Chagos News

The annual Newsletter from the Chagos Conservation Trust and the Chagos Conservation Trust US

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Back page photo: Manta Ray © Simon Hilbourne, Manta Trust

A Word from our Chair

Welcome to the latest edition of *Chagos News*! Featuring this, my first foreword as Chair, a position I am very humbled to take on after many years of being on the CCT Board. The 2025 issue also features articles about the fascinating research work happening in the Chagos Archipelago, which the Trust – aided by scientists like the authors in this issue – is dedicated to protecting, conserving, and educating the world about.

The iconic Chagos coconut crab is this edition's cover star, with a feature written by expert Dr Mark Laidre from Dartmouth College, one of our key post-AGM speakers this year. He focuses on the life-cycle of the crab, from ocean dwelling larva to hermit-style crab, occupying every larger shell via an unseen "Rightmove consortium process", before growing into the larger adult crab, as seen on this issue's cover. Concluding with the dynamic interaction between rats and coconut crabs, each the prey of the other during their lifetimes.

Rats, or rather their successful eradication from the isolated Chagos island Vache Marine in Peros Banhos, is reported on by our Programme Manager Dr Pete Carr, who describes his return six years after it has been formally declared rat-free. An important milestone, as he prepares to undertake rat eradication on other Chagos islands as part of our *Healthy islands, Healthy Reefs* rewilding project.

One of our Trust's Scientific Advisors and Trustees, the Royal Botanical Garden Kew's Dr Colin Clubbe, contributes to an article about plants of the Chagos Archipelago – an area which the Trust's founder, John Topp, was so passionate about he started the CCT Botanical Fund, which still supports research work in the archipelago till today. The article runs through a short history of the Chagos native flora, with new botanical information on native and non-native species, plus revised taxonomy into 2025.

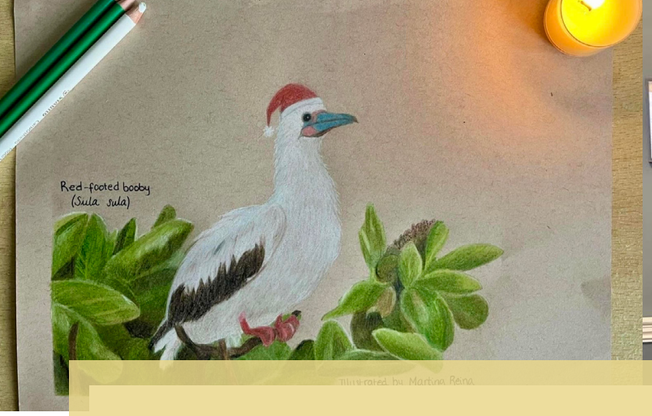
Jodey Peyton also writes about invasive non-native species on Diego Garcia, but of the invertebrate kind, stressing their significance towards biodiversity loss. It is alarming to read about the 12.5% increase in the number of invasive species on the island, the majority of which are ants, including the red fire ant. But the discovery of a new Chagos centipede is very exciting news.

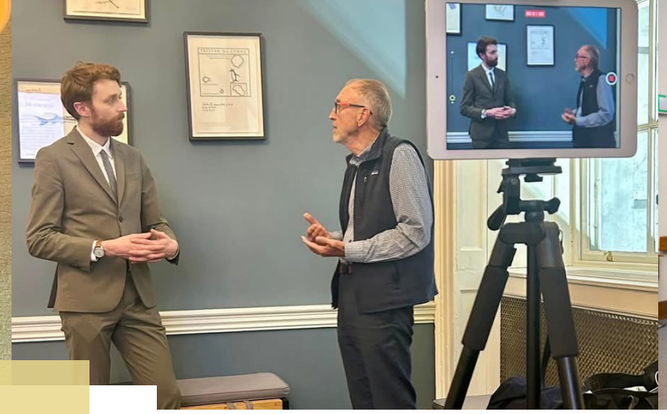
Dr Clare Embling from Plymouth University – also a speaker at this year's post-AGM event – shares her latest Chagos cetacean research, which started in 2022, and is ongoing. The interim findings highlight the importance of the Chagos islands for cetaceans, whether spinner or bottlenose dolphins, or the larger breeding humpback whale. Early trends indicate a distinct feeding pattern between the different atolls.

