Final Project Evaluation Report

We ask all grant recipients to complete a project evaluation that helps us to gauge the success of your project. This must be sent in **MS Word and not PDF format**. We understand that projects often do not follow the predicted course but knowledge of your experiences is valuable to us and others who may be undertaking similar work – remember that negative experiences are just as valuable as positive ones if they help others to learn from them.

Complete the form in English and be as concise as you can. Note that the information may be edited before posting on our website.

Please email this report to jane@rufford.org.

Your Details	
Full Name	Maximilian Hirschfeld
Project Title	Population Connectivity of Galapagos Bullhead Sharks and the Identification of Key Habitats for Conservation in the Galapagos Archipelago
Application ID	18898-2
Grant Amount	£5000
Email Address	maxh@enphocus.net
Date of this Report	01 October 2017

1. Indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.

Objective	Not achieved	Partially achieved	Fully achieved	Comments
1. Providing scientific data				Research campaigns to all proposed study sites were conducted to collect scientific data on the objectives 1.1-1.3 described below.
Model the geographic distribution of Galapagos bullhead sharks				The occurrence of bullhead sharks was recorded on all dives during the research campaigns. Additional data has been reported through citizen scientists, who are expected to continue contributing to the project. Agreements have been made with several collaborators to pool data on the species occurrence to model its distribution. We estimate to start running distribution models by the end of 2017.
Determine the demographic structure of the Galapagos bullhead shark population				The use of underwater lasers to non-invasively measure sharks underwater has proven highly effective to study the demography of bullhead sharks. Further, the sex of each shark can be externally distinguished. Since August 2016 we have also started to draw blood samples from the sharks underwater to examine blood hormone levels to determine when bullhead sharks reach sexual maturity.
Genetic structure & connectivity				During the 2016-17 research cruises, we have managed to sample large numbers of bullhead sharks from almost all study sites (see figure 1 and table 1), which is key to determine the genetic structure of the population and how connected the bullhead's

				habitats are. To analyse the genetic structure and connectivity of Galapagos bullhead sharks, we plan to export samples to Australia for sequencing and data analysis within the next year of this project.
Determine susceptibility to potential threats and vulnerability following IUCN criteria				This is one of the projects long-term objectives. Determining the vulnerability of a species following the guidelines of internationally recognised institutions such as IUCN, can only be achieved once sufficient evidence is accumulated and data from all our objectives have been analysed. To continue working towards this goal we have added additional collaborators to the team and I will participate in IUCN red list assessment training in the future.
2. Building local capacity				Based on our research funded by the first Rufford Small Grant we extended our collaborative network with the Galapagos National Park and local NGOs. We were therefore able to increase our impact through the participation in field and lab work and adding onto our outreach efforts by including more local organisations and volunteers.
3. Education, outreach & awareness				Together with our local partners our outreach programme was able to reach a large number of the local population from various age-classes, social sectors and islands. By expanding our network of local collaborators, we were able to extend the planned programme to include additional groups of kids and educational activities.
Citizen Science webpage				During the 2nd RSG we established the project´s own citizen science website, to inform the local and international community about our project objectives and outcomes and motivate anyone to

				participate actively in our research as a citizen scientist (see section 3).
Outreach & education				Our shark outreach and education programme included working with groups of kids at primary school age in collaboration with the National Park and local NGOs. A key element of this effort is the annual Galapagos Shark Day which includes kids of many age classes as well as their parents. This year we were able to provide actual experiences with the marine environment and sharks for participants of the event. Adults were included into the programme through workshops and public presentations.
4. Scientific publication & media coverage				Since the project is designed as a long-term research the publication of final results will be accomplished within a time-frame of up to 2 years. Nevertheless, publication of the various research objectives will be distributed over this time frame. For example, the first results of the project were presented at the 2nd Galápagos Conservation and Research Symposium, one of the most important channels to present scientific results to the local community (see section 4). Scientific results with recommendations for research and management are presented in reports to the Galapagos National Park in 2016 and by November 2017. Project updates have been and will be published frequently through a number of online channels and TV productions (see section 6).

