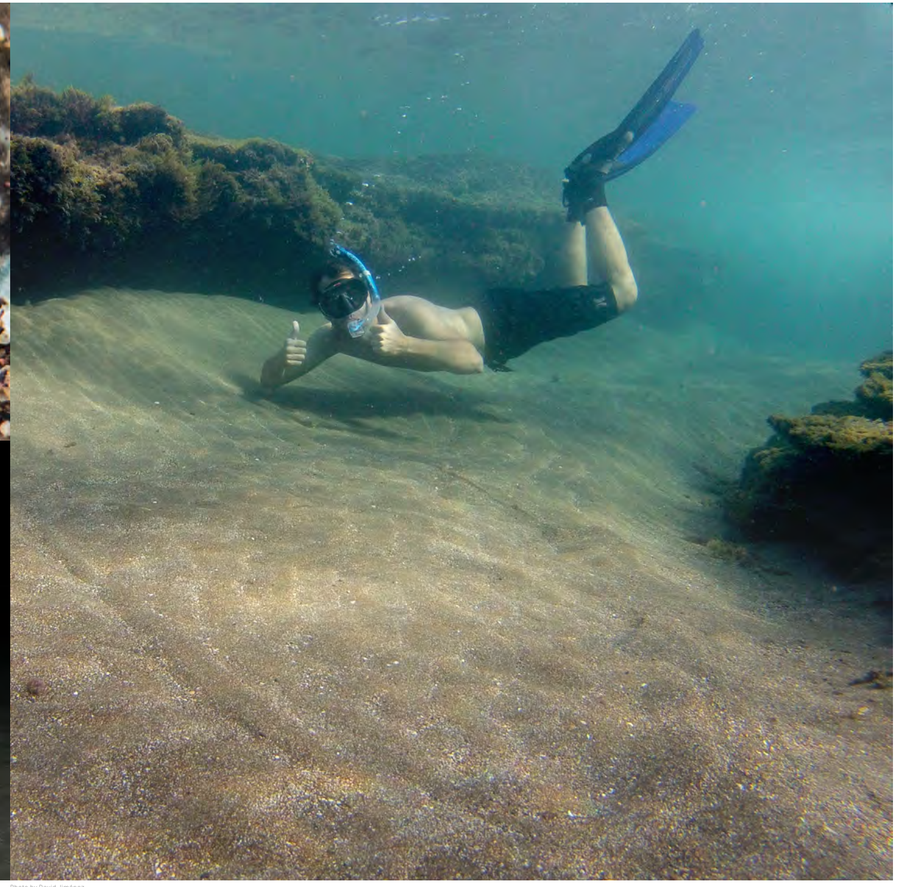


Photo by David Jiménez

Photo by Pedro Sarmiento

Gymnura altavela, which is categorised as Vulnerable on the IUCN Red List of Threatened Species. The entire Atlantic population of this ray, including in the Canaries, is decreasing due to it being taken as by-catch in both professional and recreational fisheries. However, it can be regularly encountered in Gran Canaria, where there is an important breeding hotspot.

Yet knowledge about this species is still very poor. We know nothing about its behaviour, distribution or abundance. Making use of the tools available to us – in this case the different citizen science programmes with online databases, combined with a visual sampling programme – we will be able to provide basic information about the ecology of these incredible rays.

Our goal this year is to expand the existing knowledge of this species in the Canary Islands, particularly around the island of Gran Canaria. In addition, we aim to get a better understanding of the patterns of its distribution and abundance along the coastal areas of the island. This information will enable us to better manage the habitat of this species, which is currently Vulnerable but may be reclassified as Endangered or Critically Endangered in the near future.

RAYS OF PARADISE – ECOLOGY AND DISTRIBUTION OF SPINY BUTTERFLY RAY IN GRAN CANARIA, CANARY ISLANDS

BIODIVERSITY AND CONSERVATION RESEARCH UNIT, UNIVERSITY OF LAS PALMAS DE GRAN CANARIA

2017

CANARY ISLANDS, SPAIN

Research, Conservation

Spiny butterfly ray (*Gymnura altavela*)

BRYAN KELLER

Photo by Bert Swanson | Shutterstock

WHO I AM

I grew up in Tucson, Arizona, part of the Sonoran Desert. People often ask how a kid from the desert could become so interested in the ocean and quite frankly, it wouldn't have been possible without my parents. I remember taking many trips to California to visit beaches and aquariums, visits that crafted my appreciation for marine life. The animals we saw were all mesmerisingly beautiful, but I was far more intrigued by the mystery that surrounded them. Specifically, I remember watching a pufferfish swimming by itself in a fish tank and I could have sworn it was watching me through the glass. This experience ultimately shaped my desire to study animal cognition and behaviour.

Many years later I earned my BSc from the University of Arizona. Out of all my undergraduate experiences, I am most proud of reorganising the fish collection. There are more than 175,000 specimens in the collection and they were largely unorganised as recent developments in molecular biology had rearranged the phylogenies. For a research project I organised the room like a library. I felt like the stereotypical librarian who could locate any book within seconds, except I wasn't locating novels.

During my time at the University of Arizona I interned at the National Aquarium in Baltimore. This experience opened the door to the Bimini Biological Field Station, where I would spend the next three summers. The Shark Lab, as it is often called, has greatly influenced my interest in shark research, whether it was helping Jean Finger study shark personality or swimming with a 14-foot tiger shark – my life was forever altered!

WHERE I WORK

My project, which served as my Master's thesis, was carried out at the Bimini Biological Field Station. Bimini is surrounded by the bluest water I have ever seen; it is easy to get lost staring at the picturesque scenery. Speaking of the landscape, it's impossible to get away from the ocean – it is everywhere! Bimini is so small that in certain areas I could throw a baseball right across the island, and I don't even have a good arm. The people at the Shark Lab are drawn to work on Bimini mainly for one reason: the sharks. Dr Samuel 'Doc' Gruber realised the ecological value of this island and created the lab in 1990. Without his efforts, I wouldn't be doing what I am today. Doc has changed my life and the life of every volunteer who has walked through the doors of the Shark Lab.

After earning my MSc, I enrolled at Florida State University (FSU) to work on my doctorate. I conduct field research at the FSU Coastal and Marine Lab in St Teresa, Florida, and near Charleston, South Carolina. For the next few years I will be conducting research primarily in these two regions.

WHAT I DO

The possibility of determining what factors influence animal behaviour intrigues me and my project – investigating how familiarity influences partner preference – has allowed me to do just that. Together with my advisers, I developed a protocol to examine this question and identified a behaviour that had not yet been diagnosed in sharks. The preference for associating with the familiar is widespread across the

Photo by Renee Richardson

Photo by Renee Richardson

Photo by Ryan Kelly

animal kingdom. Let me prove it. Take your dogs to a dog park and watch; they will hang out more with each other than with strangers. It's pretty basic behaviour, but do sharks do the same thing? Of course they do! My team found that sharks show a statistical preference for animals they live with compared to strangers.

After coming back to South Carolina for graduate school, I have given more than 20 presentations. This project has advanced scientific understanding of the mechanisms of group formation, and at the same time has educated children about shark conservation. Both of these outcomes will help to protect our oceans, the main goal of the Save Our Seas Foundation.

My current research focuses primarily on assessing the role of magnetic-based navigation in the movement of coastal sharks. Scientists have known for decades that certain species of sharks return to the same location each year. This is similar to a sea turtle returning to the beach where it was born. This 'philopatry' is very interesting, but we do not know what navigational mechanisms the sharks use during migration. The main theory is that they employ magnetic-based navigation, perhaps using the earth's geomagnetic field as a compass. My work will explore this possibility.

ASSESSING THE ROLE OF MAGNETIC-BASED NAVIGATION IN THE BONNETHEAD SHARK
FLORIDA STATE UNIVERSITY
2017
USA
RESEARCH
BONNETHEAD SHARK (*SPHYRNA TIBURO*)

Photo by James Kilfoil

JAMES KILFOIL

'Unmanned Aerial Vehicles (UAVs) may offer a non-invasive solution to study smalltooth sawfish in previously inaccessible environments.'

WHO I AM

From the time they were children, many marine biologists have known exactly what they wanted to be. You'll often hear stories about how growing up on the coast and swimming and diving with the fishes they now study led them to this wonderful career. I, however, was born and raised in Missouri, USA, and as a child had very little exposure to the ocean. I didn't even know the job of marine biologist existed. It wasn't until my last semester of undergraduate courses, studying abroad in Australia, that this began to change. I was able to take electives in marine biology, scuba dived for the very first time off the Great Barrier Reef and was exposed to individuals who had decided to turn their passion for the marine world into their life's work. In a word, I was hooked! I returned to the USA and immediately began applying for graduate programmes in marine biology and fisheries. I haven't looked back since and now I can't imagine doing anything else.

After I've explained how a kid from Missouri grew up to be a marine biologist, the second most common question I get is, 'Why sharks?' The simplest answer I can give is, 'Why would you want to study anything else?!' The unique morphology, physiology, behaviour and functional role of elasmobranchs provide the perfect subject for a curious scientific mind. This, coupled with recent declines in many populations on a global scale, makes the study of these animals of utmost importance if we are to ensure healthy marine ecosystems for future generations.

WHERE I WORK

The bulk of my dissertation research focuses on ways to improve video surveys used for the study of shark and ray populations. Accordingly, our efforts are often restricted to environments where using video surveys are considered a practicable research tool. This means we regularly work in clear, relatively shallow and often tropical marine environments. As a part of this work, I spend the bulk of my summers on research vessels in French Polynesia, the Florida Keys

Photo by Lisa Ailloud

Photos by James Kilfoil

EXPERIMENTAL VALIDATION OF UNMANNED AERIAL VEHICLES TO SURVEY SMALLTOOTH SAWFISH IN THE BAHAMAS

FLORIDA INTERNATIONAL UNIVERSITY

2017

BAHAMAS

RESEARCH

SMALLTOOTH SAWFISH (*PRISTIS PECTINATA*)

(USA) and The Bahamas. The diversity and density of elasmobranch populations in these study sites are very different, which enables us to develop and test new tools and techniques that can be applied broadly to a variety of systems.

WHAT I DO

Nearly half of all sharks and rays are considered 'data deficient,' which means that we lack the most basic of information needed to protect their populations effectively. We must find new and innovative sampling methods to address these current gaps in knowledge, particularly for species threatened with extinction such as the Critically Endangered smalltooth sawfish *Pristis pectinata*. A potentially independent population of smalltooth sawfishes has recently been identified in The Bahamas and has been suggested as a research priority for future recovery efforts. However, traditional sampling methods (long-lines and gill nets) are not well suited for this species in the region, given the invasive nature of the equipment and the sawfish's preference for a shallow-water mangrove habitat. Unmanned Aerial Vehicles (UAVs) may offer a non-invasive solution to study this species in previously inaccessible environments. Working with the Save Our Seas Foundation, we will be conducting the first standardised UAV survey of the smalltooth sawfish in The Bahamas. Furthermore, we will use model and captive shark proxies to estimate current detection rates for UAV surveys, while exploring technical innovations to increase detection probability. Through this work, we hope to not only further the conservation of the smalltooth sawfish, but also develop methodologies that are broadly applicable to many of the world's data deficient shark and ray populations.

WHO I AM

My interest in aquatic science started early, as I grew up fishing in Lake Victoria in Tanzania along with other young children of my age. Even before I started school, I became aware of various different fish species. This made me eager to learn more about the biology of fishes and their environments, as well as ecological systems in general. After graduating from secondary school, I was persuaded to pursue studies in fisheries for my Bachelor and Master's degrees. I wanted to learn about the creatures of the sea, most of which differ from freshwater species. Immediately after my studies, I was employed by the Tanzania Fisheries Research Institute (TAFIRI) and assigned duties in the Indian Ocean. That is how I found myself involved for the first time in marine fisheries research and coastal conservation. In the course of my research I would sometimes come across various ray species. However, I was aware that, apart from encounters such as these, especially during marine expeditions, there are still large gaps in our knowledge of these species. It was this that pushed me into conducting intensive research on rays to provide accurate scientific information about their biology and to what extent they are fished, so that effective measures can be undertaken to protect them.

