SEABIRD & SEA TURTLE ECOLOGY IN BIOT:
June - July 2019 Research Expedition Report.

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Executive summary

This scientific expedition to Diego Garcia and remote islands of the British Indian Ocean Territory (BIOT) from 18 June to 16 July 2019 successfully brought together a research team of seabird and sea turtle scientists for the first collaborative expedition to an outer island.

A seabird research team of two from The Zoological Society of London, as part of the Bertarelli Programme of Marine Science, visited BIOT, for their third outer island science expedition. The team spent 10 days on Nelson's Island and were accompanied by two turtle research biologists from Swansea University, UK and Deakin University, Australia. The team were deployed by the crew of the BPV and recovered by the BPV and British Forces BIOT.

The seabird team deployed 31 sets of short-term tracking devices on breeding red-footed boobies and recovered 29. In addition, feather samples were collected for sex-determination in the lab, and an acoustic survey was conducted to test the potential for acoustic recording devices to determine the distribution of wedge-tailed shearwater colonies on Nelson's Island.

The turtle research team were able to build on previous conservation research on the ecology of hawksbill and green turtles in the archipelago. The team gave a public talk about sea turtles in BIOT to over 70 people with a volunteer sign up. On Diego Garcia: the turtle team was assisted by 48 volunteers to recapture and maintain satellite tags for 4 immature turtles in Turtle Cove; conduct drone surveys of the lagoon to improve estimates of in-water turtle populations; conduct nesting activity surveys and download images from 14 remote cameras on the Index beach. The team excavated (and re-buried) temperature loggers deployed for 12 months at turtle nest depths. On Nelson's Island: the team patrolled beaches nightly and deployed a satellite tag on a green turtle for the first time on an outer island. Surveys of turtle nesting activities took place daily; drone surveys were conducted on 3 days to estimate in-water turtle population; and 9 remote cameras were installed to record nesting activities over the next 6 months. During a visit to Peros Banhos, the team opportunistically serviced 9 cameras set up on 5 islands in March 2019.

Updates throughout the expedition were posted on Twitter (#BIOTscience; @BIOTscience) and on the Facebook group Chagos Turtles (285 members). Expedition blogs were posted on the BIOT expedition blog website at ZSL (https://www.zsl.org/blogs/chagos-expedition/).

The preliminary findings from the seabird research team indicate that (i) breeding red-footed boobies were foraging further to the east and conducting multi-day trips compared to the same period in 2018, (ii) the island supports a significant multi-species seabird breeding colony, and (iii) acoustic recording devises can potentially detect shearwater colonies. Preliminary findings from the sea turtle team include (i) southwesterly migration outside of BIOT by green turtle satellite tagged on Nelson's Island, and (ii) high variability in inter-annual nesting activities on Diego Garcia and Nelson's Island.

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Cover photo: The team by the temporary camp on Nelson's Island (credit; Nicole Esteban)

Introduction

In July 2019, as part of the Bertarelli Programme in Marine Science (BPMS) the Zoological Society of London (ZSL) with collaborators from Swansea University (SU) and Deakin University (DU) conducted a research expedition to Nelson's Island in British Indian Ocean Territory (BIOT). The original aim had been to visit Danger Island, where the team had previously conducted a trip in January 2019, however adverse weather conditions prevented the team from safely transferring their equipment from the BIOT Patrol Vessel and the decision was made to follow a back-up plan and deploy to Nelson's Island instead. Additionally, the sea turtle team carried out research activities in Diego Garcia before travel to Nelson's Island and commenced the expedition with a presentation about sea turtle research in BIOT (Fig. 1). A schedule was drawn up with over 50 people volunteering to assist on the planned daytime surveys during the 5 days on Diego Garcia. All volunteers are required to sign and acknowledge the approved Guidelines before assisting on surveys.