2. Please explain any unforeseen difficulties that arose during the project and how these were tackled.

Generally, even with prior knowledge and after conducting a pilot study, one of the biggest challenges of this research project is to find and survey Galapagos bullhead

sharks in their natural environment. Bullheads prefer cold water and are more active at night. During the project´s pilot phase in 2015, a strong El Niño event raised water temperature in the Galapagos was above normal, even in the far western archipelago, making it difficult to encounter the species. Nevertheless, with lower water temperatures in 2016 we were able to accomplish our goals in terms of sampling similar number of sharks from all our proposed study sites. Based on these results we continued to dive throughout the Galapagos cold season and include night dives at all locations in 2017. By gaining new experience and adapting research methods we were able to capture larger numbers of bullheads sharks, including juvenile animals which are often well hidden during daylight and even exceed our expectations.

The bullhead sharks preferred habitats are often in the most remote areas of the Galapagos. This makes the field work logistically demanding. The project has well established collaborations, however, with the Galapagos National Park and researchers which facilitates the organization and operation of scientific diving in the Galapagos archipelago. Through these collaborations we have managed to increase our time in the field while reducing the costs. For example, the national park has supported our work through providing skilled park rangers for scientific diving and a portable dive compressor to operate autonomously in the field. These collaborations have resulted in delays for some field trips, but have also improved the results of the project.

One set back we struggled with was to get the photo-identification website, www.bullheads.org to function. We had planned to launch the website at latest in August 2016 in order to introduce the platform to dive and naturalist guides. Based on technical challenges of our web designer and programmer to customize the bullhead shark website we were only able to finish the website in October 2016 and introduce in a workshop on one island, San Cristóbal. Therefore, the participation of citizen scientists through the website was initially slow, but additional workshops and visits to dive agencies on San Cristóbal, Isabella, and Santa Cruz Islands from June through September 2017 have resulted in more submissions of bullhead shark photographs from citizen scientists. In 2018 refresher workshops will be held to keep the diving community involved and we are planning to develop a campaign called "Galapagos Shark Conservation Hero" to keep the community involved.

3. Briefly describe the three most important outcomes of your project.

Scientific discovery and knowledge
One of the most important outcomes of the project is the accomplishment of the proposed research objectives and the progress in scientific discovery. Between June 2016 and September 2017, we were able to meet and in some cases even exceed the expectations for most of our research objectives. First off all we have obtained a considerate number of bullhead shark observations during research campaigns, through citizen scientists, dive guides and scientific collaborators. The citizen science website will also continue to gather data. The resulting geographical data will permit a geospatial analysis of the bullhead sharks' distribution using GIS (geographic information systems) software. Further, we have during scuba diving and from

reports we have found egg cases of bullhead sharks indicating potential nursery grounds for this species (see figure 1). Therefore, the resulting spatial distribution model we will apply in the future can be used to identify habitat requirements and priority areas for management. The species distribution data will then be supplemented with information on the demography (size and sex ratios) of the population and information on the reproductive maturity of individual sharks determined through blood hormone analysis. By comparing manual measurements of bullhead sharks with photogrammetry results we confirmed the accuracy of this technique to obtain exact morphological measurements from sharks in the field. Further, we have recaptured several sharks on photographs, by comparing individual spot patterns, during research cruises and submitted by citizen scientists. This indicates the usefulness of the method to detect shark residency and movement patterns supported by citizen science data. Finally, the team was not only able to confirm the suitability of our selected study sites to study the genetic connectivity of this species, but find an additional hotspot on Española island (see table 1 and figure 1). The samples obtained from a majority of the study sites are sufficient for the first round of genetic analysis allowing us to direct future field work towards specific areas to complete a minimum of 25 samples and similar sex rations from each location. Between 2016 and 2017 we additionally obtained 138 blood samples during scuba diving. This will allow us to concentrate on particular areas with potential for reproductive activity and to look for juvenile sharks to generate representative samples sizes from all age classes.

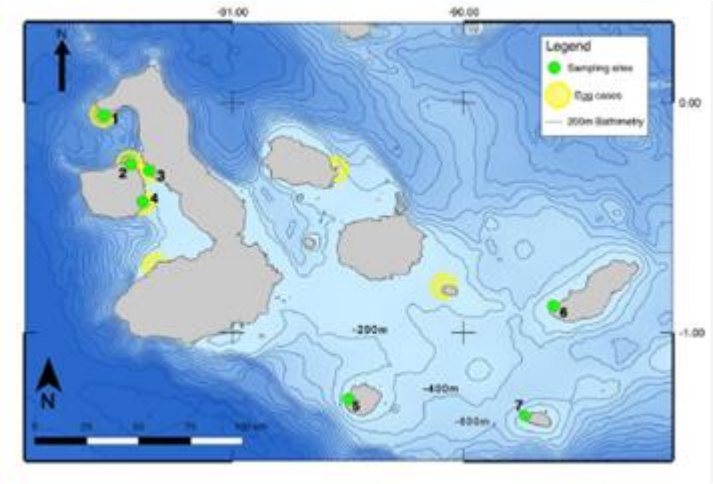

Figure 1. Map of the Galapagos archipelago indicating the sampling locations numbered 1 through 7 (green dots) and areas where egg cases were found (yellow circles). The number of sharks sampled is detailed in table 1 below.