WHERE I WORK

The project is being conducted in the Mafia archipelago, Tanzania, which consists of one large island (394 square kilometres, or 152 square miles) and several smaller islands that are also inhabited. The stretch of water between the delta of the Rufiji River and the main island is called the Mafia Channel. The river and delta create a productive estuarine ecosystem in the adjoining coastal waters, including around Mafia Island, and provide important nursery and feeding grounds for diverse marine species. The ecosystem is also influenced by monsoon winds: the north-east monsoon wind, which blows from November to March and is normally characterised by high air temperatures, low wind speeds and relatively calm seas; and the stronger wind of the south-east monsoon, which occurs between May and September and brings lower air temperatures, cloudy skies and rough seas. The two distinct monsoons result in two distinct wet and dry coastal seasons.

The Rufiji–Mafia Channel connection is linked to the system of ocean currents and coral reefs that extend towards Mafia Island in the east and together, via the northward flow of marine currents, they influence the abundance of fishes around the islands of Zanzibar. However, the unique Mafia Island ecosystem also produces a vast array of larvae, which are swept into the Indian Ocean and carried northwards by the prevailing North-east African Coastal Current, ultimately contributing to the rich diversity of marine life found as far north as the Red Sea.

Given the ecological importance of Mafia Island, I believe it is important to conduct research in

Photo by Patroba Matiku

PATROBA MATIKU

Photos by Patrobas Mahiku

ARTISANAL FISHERY OF RAYS FISH IN RELATION TO LOCAL LIVELIHOODS IN MAFIA DISTRICT, TANZANIA

TANZANIA FISHERIES RESEARCH INSTITUTE (TAFIRI)

2017

TANZANIA

CONSERVATION

RAYS

this area to understand what is really happening to its various ray species.

WHAT I DO

This project has been set up following the decline in ray landings on Mafia Island compared to other fish landing sites along the coast of Tanzania. The island's economy is heavily dependent on fishing because other sources of income are restricted. Agriculture, for example, is limited by poor soil and low capital investment, while Mafia's isolation hinders the development of business enterprises. Recent population growth on the island, together with an increase in the number of migrant artisanal fishers, has boosted the demand for marine resources. Rays are particularly vulnerable, as they are sun-dried by impoverished coastal communities on Mafia to make *Ng'onda* for future consumption. Reductions in annual ray landings, as reported by the Tanzanian Fisheries Division between 2007 and 2015, have given rise to fears that ray stocks are being overfished as a result of increased fishing effort targeting these species.

The aims of this project are to provide solid scientific information about the ray fishery around Mafia and to contribute to legislation relating to the operation and management of the fishery. To achieve this we will obtain biometric data from local fishermen at fish landing sites. We will also investigate what the fishery means for the livelihoods of the people of Mafia Island; organise public events to increase awareness about conservation; and propose strategies to avoid further declines in ray populations. We will collect social demographic data by conducting a questionnaire survey and semi-structured interviews, adapting the framework developed by Ellis (2000) to do so.

'Together with ESMOI (Ecology and Sustainable Management of Oceanic Islands), we are using Baited Remote Underwater Video Systems (BRUVS) to answer questions about the sharks of Easter Island. So far we have made two BRUVS deployments, during which we recorded 11 fish species, including the Galápagos shark! Our record is the first scientific evidence of the presence of this species at the island. The Save Our Seas Foundation made this project possible.'

WHO I AM

In my early childhood I developed a strong interest in the marine ecosystem, spending much of my free time in my grandfather's library and going through every marine journal I could find there. I didn't know it at the time, but those days left a mark on me. A couple of years later, on my first diving trip in the Caribbean, I realised that I wanted to become a marine biologist. Although cephalopods were my first love, when I started working with elasmobranchs I fell in love with them too. My first experience with shark and ray research and conservation projects was as an undergraduate student, when I participated in setting up the initial basic guidelines for the development of the Shark National Action Plan in Chile. Since then I have had the opportunity to work with great researchers on different projects relating to biodiversity, reproductive biology, feeding behaviour and photo-ID. All of them were on common shark and ray species in Chile.

Currently I am doing my PhD in collaboration with the first research group on Easter Island, the Ecology and Sustainable Management of Oceanic Islands (ESMOI). My thesis will concentrate on species biodiversity, migratory patterns and population genetics of top predators in the Easter Island eco-region, including the large population of Galápagos sharks *Carcharhinus galapagensis* in the area. Working on the ESMOI project gives me the opportunity to collaborate with the local community to help protect one of the most isolated and valuable areas in the world.

WHERE I WORK

Working on Easter Island, home to the monumental stone statues known as *moai* and beautiful landscapes protected by UNESCO as a World Heritage Site, could well make me the luckiest marine biologist in Chile.

Located in the middle of the Pacific Ocean, Easter Island – also known by its Polynesian name Rapa Nui, or Isla de Pascua in Spanish – is one of the most isolated inhabited islands in the world. It harbours the eastern coral systems of Polynesia, known for colourful fishes and high levels of endemism. However, the environmental conditions of this region make it highly susceptible to global climate change and anthropogenic activities.

Big fish assemblages are now scarce around the island. We assume that the number of fish communities were already starting to drop at the time of the ancient fishery, when the island was fully populated. Today, with modern fishing methods and an increasing number of tourists, the risk of overfishing is even higher. The big challenge facing Easter Island is to achieve sustainable fisheries but still conserve its unique marine biodiversity. Therefore, we need to acquire substantial scientific knowledge about the biology and population dynamics of the species inhabiting the area if we are to create new and effective regulations.

WHAT I DO

Baited Remote Underwater Video Stations (BRUVS) technology enables scientists to observe fish in hard-to-reach habitats and fishing-free or even threatened areas. At these fixed stations, bait is used to attract fishes and the cameras then record not only the individuals attracted to the bait, but also those that just swim in front of the lens.

By using the BRUVS, we aim to describe the pelagic species inhabiting the waters around Easter Island, their abundance and their use of habitat, including ancestral fishing zones. Thanks to the SOSF, we will carry out the first study of top predators on Easter Island using non-destructive methodology. This project seeks to fill the gaps in our knowledge in order to create marine parks with effective boundaries and to develop realistic recommendations for the correct management and conservation of the local biodiversity. We also believe that this biodiversity can be used to enhance ecotourism and help local inhabitants to shift from non-sustainable practices (overfishing) to a broader array of sustainable activities such as community-based ecotourism.

NAITI MORALES SERRANO

LOST FISHES OF EASTER ISLAND – SALAS Y GOMEZ AND RAPA NUI EXPEDITION
UNIVERSIDAD CATOLICA DEL NORTE
2017
EASTER ISLAND, CHILE
RESEARCH, CONSERVATION
SHARKS AND OTHER TOP PREDATORS

NICOLE PHILLIPS

WHO I AM

I grew up in a small town in Michigan on the 'salt- and shark-free' coast of Lake Superior. I lived more than 1,000 miles from the ocean, yet ever since I can remember I have been fascinated by marine life. At the age of 17 I travelled to Belize and came face to face with sharks and rays for the very first time. I returned home from that trip more determined than ever; I was going to become a shark biologist. A few years later I moved to Australia and attended Murdoch University, earning a double degree in marine science and biology. In 2005, I conducted an Honours research project on the most endangered of the sharks and rays, the sawfishes. It was love at first 'saw' and 12 years, a PhD and a postdoc later, I am still studying sawfishes.

WHERE I WORK

I am an assistant professor at the University of Southern Mississippi in Hattiesburg, Mississippi. Despite being located on the Gulf of Mexico, the average Mississippi resident has very little knowledge about marine life. My students and I are developing outreach initiatives to teach the general public why science and the conservation of marine life matter. As part of these initiatives, we strive to educate people about the plight of sawfishes by visiting local schools and participating in community activities. Sawfishes were historically found in Mississippi, but are believed to have gone locally extinct sometime during the 1970s and 1980s. Over the past five years, however, reports of sawfishes in Mississippi and Louisiana have been emerging, highlighting the need for research and public education about sawfishes in this region.

Although I live and work in Mississippi, my research programme has no geographical boundaries. I collaborate with researchers from all over the world, who contribute tissue samples for genetic analysis from locations in the USA, Australia, Mexico, Central America and the Persian Gulf. This is one of the best things about my work: I get to do research to help conserve sharks and rays all over the world, as well as in my local area.

WHAT I DO

The saw is undeniably the most distinctive feature of a sawfish, but it also makes these animals more susceptible to capture in fishing lines or nets and it is valued as a trophy by recreational fishers. Consequently, sawfishes have undergone substantial declines in range and abundance in the past century, although the evidence for these declines is largely anecdotal. The largetooth sawfish was once widely distributed in the Pacific, Atlantic and Indian oceans, but today 'healthy' populations may be confined to northern Australia. Species such as the largetooth sawfish that have undergone drastic declines in abundance tend to have a lower level of genetic

Photo by Nicole Phillipps

Photo by Annmarie Fearing

Photo by Annmarie Fearing

Photo by Alex Lamb

diversity, which makes them more susceptible to disease and compromises their ability to adapt in a changing environment. Such circumstances can lead to unhealthy populations that are unable to survive in the long term.

This is where my research comes in. I use molecular methods to answer questions relating to the genetic health of sawfishes. In my previous research, I assessed the genetic diversity in contemporary largetooth sawfish populations in Australia. Currently, my team and I are working towards making similar assessments for largetooth sawfish populations from about 100 years ago. To accomplish this, a network of researchers and I are collecting tissue samples from old dried sawfish saws that are housed in public and private collections worldwide. These saws contain vital information, via their DNA, about the health of largetooth sawfish populations of the past. By comparing the genetic diversity of past and present largetooth sawfish populations, we will be able to estimate how much of this diversity was ultimately lost during the declines sustained by the species.

COMPARISON OF LEVELS OF GENETIC DIVERSITY IN HISTORIC AND CONTEMPORARY SAWFISH POPULATIONS

UNIVERSITY OF SOUTHERN MISSISSIPPI

2017

WORLDWIDE

RESEARCH, CONSERVATION

SAWFISH

Photo by Nasim Hejazi

NICK PILCHER

'I have had a long-term relationship with the SOSF and can't be more proud of what we have achieved together. Their support and friendship have been amazing, and I hope that through my experiences around the globe I can repay them for the support I have had over the years.'

WHO I AM

I'm a sea turtle guy through and through. I grew up snorkelling all on my own as a kid, and as the years went by and the kilos piled on I got hooked on sea turtles – it was hard not to, really. One thing led to another and I found myself in charge of a turtle project in Saudi Arabia back in 1989. I came over to Malaysia in '93, and from there the whole Indo-Pacific opened up to me. I have roamed the seas and oceans ever since, doing my turtle thing.

As someone said recently, 'Nick saves sea turtles for a living.' My PhD is on turtles. My third daughter's first word was 'turtle'. At home we have sea turtle figurines and turtle memorabilia all over the place. It's hard to think that some 25 years and 55 countries later I am still doing the same thing, but the truth is I love what I do. I tell people I'm a professional beach bum and that I get to play with turtles for a living. Now how cool is that?

