

PROGRESS REPORT ON PROJECT SUPPORTED BY PADDY PALLIN SCIENCE GRANT

Instructions to Project Leaders for Completing This Form

Progress reports are required to be submitted 12 months after the start of the project, and then at 18-24 months as a final report. Grants usually begin on the 15TH September in the year in which the grant was awarded. Payment of the second grant installment is contingent upon the receipt of this material. Updates are to be provided during the tenure of the grant, and at the time the final report is submitted. Payment of the final grant installment is contingent upon receipt of the final summary which is to summarize the outcomes of the project during the tenure of the grant.

1. PROJECT IDENTIFICATION

1.1 PROJECT

Tiger shark behaviour revealed by their movement and tissues: implications for ecology and conservation

1.2 ADMINISTERING ORGANISATION

School of Animal Biology, The University of Western Australia

1.3 PROJECT LEADER AND PARTICIPANTS

Luciana Cerqueira Ferreira, Prof. Jessica Meeuwig

2. PROJECT DESCRIPTION & OBJECTIVES

2.1 100- Word Project Summary

My study aims at understanding the drivers of movement of tiger sharks in Australia. I will use stable isotopes signatures of tissue samples to understand spatial shifts in diet of tiger sharks. Additionally, I will use tracking data of tiger sharks to describe their migratory patterns, habitat use and temporal and spatial shifts in movement behaviour. This will allow me to understand the relationship between diet and movement patterns, and how it changes spatially. Understanding how, with what frequency and why sharks use specific habitats is important to define areas of high use that deserve special attention for conservation.

2.2 Summary of original objectives (150 words max)

The project aims to characterize movement and spatial patterns in diet of tiger sharks, as well as to define the relationship between diet, movement and the environment. The combination of data on movement and diet will allow me to address the following scientific objectives:

1. Describe the large scale movement patterns and the influence of biological and environmental drivers to the spatial ecology of tiger sharks using high-resolution satellite telemetry.
2. Define fine scale residency and site fidelity of tiger sharks in coastal waters of Western Australia.
3. Identify patterns of diet specialisation of tiger shark in key ecosystems off Western Australia.
4. Characterize population-level movement and diet latitudinal variation and its implications to tiger shark conservation.

3. PROJECT OVER DURATION OF FOUNDATION GRANT

3.1 Have there been any changes to the project? If yes give details

This could include changes to the research Project resulting from funding from the Foundation being at a lower level than requested. By indicating changes to the budget, aims and research plan in the Report, you are requesting approval from the Foundation for a revision of the Project. A 'satisfactory' assessment of the Report and the Project by the Paddy Pallin Grants Committee means that the revision has been approved.

There have been a few changes to the research plan. These changes have not affected the original aim and will add essential information to help me to reach the proposed goals.

Muscle and blood samples were collected during a 20 day expedition off Ningaloo Reef, Western Australia. Due to constraints in field data collection, we are unable to do fatty acid analysis of blood and muscle samples. However, as a result of a collaboration with researchers from James Cook University, University of Queensland and the Western Australia Department of Fisheries, additional muscle samples and historically collected vertebrae of tiger sharks will be included to our analyses. Shark vertebrae (backbones) are commonly used to study age and growth of sharks. These calcium phosphate structures, when cut longitudinally, look similar to a tree trunk, with rings within rings. The number of rings will correspond approximately to the age of the individual. More recently, the development microgeochemistry techniques (Stable Isotopes and Laser Ablation Inductively Coupled Plasma Mass Spectrometry - LA-ICP-MS) has allowed us obtain the stable isotope (C and N) and elemental (Ba, Sr, Zn, Mn, Mg) ratios of each growth ring. The ratio of elements, such as Ba and Sr, in each ring reflects the environment in which the animal was living at that specific period of its life, with shifts in these ratios reflecting movement between different habitats. Shifts in ratios of C and N will tell us about how diet changed while the individual grew. By combining information on stable isotope from tissues to the time series from vertebrae of tiger sharks from different regions, we can assess not only geographical shifts in diet but also shifts in diet and movement behaviour throughout an individual's life and across the species range in Australia. Producing a continental-scale analysis of marine apex predator diet and movements presents a rare opportunity to unveil key ecological information for this threatened species with direct relevance to its conservation.

As a consequence of the change in the research plan, the section of budget previously allocated for fatty acids will be used towards the stable isotope and elemental analyses of tiger shark vertebrae.