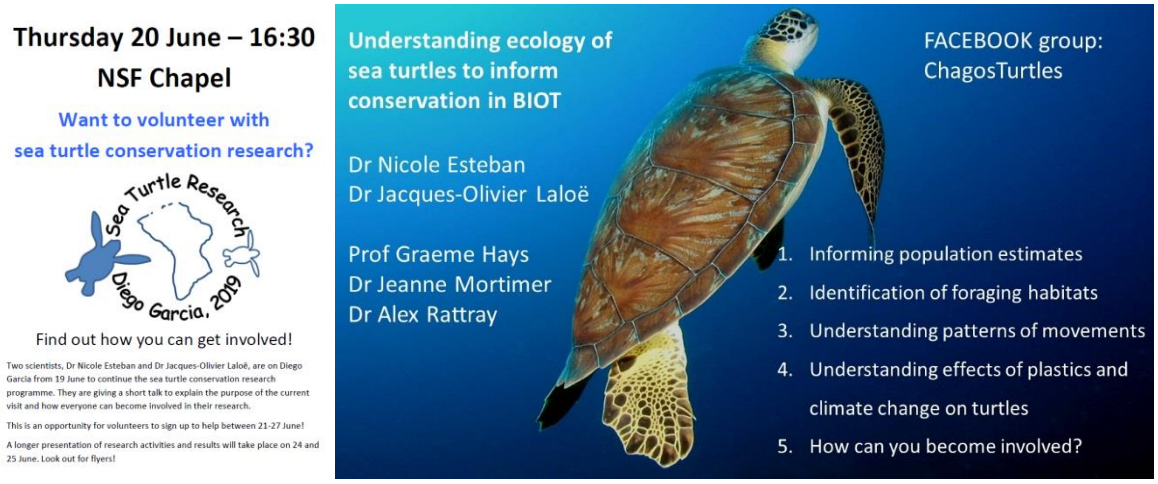

Figure 1. Expedition talk on day 1 of the expedition was advertised by a flyer circulated on various Facebook groups that attracted a packed audience of around 100 people in the Chapel. The talk focused on expedition objectives and activities and finished with a volunteer sign-up.

This research expedition was part of the ongoing four-year seabird and sea turtle ecology programme to explore the importance of the BIOT Marine Protected Area (MPA) for seabirds and sea turtles. It compliments and expands upon previous research conducted over the last two years at Barton Point (Diego Garcia), Nelson's Island and Danger Island. The expedition focused on the following six objectives:

<u>Objective 1</u>

To deploy both IgotU GPS loggers and Migrate Technology activity tags (GLS) on breeding red-footed boobies (RFBs) (*Sula sula*) in order to obtain foraging and at-sea location and behaviour data.

<u>Objective 2</u>

To collect feather samples from study birds in order to determine their sex.

<u>Objective 3</u>

To note the presence and abundance of other species of breeding seabirds on Nelson's Island.

Objective 4

Remote island trial to satellite tag nesting green turtles, *Chelonia mydas*

Objective 5

Beach and aerial surveys to inform assessment of hawksbill and green turtle populations

Objective 6

Movements of immature turtles within Diego Garcia lagoon: satellite tag maintenance and remote data download from MOTE.

Methodology

Objective 1

As used on RFBs in previous expeditions, tail-mounted GPS loggers (15g, IGotU GT-120, Mobile Action Technology Inc) and leg-mounted geolocators with activity sensors (3.0g, Intigeo C330, Migrate Technology) were attached to 31 breeding RFBs to document at-sea foraging locations and behaviour whilst rearing small chicks. Tags were deployed for between three and eight days and no apparent adverse effects were observed on either breeding success or welfare. In order to maximise retrievals, checks for tagged individuals while attending the chick in the day were extended to include checks in the evening and early morning when birds had returned to the colony to roost.

Objective 2

Three feathers were removed from the breast of each tagged bird and stored in paper envelopes. These will be analysed by technical staff at the Institute of Zoology at ZSL to determine the sex (by DNA) of the individual RFBs tagged.