WHERE I WORK

I work across a wide swath of the planet. One week I am over in the Arabian/Persian Gulf and the next I am in South-East Asia. My current projects are based in Malaysia, the Philippines, the United Arab Emirates, Oman, Qatar and Iran. In Malaysia I work with the Malaysian Department of Fisheries to get Turtle Excluder Devices (TEDs) installed on fishing nets – a project that has been amazingly successful and now TEDs are required by law. I also run a joint research project between Malaysia and the Philippines using science to expand the current Network of Protected Areas for sea turtles in the Sulu Sulawesi Seascape. I also run a study of foraging grounds, where we look at the sex of turtles in the wild to detect impacts of hatchery practices – we need to make sure there are sufficient males and females! In the Arabian/Persian Gulf I work on a multi-country green sea turtle tracking project to identify Important Turtle Areas (ITAs) that can be used to design marine protective zones. And in Qatar and Iran I have been investigating the impacts of extreme climate conditions on the sex ratio in sea turtles. This is important because the gender of sea turtles is determined by temperature, so climate change could have a catastrophic impact!

WHAT I DO

One of my major interests is working to fill some of the gaps in our knowledge relating to turtle biology and ecology, so that managers are better equipped to make good conservation decisions. In this particular case, my key interest is the impact of rising temperatures and climate change on the population structure of sea turtles. This may sound complex, but it's really quite simple: the sex of a turtle is determined when the egg is in the sand. Too warm

Photo by Samira Parisayee

Photo by Nasrin Heidari

Photo by Samira Parisayee

Photo by Samira Parisayee

and we get too many females; too cool and we get too many males. Climate change is warming the planet. So what impacts will that have on turtles? It could lead to a feminisation of the population if turtles are not evolutionarily adapted to coping with the temperature extremes.

But to study climate change can take many years and is done mostly as desk-top modelling exercises. We chose to work in the Arabian/Persian Gulf because the temperatures there are already so extreme that they mimic what many parts of the world are predicted to look like in the future. It's like a living laboratory.

We selected a site in the south of Iran called Qeshm Island, which has a large population of juvenile sea turtles that can be easily caught, and where the ambient temperatures are higher than 50°C in summer and freezing in winter. What we do is go out to arrow-shaped fish traps early in the morning at very low tide and pick up any turtles that got stranded overnight. We then use a small surgical procedure to check if the turtles are male or female, take a skin sample for genetic analysis, tag them and send them on their way.

By looking at ratios of male to female turtles and being able to link this back to beach sand temperatures and ambient air temperatures, as well as using genetics to find out where the turtles came from, we can better understand the impacts of climate change in real life. I hope you enjoy reading about our work as much as we enjoy doing it.

IMPACT OF EXTREME CLIMATIC CONDITIONS ON REPRODUCTIVE BIOLOGY OF ENDANGERED SEA TURTLES IN IRAN

MARINE RESEARCH FOUNDATION

2017

IRAN

Research, Conservation

Green turtle (*Chelonia mydas*)

WHO I AM

I study the mechanics of how sharks swim and it is no surprise that I enjoy talking about swimming all day long. Although I was born in a desert, I am at home in the water. I grew up in Arizona and learned to swim at about the same time that I learned to walk. Since then my life has revolved around water and swimming. My love of water extends to any body of water and I am especially attracted to the raw power of rivers and oceans.

I am incredibly fortunate in that I have been able to leverage the things I love into my work. My career in research started with a study of the plant ecology in a pinyon-juniper woodland in northern Arizona. I also did a survey of the plants along the Colorado River in Grand Canyon National Park. Then, for my PhD, I was able to bring my research experience back to what I love – swimming and the ocean – and I made the big switch to studying biomechanics and sharks. Currently, I work in the biology department at Florida Atlantic University and am able to share my excitement about how animals move with the graduate students and undergraduate researchers working in my lab. My goal is to provide the students I train with formative research experiences similar to my own.

WHERE I WORK

I am lucky to be able to work where I live. Florida Atlantic University is only a couple of miles from the water's edge in Boca Raton and its proximity to the ocean and great year-round weather ensure that we can do field work at any time. In addition, the clear, shallow water makes it easy to see and study marine life here (there is a reason for people coming here on vacation!).

I am interested in measuring the mechanics of swimming in the wild by studying the blacktip shark migration and aggregations that occur here every winter, from January through to early April. When the blacktip sharks are here, they are easy to see because they stand out against the white sand. They are often found very close to shore and for several years now large aggregations have been documented by aerial surveys. In a recent development, acoustic tags are now being used to study large-scale movements in this species.

WHAT I DO

I study biomechanics, so I use engineering and physics to understand how animals move. The blacktip shark migration presents a great opportunity to learn more about swimming mechanics and at the same time get a better understanding of how these sharks use their habitat. Once we have learnt more about how they move at both a large and a small scale, we can start to address conservation and management strategies for this species. We hypothesise that blacktip sharks provide important ecosystem services to the local reef communities while they are here by impacting the populations of their bait-fish prey.

I use drones at local beaches to collect video footage of aggregations of blacktip sharks swimming

Photo by S. Kajiura (red)

MARIANNE PORTER

Photo by Rachel Thomas

Photo by S. Kajiura/ocrd

MIGRATION MECHANICS – UNDERSTANDING SWIMMING KINEMATICS OF A MARINE APEX PREDATOR

FLORIDA ATLANTIC UNIVERSITY

2017

USA

RESEARCH, CONSERVATION

BLACKTIP SHARK (*CARCHARHINUS LIMBATUS*)

in the clear, shallow water. Back in the lab, I can look at their small-scale movements, like how they make their bodies curve while swimming. This enables me to examine the way a shark moves in the detail I had only previously been able to get while watching them in the lab. Now I can study swimming kinematics in a natural environment for the first time! We can also attach to the sharks tags that contain accelerometers similar to those found in smartphones. These tags will enable me to peek into the mechanics of swimming over longer distances. For example, I can see how speeds vary at different points during the migration. Basically, I get to go to work every day and learn about what I love.

WHO I AM

I'm a water guy. I grew up near Lake Ontario in upstate New York and my family vacationed in watery spots like smaller lakes and campgrounds near rivers. The ocean is different though. Just before middle school, we made a trip to Maine and that's where I saw the ocean for the first time. After that trip, I knew I'd need to spend more time near and in the ocean. Science was always my favourite subject, but my interests within it were broad and I wanted to keep my options open as the time came to choose a career. However, it didn't take too long for me to fall into the 'fish lab' in graduate school. As in science, my ichthyological interests are broad too (if it swims, I'm probably interested), but people like to generalise and as time has gone on I've been labelled an 'elasmobranch guy'. I'm sure I've been called worse over the years! Most recently, much of my time has been dedicated to studying the smalltooth sawfish, a Critically Endangered species whose last major stronghold includes Florida. A colleague and I started asking around about this species in the late 1990s, but no-one knew anything about it then. I never would have predicted that trying to satisfy my curiosity and spending personal time doing so would have led to me being called a 'sawfish guy' a couple of decades later.

WHERE I WORK

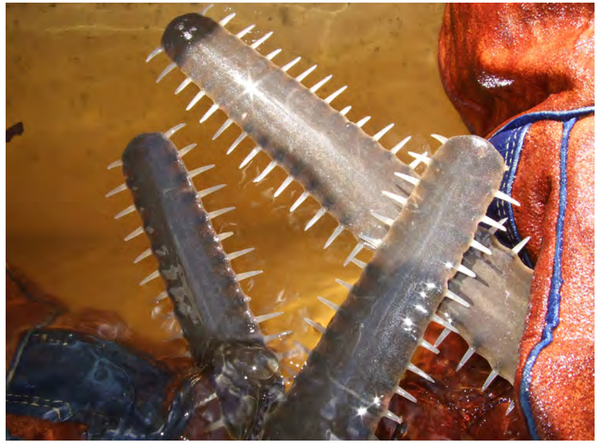
Florida's Charlotte Harbor estuarine system is a beautiful place to work. I call it a system because there are so many habitats found here that species use during their lifetime. Everything is connected. The uplands have countless ponds that connect to intricate creek systems that eventually lead to remote bays. Three large rivers deliver freshwater that helps to drive the system. Red mangroves, with their long prop roots, line much of the shoreline. This setting is where two distinct smalltooth sawfish nurseries are found and we have been studying these nurseries intensely for over a decade. Human interests such as fishing and water management affect the species that rely on the estuarine system and we have been contributing information that can be used by managers to balance human needs with those of the inhabitants of this ecosystem – including this Critically Endangered species we are fortunate to share space and time with.

WHAT I DO

While in recent years my collaborators and I have been conducting interdisciplinary research on the biology and ecology of the smalltooth sawfish in its current range of south-western Florida, our SOSF-funded project focuses on the development and implementation of techniques that can improve

GREGG POULAKIS

Photos by Florida Fish and Wildlife Conservation Commission (FWC)



our understanding of where this species might be found outside its current range. How well do we understand its range? Is the range expanding? Do sawfishes occupy historically important nurseries? To help answer these questions, we will be applying the relatively new field of environmental DNA (eDNA). Simply put, water or sediment is filtered and the samples are screened for the presence of DNA. These DNA sequences could come from a variety of species and sources, but if you know what you're looking for, the potential to answer questions such as those we've posed is exciting. We're looking forward to testing filtration techniques in the laboratory and applying what we learn to the field using our knowledge of occupied nurseries.

Once we have these important details figured out, we will collect DNA samples in two estuaries just outside the smalltooth sawfish's current range to determine whether the species might be found elsewhere. We will be like children waiting to open holiday presents as the data from those samples come back! Our goal is to develop methods that will be useful for monitoring the current status and future recovery of sawfishes in Florida, as well as in other regions of the world where they might still be found.

USING ENVIRONMENTAL DNA TO DETECT SMALLTOOTH SAWFISH IN CURRENT AND HISTORICAL NURSERY SITES

FISH & WILDLIFE FOUNDATION OF FLORIDA, INC.

2017

USA

RESEARCH, CONSERVATION

SAWFISH

WHO I AM

This story has a classic beginning. Every Sunday afternoon I would climb onto the armrest of my father's chair, joining him for what was my favourite time of the week: the screening of Jacques Cousteau's voyages on television. I pulled my little legs close, chin resting on my knees, and followed the *Calypso*'s crew on their marine adventures as though I were one of them. At my side I kept a shortlist of what I wanted to be when I grew up: photographer, veterinarian, scuba diving instructor, archaeologist, journalist, conservationist, marine biologist… The list was mixed up, tumbled around, re-evaluated, thrown away and re-written many times.

I followed the long, winding and often painful road of academia, hoping that it would one day end by the sea. The result was a colourful CV that reflects the random approach I had to a lack of both money and confidence as a young biology student. I interned wherever I could, working with animals that no-one else wanted to work with and funded by organisations that otherwise would perhaps never have seen my potential among students with shining records. But time brought experience, knowledge and confidence and here I am today, proudly calling myself a marine ecologist and working on a project that combines two disciplines I find truly fascinating: citizen science and the reproduction of South African catsharks.

WHERE I WORK

Two of the world's largest oceans meet off South Africa: the Atlantic with its cold, nutrient-rich Benguela Current to the west and the Indian with its fast, tropical Agulhas Current to the east. This unique setting has created three distinct biodiversity zones in South Africa: subtropical, warm-temperate and cold-temperate. It is no surprise that biodiversity is thriving in the country, making it an ecologist's paradise. Life on land and life in the sea have always interacted with each other. One of the best places to observe this is at Cape Point, where baboons harvest shellfish from the intertidal zone.

Humans have perfected the exploitation of marine resources and South Africa has considerable commercial and recreational fisheries. Even though the country boasts an extraordinary abundance of marine life, harvesting it with increased efficiency and decreased selectivity has taken its toll, affecting primarily the species that have a narrow geographical range. Fishing pressure on endemic species is strong in South African waters and it is crucial that we understand the biology of these species and their role in the ecosystem if there is to be a healthy ecological balance.