Table 1. Summary of tissue samples from H. quoyi obtained per location, sex and year.

Year	Sex	1.Punta Vincente Roca	2. Punta Espinoza	3. Caseta PNG	4. Punta Mangle	5. Floreana	6. San Cristobel	7. Espanola	Total
2015	Male	0	1	1	0	1			3
	Female	0	0	1	2	1			4
2016	Male	3	7	3	4	4	0		21
	Female	5	1	6	2	7	3		24
2017	Male	5	7	4	3	18	1	20	58
	Female	5	5	7	4	11	2	5	39
Total		**18**	**21**	**22**	**15**	**42**	**6**	**25**	**149**

Citizen Science and building capacity

After initial issues with the website programming we have been able to give several workshops on the project and how to participate as citizen scientist on several islands and for different audiences. For example, we presented information Galapagos bullhead sharks and the project aims to more than 300 naturalist guide candidates on three different islands, during the Galapagos Naturalist Guide Course. Finally, dive agencies in the major towns on two islands were visited and introduced to the research project, how they may participate as citizen scientists and we provided information on printed designs to engage dive guides and tourists (see figure 2). Through submissions on our website (www.bullheads.org) we have obtained reports of bullhead sharks from new locations and have identified individuals which were re-sighted at the same location after several months.

Figure 2. Project posters distributed to local dive agencies.

Dive guides, volunteers, local and international and research assistants and Galapagos National Park staff were included in research and outreach activities to foster local capacity and knowledge. Participants were able to learn scuba diving research methods to study sharks and participate in laboratory work. Research assistants were also trained in processing samples, managing data bases and using specialised computer software for the photographic identification and measuring of sharks. Members of the Galapagos dive guide association were also particularly involved in learning how to participate as citizen scientists and communicate information to tourists.

Outreach and education
The success of our outreach programme can be attributed to the involvement of many local collaborators and international partners, who were open to new ideas and the participation of a diversity of groups. Besides public presentations and workshops, our local outreach effort focus on the involvement and education of Galapagos school kids together with different local partners. Working with the Galapagos National Park our volunteers participated in the institution´s Little Park Rangers programme, which brings the classroom outdoors. During an overnight camp the kids received shark education from our volunteers. One of the most important project components is the annual Galapagos Shark Day, which was first created during the shark conservation project funded by the first Rufford Small Grant. The educational event has gained much support since then and was held for the fourth time in September 2017. To organize the educational event, we were supported by the Galapagos Science Center, the Municipality of San Cristobal Island, the association of naturalist guides, and the local NGO´s Ecociencia and GECO. Both non-government organisations worked with school kids to prepared educational activities and shows for the shark day event. Further, we worked together with the Casa de la Cultura on San Cristobal Island (as had been suggested by an external reviewer of the application to this grant) to create educational presentations and activities for kids for the Shark Day.

4. Briefly describe the involvement of local communities and how they have benefitted from the project.

As detailed in section 3, the local community of the Galapagos Islands is not only involved in research activities, but forms a central part of the projects outreach programme. Since I have received the first Rufford Small Grant, numerous local volunteers, national park staff and research assistants have been actively involved in the research and educational activities of the funded shark conservation projects. These participants have developed substantial skills and knowledge to promote shark conservation in the Galapagos and some of them work on their own projects now. I would like to emphasise that the involvement of both individuals and local organisations in our project aims to provide an opportunity to become actively engaged in research and conservation of sharks and develop new skills and ideas, thus empowering the local community to guide the Galapagos into a more sustainable future. Research funded by the first Rufford Small Grant has resulted in the protection of nursery areas for juvenile blacktip sharks. The current research also

aims to achieve tangible conservation outcomes by working with the Galapagos National Park and communicating results to the public.