Objective 3

Species of seabirds which exhibited breeding signs (nest building, eggs or chicks) were noted across the island and other non-breeding species recorded.

During the expedition to Nelson's Island in July 2018, it was discovered that the island supports a larger than previously estimated population of roosting and possibly breeding wedge-tailed shearwaters (*Ardenna pacifica*). In order to estimate the distribution of this population on the island acoustic recording devices were deployed. 10 locations were identified, evenly placed at 150m intervals, along a transect running east to west through the island some 30m inland from the northern coastline. At each location an audiomoth (open acoustic devices, Oxford, UK) was deployed for one period and set to record the surrounding acoustic environment for 5 minutes (with 10 minute intervals) between 18:00-08:00. The immediate vicinity of each sample location was also searched for signs of shearwater burrows. Audiomoths were also placed at two known shearwater colonies with burrows, for two nights, to provide calibration acoustic data.

Objective 4: Remote island trial to satellite tag nesting green turtles, *Chelonia mydas*

We used methodologies previously tested and successful in Diego Garcia (the same satellite tag brand/product, identical attachment methodology), and attached a Wildlife Computer Splash-10 Fastloc-GPS-Argos satellite tag to one green turtle nesting on the beach. We patrolled the north and south beach of Nelson's Island for the 9 nights that we were on the island and only one nesting turtle emerged during the period. A wooden box was placed around each turtle (after nesting) to prevent return to the sea (Figure 2). The transmitter was then attached with quick-setting epoxy and covered with antifouling paint. Attachment of the tag takes approximately two hours to allow time for epoxy to set and paint to dry after which time the turtle is released. After release of the turtle, all location data are acquired via Fastloc-GPS location transmissions to the Argos satellite network. Locations can be transmitted for 1-2 years.

Figure 2. All members of the expedition team worked hard for 2 hours of satellite tag attachment after a box was placed over a green turtle returning to the sea.

Objective 5: Beach and aerial surveys to inform turtle population assessments

Beach surveys: Since 2006, with the assistance of Nestor Guzman and other personnel of the Natural and Cultural Resources Program NAVFACFE PWD Environmental, we have been monitoring nesting activity along a 1.75 km-long Index Beach located on the south east coast of Diego Garcia, by counting turtle tracks twice per month throughout the year. We conducted two surveys of the Index Beach during the expedition.

A time-lapse beach photography programme was continued to assess turtle nesting tracks over long periods of time when foot patrols are not possible. The 14 camera traps set up on beach heliotrope (*Tournefortia argentea*) trees at the edge of the vegetation zone on the Index Beach were taken down, cleaned, re-batteried and images downloaded for analysis. Additional, 9 camera traps were set up on Nelson's Island (all on coconut palms *Cocos nucifera* as the only trees with good line of sight along the beach). On the return trip from Nelson's Island, we were able to download images from 9 camera traps deployed on 5 islands in Peros Banhos in March 2019.

Aerial surveys: Numbers of turtles foraging inside the Diego Garcia lagoon have not yet been estimated and to improve our knowledge of the turtle population in Diego Garcia lagoon, we continued an unmanned aerial vehicle (UAV) monitoring survey in the southern sector of Diego Garcia lagoon through a systematic transect survey method using a quadcopter drone (Autel Robotics EVO). This survey was carried out from various points around the lagoon shore to enable the science team to maintain visual contact with the UAV. The aerial survey will also support findings from satellite tracking of immature turtles in the lagoon to identify 'turtle hotspots' in the lagoon. After trials during the last expedition, we took a similar approach: a series of five 1km transect surveys separated by 100 m and parallel with the coastline were conducted around the southern tip of the lagoon. The three coves at Turtle Cove were surveyed at low water and at 10, 20 and 30 m altitudes to repeat a comparison of video footage at different altitudes in a different season. Whilst on Nelson's Island, UAV surveys of 1 km were repeated on 3 days at a distance of 50 m, 150 m and 250 m from the north and south beaches. Images will be analysed to estimate numbers of turtles and other mega marine vertebrates.