WHAT I DO

South Africa has more than 100 shark species, but only the largest and toothiest are lucky enough to receive substantial public attention. Although their importance cannot (and should not)

Photo by Lisa Schroeter

LISA SCHROETER

Photo by Maryna Nezar

Photo by Lisa Schmeier

KICK-STARTING ELMO – USING CITIZEN SCIENCE TO STUDY THE REPRODUCTIVE BIOLOGY OF SOUTH AFRICAN CATSHARKS

ELMO – SOUTH AFRICAN ELASMOBRANCH MONITORING

2017

SOUTH AFRICA

Research, Conservation, Education

Puffadder shyshark (*Haploblepharus edwardsii*),
leopard catshark (*Poroderma pantherinum*),
pyjama shark (*Poroderma africanum*),
dark shyshark (*Haploblepharus pictus*)

be denied, it is the small shark species that really make South Africa's reefs unique: 14 of 16 catshark species occur nowhere else in the world. Their local abundance has led to the misconception that there are plenty of catsharks, but the reality is that pressure from both commercial and recreational fisheries is threatening their existence. As of today, seven endemic catshark species feature as threatened to some degree on the IUCN Red List and three species are still Data Deficient. We urgently need to improve our understanding of catsharks and their biology in order to protect them.

All South African catsharks produce eggs, which remain on the reef for up to 12 months until they hatch. This makes it easy to detect breeding grounds and to monitor the development of catshark embryos in shallow water. In this project we, the South African Elasmobranch Monitoring (ELMO) team, will work with citizen scientists to gather knowledge about the breeding seasons and habitats of South African catsharks. Recreational scuba divers all over South Africa will help us to identify areas that are of exceptional importance for catshark reproduction by answering questions about the occurrence of the sharks and their eggs on their local reefs. We call this group of participants Local Reef Reporters.

Another group of divers will go a step further and closely monitor one particular reef and the development of every single egg on it over the course of a whole year. This group of divers are called Elmoblitzers. In a workshop held by the ELMO team, they will learn how to identify, tag and safely handle a shark egg. We will demonstrate how to use a torch to look through the eggcase membrane and how to record the growth and survival of a shark pup. There is a lot more interesting information that we are asking the divers to record, such as organisms growing on the egg ('biofouling'), predators, hatching success, the substrate on which the egg is found and the water temperature.

This study will actively involve the public in research and will improve our understanding of the factors that influence the survival and development of a catshark pup. Participation in the project is not limited to divers; anyone can take part by reporting sightings of catsharks or their eggs – even those found on the beach. All participating dive centres will be equipped with educational material, so if you would like to get involved feel free to visit one of the dive centres we are working with (a list will soon be published at *https://www.elmoafrica.org/elmoblitz*).

WHO I AM

I grew up fishing, exploring tidal pools and snorkelling along the west coast of Australia. At the age of nine I announced to my family that I was going to be a marine biologist. That started a lifelong journey of discovery and adventure with the ocean. I studied at James Cook University in Queensland, first for my Bachelor's degree and then for my PhD. Along the way, the opportunity to research sharks and rays presented itself. Since then, elasmobranchs have been the primary focus of my career for 30 years.

It was while I was doing my PhD in the late 1980s that I caught my first sawfish, a narrow sawfish. At the time we had no idea that this unique group of rays, with the body of a shark and the nose of a hedge trimmer, would struggle to maintain a healthy population. It was only years later that we discovered heavy population losses across all five species in the sawfish family. The animals had been savaged not only by decades of target and by-catch fisheries, but also by the loss of coastal and riverine habitats important to them. We now know that sawfishes are the most threatened group of sharks and rays on the planet.

WHERE I WORK

In 1998 I moved to Florida and began working at Mote Marine Laboratory. It was there that I ran my first dedicated sawfish research project, which investigated the conservation ecology of the smalltooth sawfish. At the time, this species had recently been listed under the US Endangered Species Act. My research helped to inform policies and regulations that have enabled the sawfish populations in US waters to show signs of recovery.

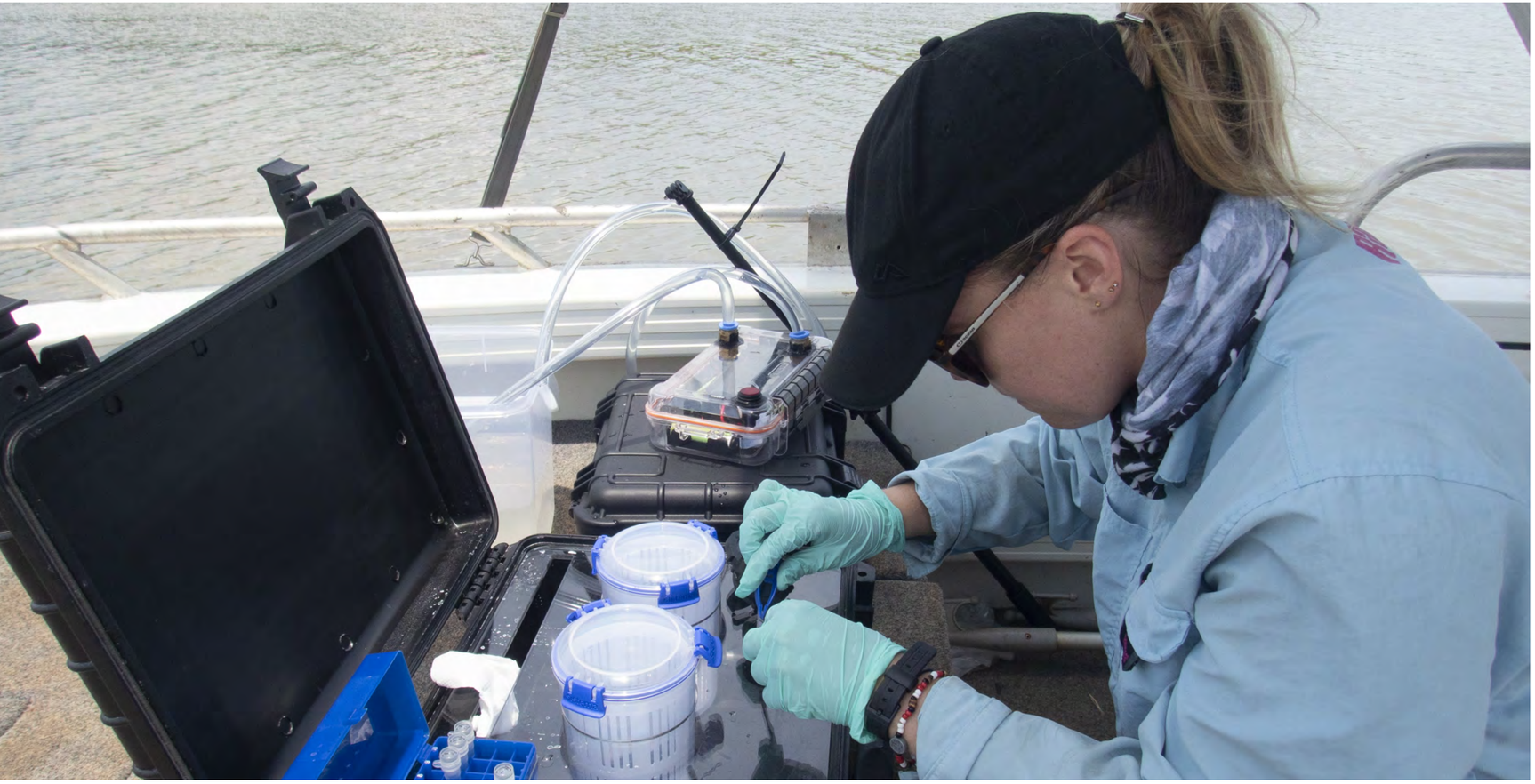
In 2007 I moved back to James Cook University to continue my shark and ray research. The waters of the Great Barrier Reef offer amazing opportunities to study this important group of ocean predators. Researching here has also given me the opportunity to do some interesting science, designed to help improve the conservation of not just sawfishes, but of sharks and rays in general. Still, the challenges that sharks and rays face in Australia are nothing compared to those in many other parts of the world where fishing is poorly controlled. In recent years, I have increasingly engaged in research that is designed to make a global difference.

WHAT I DO

Some of the scientists I work with at James Cook University have recently started using a new technique called environmental DNA (eDNA). The principle is simple: all animals that live in water shed their DNA, leaving behind a signature of their presence. If you take a water sample and filter it, you can test for the presence of a species' DNA. This technique is becoming a powerful tool for studying the distribution of rare and threatened species because

Photo by Nicole Cooper

COLIN SIMPFENDORFER



Photos by Mahé Ducasse

you don't have to search for and physically capture individuals.

In view of the potential of this technique, I decided to work alongside colleagues Dean Jerry of James Cook University and Peter Kyne of Charles Darwin University to test its potential as a tool for studying the occurrence and distribution of sawfishes. The results were clear: sawfishes could be detected using eDNA techniques. This enabled us to design a project to address one of the big problems we still face: where do sawfishes still occur?

Given the decades of human pressure on sawfish populations, the species are now rare or even extinct in many of the countries in which they were historically found. Working with partners throughout the range of sawfishes, we are using eDNA to build a picture of where they still occur. This will enable conservation efforts to be tailored to local needs and targeted in those places where success is most likely.

Ultimately, we hope that this work will help to save this amazing group of animals from the very bleak future it currently faces.

SOSF GLOBAL SAWFISH SEARCH
JAMES COOK UNIVERSITY
2017
WORLDWIDE
RESEARCH, CONSERVATION
SAWFISH

TIBU
EMBAJADOR
Santa Cruz · Galápagos

DANIELA VILEMA

Photo by Daniela Vilema

WHO I AM

Since I was a kid, I have enjoyed being surrounded by nature. I always loved going to the beach, and collecting shells on the shore was one of my favourite activities. Then when I started scuba diving, I became aware of the wonderful life that exists underwater. I will never forget the first time I saw a hammerhead shark while diving in the Galápagos Islands; it was amazing to watch this shark coming closer, gently moving its strange head. That was when I realised how marvellous and special these animals are. Soon afterwards, I got involved in a project to develop an educational campaign about the whale shark. After that, and after watching other shark species close up, I began to wonder how I could make people feel as curious about sharks as I felt and how I might involve them in the adventure of discovering and learning about sharks.

I now live on Ecuador's Galápagos Islands and I am an environmental communicator for the Charles Darwin Foundation. The foundation is an international not-for-profit scientific organisation that has been working in the Galápagos since 1959 and its research has been key for the conservation of the archipelago.

WHERE I WORK

The Galápagos archipelago is the sharkiest place in the world and one of the best diving destinations to see these incredible animals. This World Heritage Site is surrounded by one of the largest marine reserves on the planet and last year Darwin and Wolf islands, in the north of the archipelago, were declared a marine sanctuary to protect the largest concentration of sharks anywhere. If you want to interact with sharks, the Galápagos Islands are the best place to be!

Even though we live in a protected area in the middle of the Pacific Ocean, a lot of people here seldom go to the beach or do not know how to swim. The fact that local people do not have a close relationship with the ocean, combined with the poor public image that sharks have, makes it very difficult for the community to understand and support shark conservation. I will always remember a 13-year-old boy telling me that he knows more about rooster fights than about the ocean.

After taking part in the whale shark campaign in the Galápagos, I realised how knowledge and personal experience in the field have a direct impact on the perceptions people have about a topic. We have laws that protect the archipelago, but if we are looking to conserve it in the long term we need an involved and engaged community that understands how important it is to go beyond legislation when protecting the place where they live.