5. Are there any plans to continue this work?

This project was laid out as a long-term endeavour. After the project initiation in 2015, the support received through the second Rufford Small Grant and the Galapagos Conservation Trust has catalysed the project´s progress. Research activities during 2016/17 focussed on extensive field work throughout the Galapagos archipelago to firmly establish the project and obtain as many samples and data as possible. These goals were achieved, as demonstrated by the number of sharks identified and photographed and the amount of tissue and blood samples obtained from many locations throughout the islands. The next steps will be to export and analyse the samples and crunch the data. Based on these results we will be able to provide first feedback to the Galapagos National Park and present findings at scientific meetings. At the same time, additional data will be needed to close potential gaps in our sampling effort and to provide sufficient information for scientific publication of the final results and for the development of management suggestions. After initial the analysis will be able to pinpoint data gaps to focus our field research on. Furthermore, the collection of citizen science data to study bullhead shark distribution, movements and population size will continue providing new insights over the next years, highlighting the strength of the long-term duration of this project.

6. How do you plan to share the results of your work with others?

The importance and preliminary results of this research have already been presented to the Galapagos public, the Galapagos National Park, national and international researchers at the 2nd Galápagos Conservation and Research Symposium (see link below). One of the most important platforms for communicating the research aims and progress will be the project´s website, www.bullheads.org. Further, news and updates have and will be published regularly through the online media of the Galapagos Science Center and the Galapagos Conservation Trust (links below). For this purpose, we are producing several professional short videos and photographs highlighting the education and outreach work in the Galapagos.

In 2016, some of the work funded by the first Rufford Small Grant tracking juvenile blacktip sharks to provide spatial data for management has been featured in the BBC´s Mission Galapagos. The work on juvenile blacktip shark nurseries is being extended by a colleague and Rufford grantee, also featured in the documentary. The Galapagos bullhead sharks were filmed by SeaDog Productions UK, for a three-episode documentary featuring Monty Hall.

Finally, the results will be presented in international scientific symposia and published in scientific peer-reviewed journals. For example, I will present the first results at the Sharks International symposium, the largest conference on shark biology and conservation, in Brazil in 2018.

Links to online publications:

- 2nd Galápagos Conservation and Research Symposium (see link below). video report: https://www.youtube.com/playlist?list=PL5-NfOR7GiZGMZ5XnNVgwoBRIydKQCJ_y).

- Galapagos Science Center blog: http://galapagosscience.org/the-galapagos-bullshark-project/

- Galapagos Conservation Trust´s Discovering Galapagos website: http://galapagosconservation.org.uk/projects/galapagos-bullhead-shark/

- Project video: https://www.youtube.com/watch?v=MSJM6cSc9qU

- Talk Wildlife website: http://www.talkwildlife.net/galapagos-bullhead-shark-project/

7. Timescale: Over what period was the grant used? How does this compare to the anticipated or actual length of the project?

Funding provided by the 2nd Rufford Small Grant was used between June 2016 and end of September 2017 to accomplish the research and outreach objectives proposed. The funds were initially requested for the period between June 2016 and end of June 2017. An extension was requested until September 2017 to be able complete another research cruise in collaboration with other researchers and because of the timing of the Galapagos Shark Day event on 9th September 2017. The actual length of this research and conservation project extends beyond this period. The project was initiated during a pilot phase in October 2015 and was then established as a long-term research project in 2016. A large bulk of field work has been accomplished during 2016 and 2017 funded by the 2nd Rufford Small Grant. Between October 2017 and June 2018, we aim to export and analyse tissue and blood samples for DNA sequencing and the determination of blood hormone levels. We plan additional field work in the Galapagos cold season starting in June 2018 to fill any gaps in our sampling effort, such as increasing sample sizes from specific locations and age classes of sharks. The publication of the results in scientific journals will be accomplished between October 2018 and October 2019.

8. Budget: Provide a breakdown of budgeted versus actual expenditure and the reasons for any differences. All figures should be in £ sterling, indicating the local exchange rate used. It is important that you retain the management accounts and all paid invoices relating to the project for at least 2 years as these may be required for inspection at our discretion.