Objective 6: Movements of immature turtles: satellite tag maintenance and data download

Figure 1. Immature turtle capture at Turtle Cove for satellite tag maintenance (top left clockwise) a) Briefing to volunteers; b) State of satellite tag attached in November 2018; c) After careful removal of epibionts and algae; d) Two coats of antifoul paint before release

We attached 13 satellite tags to immature hawksbill and green turtles in the Diego Garcia lagoon between June 2018 and March 2019. During a visit in March 2019, we observed that much of the protective antifoul paint had sloughed off the tags which were consequently potentially less effective at transmitting due to fouling. Turtles with satellite tags were captured by hand at low tide in Turtle Cove by creeping up on them while they were feeding in shallow water. The tag and carapace were then cleaned using our standard operating procedures (scouring pad; knife for epibionts, degreasing with acetone). The tag and

attachment were then painted with antifouling paint to reduce epibiont growth and, once the paint was dry, the turtle was released (Figure 3).

Results

Objective 1

29/31 tagged birds were recaptured and the GPS(28)/GLS(29) recovered. Two RFBs were not recaptured as the nests failed due to weather conditions and the adults did not return. One GPS unit was lost at sea due to feather breakage. A summary of the tagging programme on the island is provided in Table 1.

Table 1. A summary of red-footed booby tagging activity.

RFB fitted with new BTO rings	RFB fitted with short-term GPS	RFB fitted with short-term GLS	RFB short-term GPS recovered	RFB short-term GLS recovered
29	**31**	**31**	**28**	**29**

Preliminary mapping of six sets of data from the GPS loggers show that RFBs continue to undertake movements for foraging to the east of Nelson's Island (Figure 4) as first described in 2018. However, compared to the corresponding data collected in July 2018 the resulting tracks extend substantially further to the east (up to 220km compared to <130km) from the colony. These longer trips also spanned multiple days with some RFBs remaining away from the island overnight in 2019. The latter was not recorded in 2018.

Objective 2

31 sets of three feathers were removed from the breast of each tagged bird and these will be analysed by technical staff at the Institute of Zoology at ZSL to determine the sex (by DNA) of the individual RFBs tagged.

Objective 3

As observed during the 2018 expedition, Nelson's Island supports breeding populations of: greater (*Fregata minor*) and lesser frigate (*Fregata ariel*) birds; common white terns (*Gygis alba*); lesser (*Anous tenuirostris***)** and brown (*Anous stolidus*) noddy; great crested terns (*Thalasseus bergii*); and red-footed and brown (*Sula leucogaster*) boobies. Non-breeding Sooty (*Onychoprion fuscatus*) and bridled (*Onychoprion anaethetus*) terns were also observed. Wedge-tailed shearwaters and their burrows were encountered at three locations across the island, indicating that the island is an important roosting and breeding location.

Audiomoths were deployed over eight nights to determine if they could be used as a tool to monitor shearwater presence absence on islands and the resulting acoustic data files will be analysed in due course.

