Final Evaluation Report

Your Details	
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Project Title	Galapagos sharks: developing traceability markers to identify the origin of illegal shark fishing
Application ID	24644-1
Date of this Report	04/05/2022

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
To collect new samples of Galapagos shark (Carcharhinus galapagensis)				We collected samples from San Cristóbal. We did not collect samples from Isabela as planned initially. This is because we prioritise using the samples from illegal catch to test us markers. Unfortunately, none of the samples from illegal catch corresponded to Galapagos sharks.
To extract genomic DNA and perform PCR				DNA was successfully extracted from all samples at the Galapagos Science Center facility. PCRs were successful for all samples as well.
mtDNA sequencing				Samples were sequenced for the mitochondrial D-loop region successfully.
SNP sequencing				Due to the delay with the previous processes, and delay with research permit renovation, we weren't able to send samples for SNP sequencing before the pandemic lockdown start in March 2020.
Data analyses				In 2019 we found that only the Galapagos population possess the strong unique genetic signature required to inform about provenience. And even for the Galapagos population, the validation of the markers (SNPs position and function within the genome) requires a reference genome. To date, no carcharhinid species has been sequenced for the entire genome. Nevertheless, in late 2019 we aimed at using the samples from the Chinese vessel Fu Yuan Yu Leng 999 to test our markers. Unfortunately, although the morphological report indicated the presence of at least 50 Galapagos sharks on the boat, we discarded this with genetic analyses. I participated as part of the team that analysed all the samples from this vessel, and were able to proof the relevance of genetic species identification and

				forensics in the Galapagos (The work was published in 2021: https://www.nature.com/articles/s41598-021-94126-3) At this point we defined two new objectives to the project: 1) To support the capacity building for forensic studies in the Galapagos. 2) To engage the local community in molecular research.
NEW Objective 1: To support the capacity building for forensic studies in the Galapagos				The experience from the Chinese vessel samples were a game-changing one. Not only we faced many challenges, including the difficulty of sending samples out of Galapagos for processing, but also highlighted the importance of molecular work in places like this. I decided to include this objective to develop local capacity for processing genetic samples. By partnering with multiple local, and international agencies, The Galapagos Science Center has been able to develop operational capacity to sequence DNA on a local basis (by purchasing sequencing equipment). This is a massive step into the development of molecular work, including forensics in such isolated place. Since its implementation in 2021, I have used the facility to sequence multiple species, marine and terrestrial with forensic purposes.
NEW Objective 2: To engage the local community in molecular research				With a facility fully implemented (by the Galapagos Science Center) to develop molecular work from DNA extraction to sequencing, it was an important task to engage local community. I have trained at least 13 local people in three islands on the use of this technology. Additionally, I have developed, together with the Galapagos Science Center, educational workshops for high school students to experience first-hand the molecular lab, and to learn about genetics and forensics.
Results communication				Results have been partially presented in local presentations to the Galapagos National Park and in a local symposium in 2022 at the Charles Darwin Station

2. Describe the three most important outcomes of your project.

a). One of the main findings was that within the Eastern Tropical Pacific, only the Galapagos population of Galapagos sharks has a genetic signature capable of detecting provenience with high confidence. Although restrictive in terms of applicability of molecular markers, it highlights the need for more genomic resources from other species and other populations.

b). The development of local capacity to process genetic samples. One of the most important lessons learned from this experience is the need for local capacity to produce genetic data capable to inform local authorities. Although we couldn't test our markers on samples from illegal catch, we could still prove the importance of genetic species ID for management and conservation. Additionally, the capacity to engage local people into genetic work.

3. Explain any unforeseen difficulties that arose during the project and how these were tackled.

Geographic isolation in general has been a major challenge when working in the Galapagos. This was an even larger problem in combination with the COVID pandemic. We were limited in terms of our capacity to carry out research. Bringing reagents and equipment was a massive endeavour. Sending samples out of Galapagos and/or Ecuador was nearly impossible for over a year. Therefore, we had to adapt and make sure we solve the main problem: our local capacity to process samples and produce data. After one full year from the start of the pandemic, we were able to accomplish this task.

Local regulations. The renewal of genetic and research permits with local authorities was very challenging, and time consuming. Some of these processes lasted several months, making it impossible to carry out continuous work sometimes. I made use of the administrative infrastructure from the University San Francisco de Quito (USFQ) to speed up the processes when possible. However, the pandemic delay many of these processes as well.

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

The original objectives included some work done locally, and most of the work developed abroad. Our preliminary analysis of the data pushed us to move in a different direction. First trying to apply our developed markers into genetic samples from illegal catch. To do this, we involve local students. However, most of the hands-on work was still done out of the islands. This made me define new, broad, but equally important objectives. First to develop local capacity to process samples and produce data. Second and most importantly, engage locals into this ambitious attempt. I have trained 13 local people into DNA extraction, amplification, and sequencing methods in the past year. Five of them, continue to work in the lab processing samples, and producing data relevant to the conservation of Galapagos.

5. Are there any plans to continue this work?

Absolutely. The development of molecular research and all its applications (e.g., forensics) are crucial to the Galapagos. For the local authorities to be able to respond quickly to illegal activities and to be able to present evidence based on molecular work can make a tremendous difference. I continue to be committed with this endeavour, and plan to put all my effort into taking advantage of our new facilities for this purpose. I am also convinced, more than ever, of the need to involve local community, and to develop this capacity. The pandemic left behind many lessons, particularly for a population that depends in tourism so much. Providing a new set of tools (associated to research and science) to local people will increase resilience in the local community.

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

I have shared partial results of this in local encounters with local authorities. Additionally, the work related to the Chinese vessel resulted in a scientific publication. For the future, I would like to make use of other channels (e.g., social media) to communicate the relevance of our achievements and to invite people to join these efforts.

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

I think there are two critical things moving ahead:

a) To guarantee the funding for reagents and consumables to continue to process important samples in the Galapagos.

b) To continue with training and educational programs for the local community. The impact of messages coming from the local people is strong, and we should make every effort to engage locals and share the relevance of this type of project.

8. 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?

I included the logo on the presentations related to forensic research in the Galapagos.

9. Provide a full list of all the members of your team and their role in the project.

Daniel Armijos: field assistant to collect samples and support logistics

Yasuní Chiriboga: sample processing in the laboratory and data processing

Wilson Andrade: field assistant to collect samples, and process them in the laboratory

Jaime Chaves: collaborator. Together, we worked on the implementation of the sequencing facility in Galapagos

Floriaan Devloo-Delva: data analysis and laboratory work

10. Any other comments?

I am grateful for the opportunity to develop this project. Although challenging and with results different from the expected, it highlighted a crucial need for local molecular research.

The development of local capacity to sequence DNA is a very large investment made by the Galapagos Science Center through the Barcode project and will have an impact in hundreds of projects to come. This effort has already had an impact in at least 15 projects (since the sequencers have been implemented in July 2021). Two of these projects are forensics efforts to support local management.

The Rufford funding was crucial to highlight this need in the islands, especially during the pandemic, when the samples from this project couldn't be exported for processing outside of Ecuador. Although the markers here developed could not be tested in a forensics context, I expect that this work can continue as the research activities go back to normal in the Galapagos. This project overall, represent the very first step into molecular forensics research in the islands.

Finally, the pandemic was a major limitation for all the research I conduct in the Galapagos. I was not able to use all the funding available due to the limitation for research activities in general. However, I adapted to the situation and was able to plan and to develop educational and training activities, and I used some funding for this purpose. I will wait for indications to return the remaining amount and hope I can apply for funding in the future to continue with molecular applied work.