3.2 What were your research plans and objectives for the period covered by this report? (150 words max)(The answer to this question should be consistent with the original Application or the preceding Progress Report).

The goals for the first year of the project were to carry out an expedition along the coast of Western Australia to tag tiger sharks and collect samples, and to analyse at the Stable Isotope Laboratory (Western Australian Biogeochemistry Centre- WABC) at The University of Western Australia.

3.3 Did the research project proceed as planned? What have you achieved over this period? Outline the research findings to date (200 words max)

We have conducted a successful expedition during April/May 2015 when tiger sharks were tagged, and samples were collected. Tagged sharks can be tracked on www.ocearch.org/#SharkTracker.

We tagged 20 female tiger sharks off Ningaloo Reef. Sharks ranged in size between 268 and 407 cm. One of the sharks was bearing fresh mating wounds which indicate Ningaloo Reef is a possible mating site for tiger sharks in Australia. The high number of females caught might indicate at least some degree of sexual segregation for tiger sharks off Ningaloo Reef, with females utilizing the shallow areas of the reef lagoon more frequently than males.

Initial tracking results indicate that most sharks remained in the vicinity of the location where they were tagged at Ningaloo Reef. Three sharks swam north, with one shark going as far as Darwin in the Northern

Tissue samples analysis has been arranged with WABC and is expected to be concluded by late 2015. I will prepare vertebrae for analysis during September/October at the WA Fisheries Department and analyses should be concluded by early 2016.

3.4 Have you experienced any difficulties that have affected the progress of the research project? If yes give details (150 words max)

No major difficulties were encountered. The impossibility of analysing fatty acids was surpassed by adding a larger number of muscle samples and a large number of vertebrae samples across Australia to our database which will greatly help us achieve the proposed objectives.

3.5 What are your research plans and objectives, including publication plans, for the coming year? (150 words max) (Please note that in your next Report you should report progress against these plans and objectives)

We expect to have all laboratory analyses and results by early 2016. Information on stable isotope and elemental ratio will be analysed as a function of age and location. Using the stable isotope database we expect to produce a scientific article on the spatial and ontogenetic shifts in diet of tiger sharks and its relation to movement between habitats in Australia. These results will be presented in an international conference in July 2016.

4. ACADEMIC OUTPUTS

4.1 Publications and other academic outputs directly related to this project. (Please list all publications and those manuscripts accepted for publication, for the period covered by this report)

Ferreira, L.C., Heithuas, M., Meeuwig, J.J., Meekan, M.G. *In review*. Possible mating wounds on a tiger shark (*Galeocerdo cuvier*) at Ningaloo Reef, Western Australia. Marine Biodiversity

4.2 Evidence of scholarly impact and contribution. Is there evidence that this research project is having/has had an impact in the research field or the broader public domain? Include examples of formal training (PhD/Masters) as well as other training.

If yes, give details (For instance, standard citation data on articles published in ISI journals, citations to books, re-publication, translations, reviews, invited keynote addresses, other invitations, newspaper/media/expert commentary).

Since this project started there has been great interest from the shark research community in Australia to join our efforts in creating a continental-scale project of tiger shark diet and habitat use. Researchers from James Cook University and University of Queensland have provided over 100 samples of muscle and vertebrae for our analysis. This interest from the scientific community illustrates the impact that our results will have for marine ecology and conservation in Australia. Producing a continental-scale analysis of a marine apex predator diet and movements presents a rare opportunity to unveil key ecological information for this species with direct relevance to its conservation. It also underpins the creation of science-based

We expect our results will be of great interest to the broader public, and governmental and environmental agencies.

4.3 End-user interaction and other project outcomes **If there are examples of the impact of this research Project not covered in item 4.2 above please provide details.** *For example, introduction or modification of standards/protocols within an industry sector, preparation of proposals for funding from other agencies as a result of outcomes from this project.*

This will be the first study to combine both elemental and isotopic analysis of shark vertebrae and tissue samples. This project will be a major step towards applying cutting edge biogeochemical techniques to biological samples of marine apex predators.

5. ATTACHMENTS & OTHER MATERIAL

Please provide , as separate files, any figures, graphs, images and other material that cannot be included in this form. Please also provide updated material (text and images) that can be used to revise your project summary on the Foundation's web site. Please provide text in Microsoft Word format and images in JPEG format with a minimum size of 600 x 400 pixels. If this is the final project report, the web page summary must be updated to reflect the outcomes of the project. Is any material being forwarded as additional attachments ?