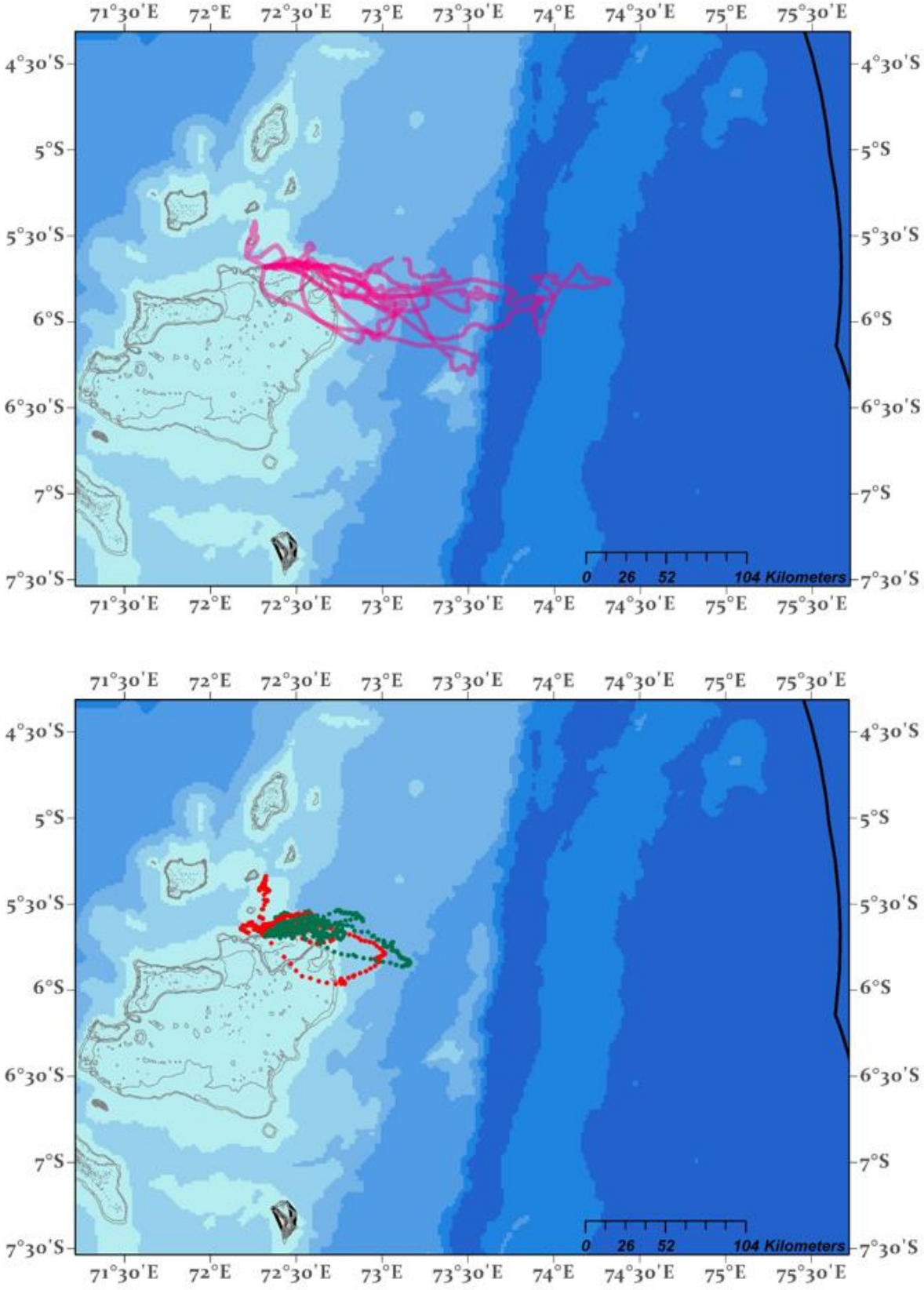

Figure 4. Breeding red-footed booby, at-sea, tracks whilst provisioning chicks at Nelson's Island, in July 2019 (top panel) and July 2018 (bottom panel).

Objective 4: Remote island trial to satellite tag nesting green turtles, *Chelonia mydas*

One turtle emerged to nest during the 10 day expedition to Nelson's Island (Table 2). By the end of the expedition, the green turtle remained in shallow waters just north of the nesting beach (less than 50 m depth). Haul-out locations indicate she laid one subsequent clutches at the expected inter-nesting interval of approximately 14 days. We continue to monitor locations as the turtle migrates in a southwesterly direction and will post an update of movements via the Facebook group Chagos Turtles.

Table 2. Nesting green turtle (*Chelonia mydas*) tagged with satellite transmitters during expedition to Nelson's Island. No other nesting turtles were encountered.