Item	Budgeted Amount	Actual Amount	Difference	Comments
1st Research Cruise	1600	1600		Total cost of the cruise was 3500, 1900 provided by the Galapagos Conservation Trust (GCT)
2nd Research Cruise	1600	1600		Total cost of the cruise was 3500, 1900 provided by GCT
Dive Gear	800	920	120	Additional dive gear such as torches and safety equipment was acquired, but paid through other sources.
Educational Print Material (Posters, flyers)	200	200		Between 2016 and 2017 we produced a great amount of education print material, much of which was supported by the GCT.
Photo-ID website	800	1100	300	The programming and website design to include the photo-identification work flow, needed additional attention. A News section was also added to regularly publish project updates.
TOTAL	**5000**	**5420**	**420**	

9. Looking ahead, what do you feel are the important next steps?

Population genetics: First, and most importantly is the export of tissue and blood samples and preliminary data analysis. Tissue samples will be sequenced using a genomics approach called SNPs (single nucleotide polymorphisms) which has only recently been discovered for the study of wildlife populations with promising results. This powerful technique will allow us to detect the genetic population structure and population connectivity of Galapagos bullhead sharks at high resolution. For this purpose, DNA will be extracted from samples at the University of Queensland, Australia, and then send to specialized sequencing facilities. The results will tell us how much structure there is between the different islands in the Galapagos and where additional samples are needed to determine the levels of population connectivity. Further, our collaborators in Perú have obtained some preliminary samples from the continental coast, but additional sampling will be needed to be able to genetically compare bullheads sharks of the two regions, which have been thought to be one population of the same species.

Reproductive hormones: Secondly, blood plasma sampled will be analysed using RIA (radioimmunoassay) with our partners at the University of Tasmania, Australia, to determine reproductive hormone levels of the sampled sharks. The hormones measured in sharks of different sex and size can then be used to estimate the size at which this species reaches maturity, a crucial factor to evaluate its vulnerability to human threats.

Citizen Science: The project's photo-identification website will continue to gather data on the residency and movement patterns of bullhead sharks in the Galapagos and provide a platform to communicate research and outreach updates. It will take a considerate amount of time to collect sufficient data through photographs, to attempt an estimation of the species population's size. At the same time we will be able to model bullhead shark's distribution in the Galapagos with preliminary data and then continue refining the models as we receive submissions of bullhead photographs. To reinforce our citizen science programme and inspire the local population to participate in conservation research we plan to develop a campaign called Galapagos shark conservation hero. The campaign aims to motivate the participation in citizen science research by creating a competition, which recognises the individuals who contribute the most to the conservation of sharks. These individuals will be publicly recognized and receive a certificate and official Shark Conservation Hero badge as well as a price which can be used in citizen science, such as an underwater camera.

The information generated from these analyses will help us to identify were to focus field work in 2018 to achieve our goals in creating scientific knowledge with management application. This includes the identification of genetically distinct groups of bullhead sharks in the Galapagos and Peru and the delineation of key habitats for protection. Some of the results will be presented to the Galapagos community and the Galapagos National Park Services at the 3rd Galapagos Science Center, and to the scientific community at the Sharks international conference in Brazil in June 2018.

Rufford Foundation regional conference: Together with two other Rufford grantees working in Ecuador, Robert Lamb and Javier Oña, we have agreed to host a Regional Rufford Conference in the Galapagos Islands, with a special focus on protected are design and connectivity in the Eastern Pacific.

10. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the Foundation receive any publicity during the course of your work?

The RSFG logo was used in all scientific and public presentations and we emphasised the importance of the foundations support to accomplish conservation goals. These include, the 1st (2016) and 2nd (2017) Galápagos Conservation and Research Symposium, the Animal Movement work shop at James Cook University, workshops with the Galapagos naturalist guides association and the Galapagos National Park naturalist guide course. I estimate that over 600 people from many different backgrounds were reached through presentations. Moreover, we have

acknowledged the RSGF on the projects website and have used the logo on our educational print material used in outreach events and online publications (see example in figure 3)

Figure 3. Educational poster on shark reproduction used at the Galapagos Shark Day.

11. Please provide a full list of all the members of your team and briefly what was their role in the project.

12. Any other comments?

I appreciate the continued support given by the Rufford Foundation, which made it possible for this long-term conservation project to fully take-off in 2016 and make substantial progress until September 2017. In October of this year I will lay out the next steps and research goals for the Galapagos bullhead shark project and aim to apply for further support through the Rufford Foundation.


TIBURONES
DEL MUNDO
VIVIERON EN EL PLANETA TIERRA ANTES QUE LOS DINOSAURIOS
450
MILLONES DE AÑOS
ALREDEDOR
500
ESPECIES
5 Y 7
VIVIR