In the final article, Dr Holly Stokes from Swansea University provides further insights into sea turtle ecology, as a follow-up to her *Chagos News* cover story article in the 2023 edition, describing the moment a female turtle emerges from the sea to transit the beach and lay 100+ eggs above the high-water line. The threatened species of both green and hawksbill turtles travel from across the whole southwest Indian Ocean region to find nesting refuge in the Chagos. These are species close to our hearts at CCT, as reflected in the Trust's logo.

Enjoy the read!

Chris Davies





Director's Report

Amidst the uncertainty that still surrounds the future of the Chagos Archipelago's sovereignty, the Chagos Conservation Trust has continued to remain politically neutral and ready to work with any like-minded organisation this year. And through our work, we continue to do everything we can to protect, conserve, and promote a better understanding of the islands' precious ecosystems.

Since the last issue of Chagos News, I hosted the largest-ever turnout for a CCT event, with 100 people attending the post-Annual General Meeting (AGM) speaker event – in person and virtually – at the Geological Society in London. The event highlighted the research projects happening in the Chagos that the Trust either supports or is involved in.

Talks were given by Trustee Dr Bryan Wilson from Oxford University on brain coral; Swansea University's Dr Kimberley Stokes on turtles; the Zoological Society of London's (ZSL) Rachel Jones on plastic pollution; the Manta Trust's Dr Joanna Harris on manta rays; Exeter University's Dr Claire Collins and Dr David Curnick, from ZSL and the Ocean Predator Lab, on sharks; and CCT Programme Manager, Dr Pete Carr, who gave an update on CCT's key rewilding project, Healthy Islands, Healthy Reefs. A recording of the event is on the CCT YouTube channel.

At the preceding AGM, the Trust welcomed its new Chair, Chris Davies, a long standing Board member, like Professor John Turner, who became CCT's first Deputy Chair. The Natural History Museum's Dr Ken Johnson became the new Secretary, and Swansea University's Dr Nicole Esteban joined the Board as Trustee and Scientific Advisor, due to her expertise on Chagos turtles. Dr Esteban, who runs the Swansea Marine Conservation Ecology Lab (MarCEL), was recently awarded the ZSL Marsh Award for Marine and Freshwater Conservation.

Since then, our first-ever Intern, Martina Reina-Canitrot, has also joined the CCT team in partnership with Swansea University. Because it is a pilot scheme, she will work part-time for both the Trust and the Bioscience Department before returning to her marine biology degree next summer. Martina has been working across the organisation, from drafting the CCT Social Media Policy to drawing the picture that featured on last month's festive e-card. And because it has been a success, a full-time intern will follow her in September.

Pascalina Nellan also joined the Trust on a part-time basis. As the Content Officer for the CCT-funded website for and about the Chagossian community, she will keep it relevant and up-to-date. Dr Josh Greatorex-Davies is the most recent Trustee recruit, who has become our Digital Lead, and will help start members' talks next month.

Our first talk will be online by Dr Sam Purkis, one of the founders of our sister organisation US-CCT, entitled 'Scaling Coral Reef Conservation: Biodiversity Assessment from Orbit'. If you would like to attend this, or the post-AGM speaker event, featuring talks by Dr Mark Laidre on Chagos coconut crabs and Dr Clare Embling on cetaceans, amongst others, please email intern@chagos-trust.org to be put on our contacts list.

Sadly, a former CCT Chair, Professor Charles Sheppard, who was awarded an OBE in 2014 for his services to environmental conservation in the Chagos, has passed away since the last issue. He published a new book, *The Chagos Archipelago: A Biological Biography*, shortly before his passing – just one in a long list of works about the islands, having spent half a century dedicated to research there. During this time, he facilitated studies by more than 100 scientists, and his scientific input led to the archipelago becoming one of the world's largest no-take marine reserves in 2010.

If you would like to join the CCT Board, and have specific skills (we are looking for a Membership Secretary, for example), as well as a few hours each week to volunteer, then reach out to us on info@chagos-trust.org for an informal chat. Trustees not only attend meetings, but also gain invaluable skills through events like the recent media training we held at Somerset House in London, plus a strategy session at Swansea University where the Board and staff revisited our five-year strategy at its half-way mark to ensure we are still on track – which we are!

To stay up-to-date with all our news, make sure to keep an eye on our website and follow us on the CCT social media platforms: Facebook, Instagram, LinkedIn, YouTube and Twitter/X. We also post about environmental issues relevant to the Chagossian and wider scientific communities, as well as related conservation news from other successful rewilding projects, to scientific papers on the waters off the Chagos Archipelago.