WHAT I DO

I have been working in the Galápagos Islands with the local community through outreach and environmental education, focusing mostly on shark

Photo by Ibrah Rodriguez

Photo by Daniela Vilema

CHARLES DARWIN FOUNDATION – GALÁPAGOS MARINE EDUCATION PROGRAMME

CHARLES DARWIN FOUNDATION

2017

GALÁPAGOS ISLANDS, ECUADOR

EDUCATION

SHARKS AND RAYS

conservation. Only four of the archipelago's islands are inhabited, with a population of about 25,000 in total, which enables us to work closely with most of the community.

Thanks to a grant from the Save Our Seas Foundation, last year we developed a shark campaign called 'Protect the fins and the ocean wins'. Its aim was to change negative perceptions about sharks and promote the Galápagos as an example of co-existence between humans and these animals. We developed workshops, field trips, contests and public events to communicate specific messages about the physiology, ecological role, population status and socio-economic value of sharks, as well as the importance of shark conservation and the role of science in obtaining this information. We created 'shark ambassador' characters, using representative species of the Galápagos to help us to spread our messages.

Finally, to encourage people to have a closer relationship with the ocean, we developed a shark story competition for all the schools of Santa Cruz Island. After motivating children to research sharks for the contest, we took the winners on a field trip to snorkel with sharks in their natural habitat. Our campaign reached 1,178 children aged between nine and 12 years across the four inhabited islands, totalling about 80% of children of this age group in the Galápagos.

This year we will continue our work involving the local community in the shark world, encouraging them to protect these wonderful species through a marine ambassador's education programme. If a sustainable co-existence with sharks is possible in the Galápagos, it can be possible anywhere else.

KEVIN WENG & ANDREW GRAY

Photo by Ryan Gray

Kevin Weng

Andrew Gray

'I want to be the fly on the wall when animals are doing interesting things, to see the details of their lives and understand why they do what they do.'

WHO I AM

I didn't discover surfing and diving until later in life, but I grew up swimming competitively and my childhood of swimming laps under water and sitting on the bottom of the pool was the springboard into a love affair with the ocean. If there is ever a way to combine water sports and science, sign me up! Perhaps that's why studying the humphead wrasse is my favourite thing: we catch a fish by swimming after it! Throughout my career I've always wanted to see the inner workings of fish life, to be there when interesting biology is happening. This has led to many years of study and adventures around the globe. The opportunity to be underwater in the last great places on earth, and hopefully contribute to their conservation, is what drives me.

WHERE I WORK

I've been to many places around the world where I should have seen lots of humphead wrasse, but didn't. From Indonesia to the Philippines, Palau, Guam, Kiribati and Papua New Guinea, when humans begin harvesting a system, this species is among the first to go. As a giant reef fish with few natural predators, it is naturally curious and is quite likely to just come over and say hello. There are now so few places with healthy populations, it is in fact a challenge to study this species.

I went to Palmyra Atoll to conduct the first long-term study of the spatial ecology of humphead wrasse. Palmyra is a tiny speck of reef in the middle of the Pacific Ocean and a protected wildlife reserve. We discovered that the species has one of the largest home ranges of any coral reef fish, but since Palmyra is an isolated atoll surrounded by the great deep blue, reef fish there have limited territory. Wanting to study humphead wrasse in a bigger playground, we found an exceptionally vibrant population in the Amirante Islands, a remote area of the Seychelles.

Located in the central Indian Ocean, and discovered by Vasco da Gama in 1503, the Amirantes have a very small human population and their remoteness has spared them from the human impacts that have extirpated the humphead wrasse from much of its original range. On one of our first dives, I entered the water and was immediately faced with a swirling group of 12 humpheads. It is incredibly rare to see so many individuals of this species that

Photos by Ryan Daly

D'ARROS AND ST JOSEPH AS A REFUGE FOR THE ENDANGERED HUMPHEAD WRASSE IN SEYCHELLES

VIRGINIA INSTITUTE OF MARINE SCIENCE, COLLEGE OF WILLIAM & MARY

2017

SEYCHELLES

RESEARCH

HUMPHEAD WRASSE (*CHEILINUS UNDULATUS*)

is classified as Endangered on the IUCN Red List. However, we faced many challenges, with ripping currents, bull sharks and a dense panoply of reef fish obstructing our view of the humpheads!

WHAT I DO

I want to be the fly on the wall when animals are doing interesting things, to see the details of their lives and understand why they do what they do. For marine fishes, which live in an opaque environment, this often means watching them indirectly by means of tracking devices such as satellite tags and acoustic tracking networks. Using these approaches combines a range of exciting activities, such as fishing, diving, boating, surgery, designing hardware to withstand the marine environment and analysing data on the computer. Our study at Palmyra Atoll revealed that the humphead wrasse's home range and rarity make it a good umbrella species for coral reef conservation. An umbrella species is one whose protection results in large areas of quality habitat, thus benefiting many other species as well.

Our new study in the Seychelles will reveal movement patterns across a 100-kilometre scale tracking network. We may discover patterns that are not possible on a tiny isolated atoll and that may be more representative of reef habitats throughout the Indo-Pacific. Such discoveries will tell us what marine reserves need to look like in order to protect this iconic species – and all its cousins on the reef.

WHO I AM

My passion for marine life began at a very early age and during my childhood I spent much of my time snorkelling or swimming in the waters off Western Australia. I began working at an aquarium as a diver/aquarist during my undergraduate years, which further propelled me towards a life working with sharks and rays. This led into my postgraduate studies on sharks and rays. While working towards my Honours and PhD, I began studying the ecology of sharks and rays in Shark Bay, a World Heritage Area. I then began doing research in fish markets in Indonesia where, at the time, not even baseline data were available for this fishery. The discovery of more than 20 new shark and ray species in Indonesia pulled me into the dark side – taxonomy! Since 2005, I have been involved in describing more than 60 species of sharks and rays. The ultimate goal of my research has always been to provide accurate scientific knowledge to better aid conservation efforts.

WHERE I WORK

Although I am based in the cool-temperate climate of Tasmania, my work has always focused on tropical regions and over the past four years it has taken me into the wilds of Papua New Guinea (PNG). Few places on the planet can compete with this geologically complex country in terms of biodiversity and range of habitats. Yet when it comes to sharks and rays, we know so little of what occurs there and to what level they are exploited or adversely affected by humans. PNG is still so raw and wild at heart and although field surveys are very difficult, those that I have undertaken there have been awe-inspiring. From the muddy mangroves of the Fly River delta to the lush and raw terrain of Bougainville, the tropical paradise of New Ireland and the underwater gems of Milne Bay, field work in PNG is tough to beat.

During our field work, we have been able to document many new records for PNG and discover good populations of a number of highly threatened species. On our very first field trip, we came across two species of river shark (*Glyphis* spp.) on only the third day. Sawfishes were also found to be encountered regularly by fishers in some areas. All four species known to occur in PNG were found on one survey trip. Anecdotal information suggests that sawfishes are very common in some areas, but these areas remain poorly surveyed.

WHAT I DO

Our project is going to undertake detailed surveys of key areas for sawfishes. Recent literature reviews of published and unpublished reports have isolated the key areas where sawfishes occur, or have occurred, in PNG. We will collect information from local fishers in these areas as well as undertake surveys of our own to find sawfishes. We will work closely with the University of Papua New Guinea during our surveys, with the aim of providing some capacity

WILLIAM WHITE

Photos by Michael Grant | James Cook University, Townsville

Photo by P. Aipa

Photo by Michael Bland | James Cook University, Townsville

INVESTIGATION OF THE STATUS OF SAWFISHES (PRISTIDAE) IN PAPUA NEW GUINEA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL ORGANISATION

2017

PAPUA NEW GUINEA

Research, Conservation

Sawfish

building for several local students. Information guides will be produced to give to local villages. Fishers and villagers will be interviewed about their interactions with sawfishes, any economic benefit (e.g. selling parts) or cost (e.g. destroying nets) these interactions have, and trends in their interactions over the years. The cultural importance of sawfishes to different groups or villages will also be investigated.

PROJECT LEADER PROFILES – SUMMARY

AN INTRODUCTION TO OUR PROJECT LEADERS WHOSE PROJECTS ARE A CONTINUATION FROM THE PREVIOUS YEAR(S) AND WERE FUNDED DURING 2017. THEIR COMPLETE PROFILES ARE AVAILABLE IN PREVIOUS ISSUES OF OUR ANNUAL REPORT AS WELL AS ON OUR WEBSITE.

Photo by Renee Capozzola | Biosphoto

MOHAMMED ABUDAYA

ASSESSMENT OF THE GAZA FISHERY OF THE GIANT DEVIL RAY
AL-AZHAR UNIVERSITY – INSTITUTE OF WATER AND ENVIRONMENT
2014–2017
GAZA, PALESTINE
RESEARCH, CONSERVATION
GIANT DEVIL RAYS (*MOBULA* SPP)

Conservation is never an easy task, but it's even harder in a battleground. Mohammed works with fishing communities in Gaza to find out how to protect mobula rays during their visits to the east Mediterranean Sea.

IVY BAREMORE

CHARACTERISING THE EMERGING DEEP-WATER SHARK FISHERIES IN BELIZE
MARALLIANCE
2015–2017
BELIZE, CENTRAL AMERICA
RESEARCH, CONSERVATION
HEXANCHUS GRISEUS, *H. NAKAMURAI*,
HEPTRANCHIAS PERLO,
CARCHARHINUS SIGNATUS

As pressure on marine resources increases, fishers have to explore deeper and deeper waters to make a living. What does this mean for Belize's deep-sea sharks? Ivy aims to understand the threat to these animals before it is too late.

FÉLICIE DHELLEMMES

ECOLOGICAL CONSEQUENCES OF PERSONALITY IN SHARKS
BIMINI BIOLOGICAL FIELD STATION FOUNDATION (BBFSF)
2016–2017
BIMINI, BAHAMAS
RESEARCH, CONSERVATION
LEMON SHARK (*NEGAPRION BREVIROSTRIS*)

Did you know that individual sharks have different personalities? Félicie is working with lemon sharks to discover what impact their different characters might have on their lives. Could the persona of a shark cause it to live longer or be braver than other sharks?

PHOTO BY MICHAEL SCHOFL

CHANTEL ELSTON

THE ECOLOGY OF STINGRAYS IN ST JOSEPH ATOLL, SEYCHELLES
SOSF D'ARROS RESEARCH CENTRE
2014–2017
ST JOSEPH ATOLL, SEYCHELLES
RESEARCH
MANGROVE STINGRAY (*HIMANTURA GRANULATA*),
COWTAIL STINGRAY (*PASTINACHUS SEPHEN*),
PORCUPINE STINGRAY (*UROGYMNUS ASPERRIMUS*)

St Joseph Atoll is a special place in the remote Indian Ocean. It's home to numerous stingray species, including cowtail, mangrove whiptail and porcupine rays. Chantel is investigating how many of these animals there are, what they eat, where they live and how they move.

DEAN GRUBBS

HABITAT USE, RESIDENCY AND POPULATION GENETICS OF THE ENDANGERED SMALLTOOTH SAWFISH OFF ANDROS ISLAND
FLORIDA STATE UNIVERSITY RESEARCH FOUNDATION
2015–2017
ANDROS, BAHAMAS
RESEARCH, CONSERVATION
SMALLTOOTH SAWFISH (*PRISTIS PECTINATA*)

Sawfishes are rapidly disappearing from our seas, so when a healthy population was discovered off Andros Island in The Bahamas, the area became a very important place. Dean aims to understand this rare community of sawfishes in order to protect them.