Argos ID	CCL (cm)	CCW (cm)	Date	Name	Release time (h)
182221	104.5	95.0	07/07/2019	Hannah	23:00

Objective 5: Beach and aerial surveys to inform turtle population assessments

Detailed beach surveys were conducted along the length of the DG Index Beach on 2 mornings in June 2018 and around Nelson's Island every day of the 10 days on island. As expected, only green turtle tracks were observed. These data will enable us to refine our estimates of the numbers of turtles nesting annually at Diego Garcia and Nelson's Island. We observed considerable interannual variation between nesting observations in 2018 and 2019. Remote camera traps are now set up on Nelson's Island, on 5 islands in Peros Banhos and on Diego Garcia (attached to trees with good line of sight along the beach). These cameras are programmed to take images of the beach every morning and will operate for at least six months in an ongoing programme to improve estimates of nesting activities on remote beaches.

Figure 5. Remote camera traps have been set up on trees bordering the beach with good line of sight to photograph the beach every morning as shown in this photo.

Objective 6: Movements of immature turtles: satellite tag maintenance and data download

With the assistance of 30 volunteers, we captured 4 satellite tagged turtles during low tide conditions (Table 3) and cleaned and painted tags before release. Of the 23 turtles satellite tagged to date, 12 tags are still transmitting. Analysis of the tag locations is underway and updates will be presented once all tags have stopped transmitting. These locations will allow us to investigate the extent of movements of immature turtles at Diego Garcia and hence will allow us to identify key areas used by the turtles. During the expedition, we downloaded additional data from the local MOTE receiver installed on Diego Garcia that captures up to 20 times more locations than by satellite uplink.

Table 3. Overview of satellite tagged hawksbill immature turtles captured in Turtle Cove for tag maintenance (22 June 2019).

Argos ID	CCL	Wt	Tagged date	Prev. flipper tagged	Name
64791	59.2	16.0	23/11/2018	Y	Rafaelle
64798	56.0	15.45	26/11/2018	Y	Little Sissy Roo
52253	53.8	16.0	14/07/2018	N	Damian Jr
52236	57.7	15.5	15/07/2018	N	Tigger

Discussion:

Value of research to BIOTA: Understanding where and when breeding seabirds in BIOT make use of the surrounding MPA, and the identification of foraging locations, is important as an indicator of the conservation impact of the MPA and hence of direct relevance to BIOT's conservation priorities. The data collected on this expedition contributes to our understanding of this. In addition, as boobies are associated with sub-surface predators (i.e. tuna, shark and billfish) when foraging, the larger set of data from multiple booby colonies across the archipelago could identify areas that are important for these types of predators at particular times of year and hence inform enforcement activities. The data collected on seabird presence/absence and breeding status on Nelson's Island contributes to this. This expedition provides further comprehensive data on the at-sea distribution of breeding seabirds in BIOT during different years and seasons and on different islands across the BIOT archipelago. This is the second trip that the team have conducted to Nelson's Island and will therefore help us to identify interannual trends or variability in the foraging ecology of this breeding population

While understanding how seabirds use the surrounding MPA is vital for examining its efficacy a solid baseline of seabird status and distribution across the archipelago is essential in order to determine the impact of the MPA on seabird populations. The data collected as part of this trip adds to this. In addition, the testing of the acoustic devices for detecting the more cryptic species, such as shearwaters, will aid in the development of potential methods whereby technology can improve our ability to monitor seabirds on these remote and hard to access islands.

This expedition contributes to the sea turtle conservation research to increase our understanding of movement of both hawksbill and green turtles during breeding and foraging periods. We continued our programme to attach satellite tags to nesting green turtles and this is the first time we have attempted to attach satellite tags to turtles on a remote island. With

additional tag attachments, we will be able to assess whether there are latitudinal effects on post-nesting migration and so inform conservation management of the species.