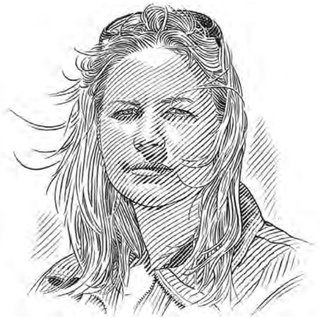
Photo by Michael Scholl

DANIELLE VAN DEN HEEVER

FORAGING ECOLOGY OF WEDGE-TAILED SHEARWATERS (*ARDENNA PACIFICUS*) BREEDING AT ST JOSEPH ATOLL, SEYCHELLES
NELSON MANDELA METROPOLITAN UNIVERSITY
2016–2017
ST JOSEPH ATOLL, SEYCHELLES
RESEARCH
ARDENNA PACIFICUS

During some times of the year, nights at St Joseph Atoll are pierced by a chorus of ghost-like calls made by shearwater seabirds. Danielle is investigating their diet, feeding behaviour and diving patterns.

Photo by Michael Scholl



ALISON KOCK

SHARK RESEARCH COMPONENT OF THE SHARK SPOTTERS PROGRAMME
SHARK SPOTTERS
2015–2017
FALSE BAY, CAPE TOWN, SOUTH AFRICA

RESEARCH, CONSERVATION, EDUCATION
WHITE SHARK (*CARCHARODON CARCHARIAS*)

False Bay is home to one of the world's largest white shark populations and a growing human community. This creates a number of challenges for both people and sharks. Alison is finding out how these apex predators shape the bay and what would happen if they disappeared.

RUTH LEENEY

DOCUMENTING AND PROTECTING CRITICALLY ENDANGERED SAWFISHES IN MADAGASCAR
BENGUELA RESEARCH & TRAINING
2015–2017
WESTERN MADAGASCAR

RESEARCH, CONSERVATION, EDUCATION
GREEN SAWFISH (*PRISTIS ZIJSRON*),
FRESHWATER SAWFISH (*P. PRISTIS*)

Based in one of the world's most unusual and unexplored ecosystems, Ruth aims to unravel the mystery of Madagascar's sawfishes. Which species are present? What threats do they face? Can communities be convinced to protect them?

Photo by Ruth H. Leeney

MABEL MANJAJI MATSUMOTO

ELASMOBRANCH BIODIVERSITY MONITORING AND ASSESSMENT IN SABAH, NORTHERN BORNEO
UNIVERSITY MALAYSIA SABAH
2016–2017
SABAH, MALAYSIA

RESEARCH, CONSERVATION
SHARKS AND RAYS

In Sabah, Malaysia, access to the ocean is easy for researchers – and fishers. The area is also home to at least 95 species of sharks and rays. Mabel is visiting local fish markets to discover important information about these animals and how they are being exploited.

EVA MEYERS

DISCOVERY OF AN ANGELSHARK NURSERY AREA IN THE CANARY ISLANDS
BIODIVERSITY AND CONSERVATION RESEARCH UNIT, UNIVERSITY OF LAS PALMAS DE GRAN CANARIA
2015–2017
CANARY ISLANDS, SPAIN

Research, Conservation
Angelshark (*Squatina squatina*)

Although they grow to be 2.5 metres long, angel sharks are notoriously difficult to spot. They are flat, perfectly camouflaged – and also rare. Eva is learning about one of the few remaining populations of these enigmatic creatures.

Photo by Carlos Suárez

JEANNE MORTIMER

COMMUNITY MONITORING OF NESTING SEA TURTLES AT D'ARROS AND ST JOSEPH, SEYCHELLES
SOSF D'ARROS RESEARCH CENTRE
2013–2017
D'ARROS ISLAND AND ST JOSEPH ATOLL, SEYCHELLES

Research, Conservation, Education
Turtles

The beaches of D'Arros Island and St Joseph Atoll are very important places for mother sea turtles to come and lay their eggs. Jeanne is training Seychellois monitors to observe nesting turtles and collect data about them.

LAUREN PEEL & GUY STEVENS

MOVEMENT PATTERNS, TROPHIC ROLE AND ECOLOGY OF REEF MANTAS IN THE D'ARROS MARINE PROTECTED AREA

AUSTRALIAN INSTITUTE OF MARINE SCIENCE | SOSF D'ARROS RESEARCH CENTRE | THE MANTA TRUST

2013–2017

D'ARROS ISLAND AND ST JOSEPH ATOLL, SEYCHELLES

Research

Reef manta ray (*Manta alfredi*)

There is a very lucky population of manta rays that lives at D'Arros Island in the Seychelles. These mantas not only live in a relatively pristine habitat, but are also safe from fishing. This gives researchers a unique opportunity to learn about how these intriguing animals live when they are free from human influence.

ORNELLA WEIDELI

HABITAT AND RESOURCE PARTITIONING OF JUVENILE SHARKS AND THEIR ROLES IN REMOTE COASTAL ECOSYSTEMS

SOSF D'ARROS RESEARCH CENTRE | CRIOBE | EPHE

2014–2017

ST JOSEPH ATOLL, SEYCHELLES

Research

Blacktip reef shark (*Carcharhinus melanopterus*), sicklefin lemon shark (*Negaprion acutidens*)

Sharks don't look after their pups, but they do choose a safe place to give birth. Ornella studies young blacktip reef and sicklefin lemon sharks in St Joseph's lagoon to see how they get along while growing up together.

BARBARA WUERINGER

TROPHIC POSITION AND ECOLOGICAL ROLES OF EURYHALINE ELASMOBRANCH PREDATORS

SHARKS AND RAYS AUSTRALIA PTY LDT

2015–2017

CAPE YORK PENINSULA, NORTH QUEENSLAND, AUSTRALIA

Research, Education, Conservation

Sawfish

Northern Australia is one of the last strongholds for largetooth sawfish and it is an important home for other endangered species too. Barbara is investigating the role of sawfish within the ecosystem and working with citizen scientists to raise awareness about this critical habitat.

Photo by Sam Lewis


Photo by Clifford BM Abbey Stock Photo

SCHOLL MICHAEL | CHIEF EXECUTIVE OFFICER

Michael is the chief executive officer of the Save Our Seas Foundation, which allows him to merge decades of experience in science, conservation and education and his lifelong passion for conserving sharks and the oceans.

Born in land-locked Switzerland along the shores of Lake Geneva, Michael's love for the ocean transcended his personal geography. He attended the University of Lausanne in Switzerland and graduated from the University of Aberdeen in Scotland with a BSc in zoology.

His initial field experience with sharks began in 1995 at the Bimini Biological Field Station in The Bahamas. He then spent the next decade studying the population and ecology of white sharks around Dyer Island in South Africa. In 2002, he founded the White Shark Trust to support research, education and conservation projects focused on white sharks.

His genetic, tagging and fin-printing studies were integral to discovering a link between South African and Australian white shark populations. This work was a major factor in the decision to list white sharks on CITES in 2004.

Michael's research and conservation efforts have been featured in numerous television documentaries produced by the likes of BBC, National Geographic and Discovery Channel, as well as publications such as *Science*, *Nature*, *BBC Wildlife Magazine*, and *Africa Geographic*. In 2006, Michael co-authored *South Africa's Great White Sharks* (Struik Publishers) with photographer Thomas P. Peschak.

Michael taught bilingual high school and IB level biology, mathematics and physics classes in Lausanne, Switzerland, and worked for South African explorer Mike Horn on the Pangaea Expedition, assisting Young Explorers worldwide to establish environmental and social projects.

BRUYNDONCKX NADIA | EXECUTIVE ASSISTANT AND SCIENTIFIC ADVISOR

Nadia is a doctor in biology who joined the team of the Save Our Seas Foundation in spring 2013. Based in Geneva, she works with Michael Scholl as an executive assistant and scientific advisor.

Animals and nature have fascinated Nadia since her childhood so it was a natural progression for her to study biology to better understand the wonders of the animal kingdom. For her PhD she researched the conservation and co-evolution of bats and parasites using several molecular tools. Bats, she established, are fascinating animals that can help to explain the role of scientists and make people sensitive to conservation and other environmental issues. Having completed her own PhD, Nadia became the coordinator of a doctoral programme, organising courses and workshops for PhD students in ecology and evolution. In 2012 she took over the administration of a biology department, dealing with finances and human resources.

A field biologist familiar with unpopular animals, Nadia also has solid expertise in administrative management. But it was while qualifying for her advanced diver certificate that she became sensitive to the vulnerability of the oceans and the importance of preserving them. After several years in science and administration, she decided to use her diverse skills to help to promote the conservation and protection of marine environments.

FOWLER SARAH | SCIENTIFIC ADVISOR

Sarah has a first class joint honours degree in zoology and marine zoology from the University College of North Wales, an MSc in conservation from University College London and 30 years of professional experience as a marine biodiversity conservation expert. She has worked in various capacities for government departments, national and international NGOs and a biodiversity consultancy. Having been appointed to the IUCN Shark Specialist Group in 1991, she chaired it for many years and is now its vice-chair for international treaties.

Sarah founded the European Elasmobranch Association and its UK member, the Shark Trust (and is a trustee of the latter). She was appointed Officer of the Order of the British Empire for services to marine conservation in 2004, and a Pew Fellow in Marine Conservation in 2005. She became principal scientist for the Save Our Seas Foundation in 2011.

SOSF STAFF

GRUBBS DEAN | SCIENTIFIC ADVISOR

Dr Dean Grubbs is a fish ecologist with interests in the biology of exploited and poorly studied estuarine and marine taxa. Much of his research addresses specific gaps in biological knowledge necessary for the management and conservation of coastal and deep-water sharks and rays. Dean specialises in the use of fishery-independent surveys to study population dynamics and the drivers of distribution patterns of fishes and to facilitate studies of life histories, reproductive biology, trophic ecology and systematics. Dean has also tagged and released more than 10,000 sharks representing over 40 species during the past 25 years. He employs a variety of tagging and telemetry techniques to examine movement, migration and patterns of habitat use and to delineate essential and vulnerable habitats for exploited, threatened or poorly studied species.

Dean is a native of Florida and his early years spent fishing and exploring the waters of the north-eastern Gulf of Mexico led to an early interest in marine biology. He received Bachelor's degrees in marine science and biology from the University of Miami and a doctoral degree in Fisheries Science from the College of William & Mary's Virginia Institute of Marine Science. Dean was a post-doctoral researcher and faculty member at the Hawaii Institute of Marine Biology before moving to Florida State University (FSU) in 2007. He is a member of the IUCN Shark Specialist Group, the National Oceanographic and Atmospheric Administration (NOAA) Office of Protected Resources' Smalltooth Sawfish Recovery Team and NOAA's SouthEast Data Assessment and Review Advisory Panel for Highly Migratory Species. Dean is currently the associate director of research at the FSU Coastal and Marine Lab, where he mentors graduate and undergraduate students and maintains an active research programme on the ecology of deep-water and coastal fishes. His research has been featured in many television documentaries, including National Geographic TV, National Geographic Wild, Discovery Channel and the US Public Broadcasting System.

CHIN ANDREW | DIRECTOR OF CONSERVATION

Dr Andrew Chin is a fisheries scientist whose work focuses on shark and ray biology and ecology, and how the information from this research can be translated into conservation and sustainability. Specifically, Andrew is interested in how fishes use coastal and marine habitats and how patterns of use affect their vulnerability to pressures such as fishing, habitat loss and climate change. His recent research spans the life history and biology of sharks by means of tagging and acoustic telemetry, as well as risk assessment. As an applied scientist, Andrew is also very interested in how fishes, sharks and rays interact with people and how their populations can be managed, as well as in impacts on their populations.

Andrew grew up in South-East Asia but currently lives in Queensland, Australia, where he received his PhD from James Cook University. He has a diverse marine background, having worked as a marine biologist in the tourism industry and as an education officer in a public aquarium. He also spent 10 years working at the Great Barrier Reef Marine Park Authority, the Australian federal agency charged with protecting the Great Barrier Reef. In 2017, Andrew launched SharkSearch Indo-Pacific, an effort that blends formal research, citizen science and public outreach, and aims to develop a scientifically robust shark diversity checklist and conservation account for every country and territory in the Pacific by 2022. He is also one of the founders of the Oceania Chondrichthyan Society and a member of the IUCN Shark Specialist Group.

STEVENS GUY | SPECIAL MOBULIDAE ADVISOR

Guy has always been fascinated by the natural world, especially life under the sea. He progressed through school and university with this in mind, graduating from the University of Plymouth in 2002 with a degree in marine biology and coastal ecology. After university he moved to the Maldives to work as a marine biologist and in 2005 he founded the Maldivian Manta Ray Project (MMRP) to help protect the country's manta population through active research and education. Guy's conservation efforts in the Maldives have led to the creation of several Marine Protected Areas (MPAs) at key manta aggregation sites. For six years his MMRP work in the region was funded and supported by the Save Our Seas Foundation (SOSF). In 2011 Guy went on to found the Manta Trust. The mission of this UK-registered charity is to advance the worldwide conservation of mobulid rays and their habitat through robust science and research and by raising awareness about them and providing education, influence and action. With a vision of a world in which manta and mobula rays thrive within a globally healthy marine ecosystem, the trust now has projects in 16 different countries.

The SOSF also supports various other mobulid ray research and conservation projects globally. As a leading expert on the science and conservation of mobulid rays, Guy has a role within the Foundation to advise it on such projects so that an effective conservation strategy for these increasingly vulnerable species is realised.

Guy completed his PhD thesis on the 'Conservation and Population Ecology of Manta Rays in the Maldives' at the University of York in the UK and wrote the reference book *Manta: the Secret Life of Devil Rays*.

SOSF COMMUNICATION | KALK BAY | WESTERN CAPE | SOUTH AFRICA

KUBICKI STEFAN | IT AND WEB OFFICER

Stefan grew up in North Dakota, about as far away as it's possible to get from the coast in the USA. He first developed a fascination with sharks and the underwater world thanks to nature documentaries and well-worn issues of *National Geographic*. He began his career as an analyst at a UN-based NGO in New York before moving to London, where he worked as a web developer and advisor to several startup companies. He joined the Save Our Seas Foundation in 2010. Aside from his work for the foundation, Stefan is an award-winning filmmaker whose films have screened at festivals around the world.

SCHULTZ JADE | CONTENT MARKETER AND SOCIAL MEDIA MANAGER

From a young age when she and her family would go on holiday to nature reserves and the seaside, Jade has felt a very strong connection to the natural world and a great appreciation for its overwhelming beauty. With time however, she realised that this was a view few others shared. Having experienced in particular how little other people know about the wonders of the ocean, she became acutely aware that they know even less about the dangers that the marine realm faces.

With a background in marketing and media experience, Jade understands that the media is extremely powerful when it comes to spreading a message and raising awareness– and, in fact, in today's digital world it is an invaluable conservation tool. She believes that the knowledge and experience that she is able to bring to the Save Our Seas Foundation's Conservation Media Unit, together with the passion and dedication of the other team members, can and will make a positive difference in the mindset of the public – and, ultimately, the health of our oceans.

EHRLICH PHILIPPA | CONSERVATION JOURNALIST

Pippa first fell in love with conservation media after reading the story of the Knysna elephant; she was mesmerised by the animal and the characters and mysteries that surrounded it. After graduating with a Bachelor of Journalism, she spent a year in Thailand and the USA, where she came to appreciate fully the rarity of healthy ecosystems. On her return to South Africa she was inspired by the rich underwater worlds of False Bay and southern Mozambique.

After two years as an investigative journalist for the television programme *Carte Blanche*, Pippa decided that the only stories she really wanted to engage with were those that explored nature and our relationships with it. This was unfortunate because next she found herself in the world of corporate campaigns and commercial media production. Luckily nature won out and she was appointed conservation journalist for the Save Our Seas Foundation (SOSF).

Now, armed with a deep connection to the ocean and a 'colourful CV', Pippa aims to find the balance between traditional journalistic storytelling and a more popular, creative and emotive approach. She is increasingly amazed by the SOSF scientists she speaks to and is excited to help them share their stories.

SOSF D'ARROS RESEARCH CENTRE | D'ARROS ISLAND AND ST JOSEPH ATOLL | AMIRANTES | SEYCHELLES

DALY RYAN | RESEARCH DIRECTOR

As a child growing up along the coast of South Africa, Ryan spent every spare moment surfing, diving and exploring the shoreline and rock pools of South Africa. After gaining a Bachelor's degree in zoology and ocean and atmosphere science from the University of Cape Town, he completed his Master's degree in marine biology at Rhodes University, South Africa. Between 2010 and 2015 he led studies on the ecology and migration dynamics of bull sharks and tiger sharks in southern Mozambique. The work on bull sharks earned him his PhD from Rhodes University in South Africa in 2014. Ryan's current research interests include marine conservation, shark ecology, migration and behavioural patterns, predator–prey interactions and the habitat use and aggregation dynamics of keystone teleost species.

KEATING DALY CLARE | PROGRAMME DIRECTOR

Clare's affinity for the ocean comes as a surprise to some people. She spent her childhood exploring forests and streams in her native Minnesota in the USA, far from the tidal pools and ocean creatures that usually draw people to the ocean. But soon after her first scuba dives in the shallow waters of the Caribbean, she realised that salt water was indeed the cure for anything. Before her starter career as a scuba instructor, Clare completed a Bachelor's degree in business and economics at Colorado College in the USA. She then went on to teach diving in Thailand and the Philippines before moving to Mozambique to embark on a research project studying bull sharks and later tiger sharks. While working as a shark research assistant, Clare also conducted research on the sustainable financing of marine protected areas in southern Mozambique, which earned her a Master's degree in commerce from Rhodes University. Her current research interests include marine protected areas, conservation finance and seabirds, as well as the migration and behavioural patterns of marine species.

SOSF SHARK EDUCATION CENTRE KALK BAY | WESTERN CAPE | SOUTH AFRICA

YELD HUTCHINGS ELEANOR | EDUCATION CENTRE MANAGER

Dr Eleanor Yeld Hutchings currently works for the Save Our Seas Foundation, managing the Shark Education Centre in Kalk Bay, South Africa. She is also the specialist marine biologist presenter for the award-winning South African television documentary series *Shoreline*, which has just completed its second season exploring the coast of South Africa.

Eleanor gained her PhD from the Marine Biology Research Centre, University of Cape Town. Her research was on the parasites of a number of endemic South African shark species, focusing on the discovery and description of several species new to science, the transmission of blood parasites and the ecology of parasite communities with potential for application in the assessment of fisheries stock.

Demonstrating a special affinity for connecting civil society with the marine environment, Eleanor in the past has managed WWF-South Africa's People and the Coast programme and, with a tourist guide certificate for marine and coastal tourism, has run a specialist company guiding tours of the marine environment. She is a qualified scuba diver (both commercial and PADI Rescue level) and dive/boat skipper, and she is kept level-headed by trail-running in the Table Mountain National Park. She lives with her husband and son in the seaside village of Kommetjie.

Photo by Nicholas James Good | Fresh Air Crew

SOSF SHARK EDUCATION CENTRE
KALK BAY | WESTERN CAPE | SOUTH AFRICA

METCALF CLAIRE | FACILITIES ADMINISTRATOR

Raised in various small West Coast fishing and mining towns of South Africa and Namibia, with parents whose free-range approach to parenting meant lots of time outside exploring beaches, Claire is a firm believer in the power of experiential education in moulding future generations to become effective conservationists.

Claire joined the Save Our Seas Foundation Shark Education Centre in May 2016 after almost eight years with Liberty Life Financial Services as a franchise business support administrator. With a diploma in administration and legal studies from Montrose Business College in Cape Town, in her role as the facilities administrator she brings a high level of organisation and structure to the dynamic working environment that is the Shark Education Centre. She is enjoying every minute of the varied opportunities this role brings and, in addition to seeing to facilities maintenance and administration, she has become a vital part of the team, joining school groups as they learn about, explore and appreciate the ocean. She has also made it her personal mission to convince the education centre's resident puffadder shysharks to eat their food.

With a family that has earned – and continues to earn – its income almost entirely from the sea, Claire has a vested interest in the conservation of the oceans for current and future generations. She believes that she is in exactly the right place to be able to contribute to this.

MILLAR PAUL JAMES | EDUCATOR

As an educator and conservationist whose own fascination with the marine world began with surfing and diving around Cape Town, Paul believes that initiating or growing people's experience, knowledge and appreciation of our oceans has a vital role to play in protecting our natural world. In between chasing swells up and down the coast of South Africa and enjoying the icy waves of local surf spots, he squeezed in some terrestrial time at the University of Cape Town, studying environmental and geographical science and education.

Paul draws on his significant experience in schools and environmental education when running the SOSF Shark Centre's programmes. His classes welcome the range of strong opinions inevitably encountered when educating people about sharks.

MAYIYA ZANELE | ASSISTANT EDUCATOR

Zanele was born in the northern part of South Africa's Eastern Cape. As a young girl she enjoyed cooking very much, so when she completed her matric she decided to make hotel and catering management her career. In March 2008 she started working for the Save Our Seas Foundation (SOSF) as a housekeeper at the Shark Education Centre. As well as carrying out her housekeeping duties, she assisted with the bookshop and showed the public around the centre. In June 2009 she joined Alison Kock on the research boat to Seal Island in False Bay and there she saw a great white shark for the first time in her life. By the end of that trip she had fallen in love with the sea and decided to become an educator so that she can pass on her enthusiasm to the upcoming generations of South Africans.

Although she enjoyed her job during those years, she told herself that one day she would fulfil her dreams. Her previous duties at the centre were the steps of the ladder that enabled her to get where she is today. The experience that she gained by showing the public around the centre, reading marine books and helping with school groups helped her a lot. Getting an opportunity to teach young people about marine life makes her very proud, in particular because most South African children, especially those who grow up in townships and rural areas, do not have a direct connection to nature or the ocean. After the training that she did during the probation period in her new role as assistant educator, Zanele explained, 'I can truly say that to achieve success you have to believe in yourself, have a vision and work hard because there were so many challenges during the training, like presenting in front of big school groups.' But through hard work she's made it.

SOSF SHARK RESEARCH CENTER | NOVA SOUTHEASTERN UNIVERSITY, OCEANOGRAPHIC CENTER, FLORIDA, USA

SHIVJI MAHMOOD | DIRECTOR

Mahmood is professor of marine science at Nova Southeastern University's (NSU) Oceanographic Center in Florida and a director of the SOSF Shark Research Center. He received his undergraduate degree in biological sciences at Simon Fraser University in Canada, his Master's from the University of California, Santa Barbara, and his PhD from the University of Washington. He has been a faculty member at NSU since 1993 and a director of the SOSF Shark Research Center since 2010.

Mahmood credits his lifelong fascination with biology to growing up in Kenya, where he was routinely exposed to African wildlife and undersea environments as a child and teenager. His interests in marine science in particular were boosted when as an undergraduate student he assisted one of his professors with kelp-bed ecology research in a pristine part of British Columbia. That experience proved transformative, leading to a career in marine and conservation science and education.

In addition to leading the research and education programmes of the shark research centre, Mahmood directs the Guy Harvey Research Institute, emphasising collaborative projects between the two entities to achieve larger and more impactful research and conservation outcomes. He specialises in integrating laboratory genetics-based and field-work approaches to study and solve problems pertaining to the management and conservation of sharks and rays, billfishes and coral reef ecosystems.

Mahmood's work consistently receives worldwide attention. His research developing rapid DNA forensic methods to identify shark body parts is being used by US and other national fisheries management agencies to reduce the illegal fishing of threatened species. This work is also on exhibit at the Smithsonian Museum's Sant Ocean Hall in Washington, D.C. and his team's research discoveries have been widely reported in the national and international media.