Conclusion: The June-July 2019 expedition to DG and Nelson's island has added more information to our knowledge of the foraging locations and behaviour of breeding red-footed boobies, and breeding and foraging movements of sea turtles during the South East monsoon period and compliments research conducted in the same place and time as previous years. It also allows comparisons to be made with data that have been collected from other sites (such as Danger Island and Diego Garcia) since 2016. As observed during last year's expedition, Nelson's Island supports significant breeding populations of a range of seabird species and hence is an ideal island to test alternative technologies for the development of a suite of technology-based seabird monitoring tools. We observed considerable inter-annual variation of turtle nesting activities on Nelson's Island between 2018 and 2019 and consideration will be placed on strategies for further turtle tagging on remote islands.

While on Nelson's Island (3rd July 2019) the team participated in a presentation and Q&A session at the World Conference of Science Journalism hosted in Geneva, Switzerland. This was made possible via a live video link from the island, which is a first for a research expedition in BIOT in the northern atolls.

One final point of note is that as in 2018 no coconut crabs (*Birgus latro*) were observed on Nelson's Island.

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Seabird and sea turtle research expedition data summary

Expedition ID	Dates	Location (place or coordinates)	Taxa or Species	Objective	Method	Data
July 2019 seabirds	02-12/07/2019	Nelson's Island	Red-footed booby	Use of MPA during breeding season	Tagging: GPS loggers & Geolocators	Foraging tracks of ~29 breeding individuals
July 2019 seabirds	02-12/07/2019	Nelson's Island	Red-footed booby	Sex determination	Feather sampling	Feather samples from 31 individuals.
July 2019 seabirds	02-12/07/2019	Nelson's Island	Wedge-tailed shearwater	Population distribution	Acoustic recorders	8 sets of overnight recordings.
July 2019 sea turtles	18/06-16/07/19	Diego Garcia	Hawksbill and green turtle	Foraging population size estimation	Aerial surveys (quadcopter UAV)	2 sets of 1km transects (10, 20, 30 m alt) of Turtle Cove
July 2019 sea turtles	18/06-16/07/19	Diego Garcia	Hawksbill and green turtle (immature)	Population distribution	Tagging: Fastloc-GPS satellite-MOTE tags	Foraging tracks of 2 green and 21 hawksbill turtles
July 2019 sea turtles	18/06-16/07/19	Diego Garcia	Hawksbill and green turtle (adult)	Nesting population size estimation	Foot patrol; 14 cameras attached to trees on Index Beach	2 surveys of Index Beach; 3 months of daily beach photos
July 2019 sea turtles	18/06-16/07/19	Diego Garcia	Hawksbill and green turtle (adult)	Nest incubation conditions	Temperature loggers (30-70cm depth; shaded & unshaded)	2 sets of sand temperature data (July 18-June 19)
July 2019 sea turtles	18/06-16/07/19	Nelson's Island	Green turtle (adult)	Use of MPA & distant foraging grounds	Tagging: Fastloc-GPS satellite tags	Breeding, migration (& foraging) track of 1 individual
July 2019 sea turtles	18/06-16/07/19	Nelson's Island	Hawksbill and green turtle (adult)	Foraging population size estimation	Aerial surveys (quadcopter UAV)	3 sets 1km transects (30m alt) N&S coast
July 2019 sea turtles	18/06-16/07/19	Nelson's Island	Hawksbill and green turtle (adult)	Nesting population size estimation	11 remote cameras attached to trees	No data collected yet
July 2019 sea turtles	18/06-16/07/19	Peros Banhos: Vache Marine (4), Ile du Coin (2), Ile Poule (1), Moresby (1), Passe (1)	Hawksbill and green turtle (adult)	Nesting population size estimation	9 remote cameras attached to trees	3 months of daily beach photos

NOTE: For further information please contact Malcolm Nicoll at malcolm.nicoll@ioz.ac.uk (seabirds) or Nicole Esteban at n.esteban@swansea.ac.uk (sea turtles)