DODGE RICHARD | DIRECTOR

Having conducted research on coral reefs worldwide, Dr Richard E. Dodge is a recognised authority on reef ecosystems. With expertise involving reef ecology and ecology, he is also the author of many publications in scientific literature. His interests include the study of natural and man-induced impacts on coral reefs from factors including climate change, ship groundings and oil spills with their related mitigation, pollution and sedimentation; coral skeletal growth and sclerochronology; coral reef restoration; reef mapping and assessment; and Habitat Equivalency Analysis.

Richard gained a BA degree from the University of Maine in 1969 and an MPhil and PhD in geology and geophysics from Yale University in 1973 and 1978. He is dean of the Nova Southeastern University Oceanographic Center as well as executive director of the center's National Coral Reef Institute, which is dedicated to providing management research outcomes on reef monitoring, assessment and restoration.

SOSF STAFF

SOSF ISLAND SCHOOL SEYCHELLES MAHÉ, SEYCHELLES

VEL TERENCE | PROJECT ADVISOR AND EDUCATOR

Before joining University of Seychelles in 2015 as a science laboratory technician and a field lecturer for BSc environmental science students, Terence Vel spent 16 years as a laboratory technician in various secondary schools. Twenty-one years ago he became a founder of Wildlife Clubs of Seychelles and during this time has managed the organisation's projects and coordinated environmental programmes in 40 schools on Mahé, Praslin and La Digue.

In 2000 he worked as a technician on a project called 'Avian ecosystems in Seychelles', which was funded by the Global Environment Facility and implemented by the former BirdLife Seychelles. The project involved two distinct phases: in the first, ecological research was carried out on a number of the Seychelles' Inner Islands to investigate their biology and conservation potential; during the second, endemic Seychellois birds were translocated from certain islands to others that were more suitable.

In 2008 Terence embarked on studies for a diploma in environmental education and social marketing at the University of Kent's School of Anthropology and Conservation. This led him to The Darwin Initiative Rare Pride Campaign to work on a project called 'Investing in island biodiversity: restoring the Seychelles paradise flycatcher'. The project was based on La Digue Island and aimed to translocate a small population of birds on Denis Island.

Terence also conducts outreach programmes that focus on marine education for youth groups from the community.

FLEISCHMANN KARL | PROJECT SUPERVISOR

Dr Karl Fleischmann joined University of Seychelles in 2014 as a senior lecturer in environmental science. Earlier in his career he had spent two years at Seychelles Polytechnic as an instructor in A-level biology; later he returned to the Seychelles to undertake field work for his doctoral research. His long and varied career in education at secondary and tertiary level includes periods in Tanzania as well as in his home country of Switzerland. In 1988 he embarked on Master's studies in environmental sciences and geobotany at the Swiss Federal Institute of Technology (ETH) and at the University of Zurich. He followed these with studies, also in Zurich, on the subject of problems with invasive alien plants in the Seychelles, which led to his PhD. Since 1997 Karl has been coordinating research projects in the field of vegetation rehabilitation and nature conservation in the Seychelles. His work has been published in numerous academic journals and his research reputation has led to invitations to lecture to scientific audiences in both German and English. For five years he edited an international journal, *Perspectives*, a source of articles about the ecology, evolution and systematics of plants. Between 2008 and 2011 Karl was the deputy dean of the faculty of science and a member of the academic board at the Mwenge University College of Education in Moshi, Tanzania. The Ministry of Education, St Gallen, has awarded him the title of professor.

Photo by Michael Scholl

SOSF CENTRES

SOSF Headquarters – Geneva, Switzerland | Scholl Michael

SOSF D'Arros Research Centre – D'Arros Island and St Joseph Atoll, Les Amirantes, Seychelles (328) | Daly Ryan & Daly Clare

SOSF Shark Education Centre – Kalk Bay, Western Cape, South Africa (105) | Yeld Hutchings Eleanor

SOSF Shark Research Center – Nova Southeastern University (NSU), Oceanographic Center (OC), Dania Beach, Florida, USA (157) | Shivji Mahmood

SOSF PARTNERS

Shark Spotters – Finding a balance between recreational water user safety and white shark conservation (149) | Waries Sarah, Kock Alison & Sikweyiya Monwabisi

Cetacea Lab – Identifying critical habitat for killer whales in northern British Columbia (217) | Wray Janie & Meuter Hermann

The Acoustic Tracking Array Platform ATAP – A nationwide marine science platform (227) | Cowley Paul

Bimini Biological Field Station Foundation – Elasmobranch research, education and conservation in Bimini, Bahamas (260) | Gruber Samuel & Guttridge Tristan

The Manta Trust – A global strategy and action plan for the long-term conservation of mobulid rays (291) | Stevens Guy

SOSF SPONSORSHIPS

Award – Eugénie Clark Award at the American Elasmobranch Society (AES) Scientific Conference – July 2017 | Austin, Texas, USA (335) | Grubbs Dean

Conference – 4th Southern African Shark and Ray Symposium (SASRC) – September 2017 | Hermanus, South Africa (333) | McCord Meaghan

National Geographic Magazine NGM | (368)

Student Travel Grant and Keynote Speakers – European Elasmobranch Association (EEA) Scientific Conference – October 2017 | Amsterdam, NL (228) | Hood Ali

Student Travel Grant – American Elasmobranch Society (AES) Scientific Conference – July 2017 | Austin, Texas, USA (229) | Grubbs Dean

Student Travel Grant – Oceania Chondrichthyan Society (OCS) Scientific Conference 2018 – February 2018| North Stradbroke Island, Autralia (255) | Chin Andrew

Student Travel Bursaries – International Conference on Fish Telemetry (ICFT) – June 2017 | Cairns, Australia (372)

Sponsorship – Development and building of the Tetrahedron Squid – Directional Hydrophone Development | Mauritius (371) | Schnoller Fabrice

Sponsorship – Documentary: *Seeking Sanctuary* | Seychelles (396) | Jones Nick

Sponsorship – Sawfish Expedition in Andros, Bahamas | Bahamas (373) | Grubbs Dean

Sponsorship – University of the Seychelles | Seychelles (338) | Fleischmann Karl & Terence Vel

WaveScape – December 2017 | Clifton Beach, Cape Town, Western Cape, South Africa (334) | Frylinck Ross

FUNDED PROJECTS

A: ALL SOSF PROJECTS FUNDED IN 2017
IN ALPHABETICAL ORDER OF THE PROJECT TITLE

A comparative marine biodiversity assessment of D'Arros Island and St Joseph Atoll (397) Daly Ryan

Analysis of coral reef monitoring surveys 2011–2017 at D'Arros Island and St Joseph Atoll (398) Gadoutsis Elena & Hawkins Julie

Artisanal fishery of rays fish in relation to local livelihoods in Mafia District, Tanzania (394) Matiku Patroba

Assessing the role of magnetic-based navigation in the bonnethead shark (392) Keller Bryan

Assessment of the Gaza fishery of the giant devil ray *Mobula mobular* (265) Abudaya Mohammed

Beginning of sharks conservation in Albanian territorial waters by performing fisheries survey and sensitising communities (374) Bakiu Rigers

Building the future station for the Bimini Biological Field Station (379) Gruber Samuel

Characterising the emerging deep-water shark fisheries in Belize (299) Baremore Ivy

Charles Darwin Foundation – Galápagos marine education programme (387) Vilema Daniela

Community monitoring of nesting sea turtles at D'Arros Island and St Joseph Atoll, Seychelles (256) Mortimer Jeanne

Comparison of levels of genetic diversity in historic and contemporary sawfish populations (381) Phillips Nicole

Conservation and ecological research of smalltooth and largetooth sawfishes in Mexico (375) Bonfil Ramón

D'Arros and St Joseph as a refuge for the endangered humphead wrasse in Seychelles (403) Weng Kevin & Gray Andrew

Detection of sharks using environmental DNA from seawater samples (400) Dejean Tony & Fumagalli Luca

Developing tools for classifying shark behaviour from bio-logging data (401) Hounslow Jenna & Gleiss Adrian

Discovery of an angelshark *Squatina squatina* nursery area in the Canary Islands (344) Meyers Eva

Diversity, abundance and distribution of elasmobranchs at St Joseph Atoll (404) Daly Ryan

DNA testing to identify mislabelling of seafood in Guatemala (390) Hacohen Ana

Documenting and protecting Critically Endangered sawfishes in Madagascar (307) Leeney Ruth

Ecological consequences of personality in sharks (367) Dhellemmes Félicie

Elasmobranch biodiversity monitoring and assessment in Sabah, northern Borneo (343) Manjaji Matsumoto Mabel

Estimating the abundance of the white shark in southern Africa with an integrated population model (378) Irion Dylan

Experimental validation of unmanned aerial vehicles to survey smalltooth sawfish in The Bahamas (393) Kilfoil James

Finprinting – An international white shark photographic identification catalogue system (310) Scholl Michael

Foraging ecology of wedge-tailed shearwaters breeding at St Joseph Atoll, Seychelles (352) Van den Heever Danielle

Habitat and resource partitioning of juvenile sharks and their roles in remote coastal ecosystems (290) Weideli Ornella

Habitat use, residency and population genetics of endangered smalltooth sawfish off Andros Island (302) Grubbs Dean

Home range scaling in sicklefin lemon sharks through ontogeny – Tests of bioenergetics mechanisms (402) Byrnes Evan

Impact of extreme climatic conditions on reproductive biology of endangered sea turtles in Iran (382) Pilcher Nick

Investigation of the status of sawfishes (Pristidae) in Papua New Guinea (388) White William

Kick-starting ELMO – using citizen science to study the reproductive biology of South African catsharks (395) Schroeter Lisa

Lost fishes of Easter Island – Salas y Gomez and Rapa Nui expedition (380) Morales Serrano Naiti

Migration mechanics – understanding swimming kinematics of a marine apex predator (383) Porter Marianne

Movement patterns, trophic role and ecology of reef mantas in the D'Arros Marine Protected Area (230) Peel Lauren & Stevens Guy

Periodicity and visitation rates of manta rays *Manta alfredi* to cleaning stations at D'Arros Island (405) Daly Ryan

Project AIRSHIP – a novel, non-invasive and continuous approach to detecting sharks at our beaches (389) Adams Kye

Rays of paradise – ecology and distribution of spiny butterfly ray in Gran Canaria, Canary Islands (391) Jiménez David

Sawfish status in Indonesia (376) Dharmadi

Sharks on the urban edge – Shark research component of the Shark Spotters programme (306) Kock Alison

SOSF Global Sawfish Search (385) Simpfendorfer Colin

Status of sawfish in the Casamance River, Senegal, West Africa (377) Downing Nigel

The ecology of stingrays in St Joseph Atoll, Seychelles (288) Elston Chantel

Trophic position and ecological roles of euryhaline elasmobranch predators (309) Wueringer Barbara

Using environmental DNA to detect smalltooth sawfish in current and historical nursery sites (384) Poulakis Gregg

B: ALL SOSF PROJECT FUNDED IN 2017

SORTED BY CATEGORY AND IN ALPHABETICAL ORDER OF THE PROJECT TITLE

KEYSTONE GRANTS – CONTINUATION

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Photo by Michael Scholl

The SOSF team at the annual meeting of the scientific advisors in November 2017 in Sopchoppy, Florida, USA, at the Florida State University Coastal and Marine Laboratory. From left to right: Michael Scholl, Dean Grubbs, Nadia Bruyndonckx, Sarah Fowler and Andrew Chin.

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Two silky sharks *Carcharhinus falciformis* meet at the surface at sunset in the Gardens of the Queen, Cuba
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