And we continue to advise regional networks, the media, UK government, and anyone who requests information about the Chagos environment and the scientific work we are carrying out there. We can achieve more together, so partnerships will remain key for CCT moving forward, to help us attain our aims.

Sarah Puntan-Galea

Photos
p4: (top left) CCT festive e-card illustration by Intern, Martina Reina-Canitrot; (top right) Trustee Dr Colin Clubbe with media trainer Dominic Riding; (bottom left) Professor Charles Sheppard; (bottom right) Dr Nicole Esteban.

this page: (top left) CCT Board members at the AGM (left to right): Treasurer James Clarke, Programme Manager Dr Peter Carr, CCT Director Sarah Puntan-Galea, Secretary Dr Ken Johnson, ChIP Lead Dr Bryan Wilson, Chair Chris Davies; (top right) Director Sarah Puntan-Galea hiking with her dog Digby!

Plants of the Chagos Archipelago

By Dr Colin Clubbe and Sara Bárrios, Royal Botanic Gardens Kew; Jodey Peyton, UK Overseas Territories Conservation Forum; Danielle Frohlich, SWCA Environmental Consultants; Dr Quentin Groom and Sofie Meeus, Meise Botanic Garden.

Coconut chaos © Colin Clubbe

Terrestrial plants of the islands of the Chagos Archipelago have fascinated botanists since Dr William Hemsley first discussed the botany of Diego Garcia in 1886. A relatively young archipelago, the Chagos Islands have been colonised by plants since land first appeared above sea level after the last ice age and there was sufficient soil to support them – probably less than 4,000 years.

Seeds and spores arrived by wind, sea or attached to passing seabirds to colonise the emerging islands. This original native flora is considered to comprise 41 species of flowering plants and four species of fern, plus a variety of mosses and liverworts. No endemic species of plant, unique to the archipelago, have been recognised.

Today the nature of the flora reflects past exploitation of individual islands as new species became established, associated with human activities as the islands were colonised and cultivated. Approximately 420 species of flowering plants and ferns have now been recorded, but the increase reflects non-native plants introduced to the Chagos either accidentally or deliberately by humans' activities.

Some of the non-native plants have become invasive and are threatening native species and habitats and are the subject of control. The most significant of these harmful invasives is *Cocos nucifera* (coconut), which was extensively planted to harvest its valuable oil. Once the plantation era ended and cheaper alternatives to coconut oil were widely available the plantations were abandoned, allowing the coconuts to spread uncontrolled to such detriment of the native vegetation and, consequently, on nesting options for native birds. CCT's *Healthy Islands, Healthy Reefs* programme (https://chagos-trust.org/our-work/healthyislands), with its vegetation management plan (see Pete Carr's article in Chagos News, No 61) is an ambitious rewilding programme aimed to reset this balance.

Our knowledge of plant distribution across the Chagos Archipelago was greatly increased by the pioneering work undertaken by CCT's Founder, Commander John Topp, in the mid-1980s when he was the island's British Representative, and further between 1993 and 2002 when he was the British Indian Ocean Territory Conservation Consultant. He undertook botanical surveys on most of the islands and, working with colleagues at Kew, compiled an invaluable island by island species checklist containing 278 taxa. John's checklist documented 234 non-native taxa, 128 of which had only been recorded from Diego Garcia, the primary entry point for new species (Topp, 1988; Topp & Sheppard, 1999).

Occasional botanical forays were part of other expeditions in the ensuing decade, most notably the 2010 expedition (see Chagos News No 36) with collections incorporated into the Kew Herbarium.

The earliest specimens lodged at Kew are from the Transit of Venus Expedition in 1874. More recent botanical activities have focused on the creation of new vegetation maps for each island and the ground truthing needed to refine these maps. Spatial analysis work conducted by the Royal Botanic Gardens Kew resulted in the production of a new set of vegetation maps for the major islands of the Chagos Archipelago, providing the baseline information required for rewilding and long-term management of these islands.

These maps are available on CCT's Chagos Information Portal. Based on satellite imagery, they provide an overview of the major vegetation types and their distribution. But they require ground truthing to confirm species composition and transitional areas. The ground truthing for

Herbarium specimen from the 1874 Transit of Venus Expedition © Trustees of the Royal Botanic Gardens Kew

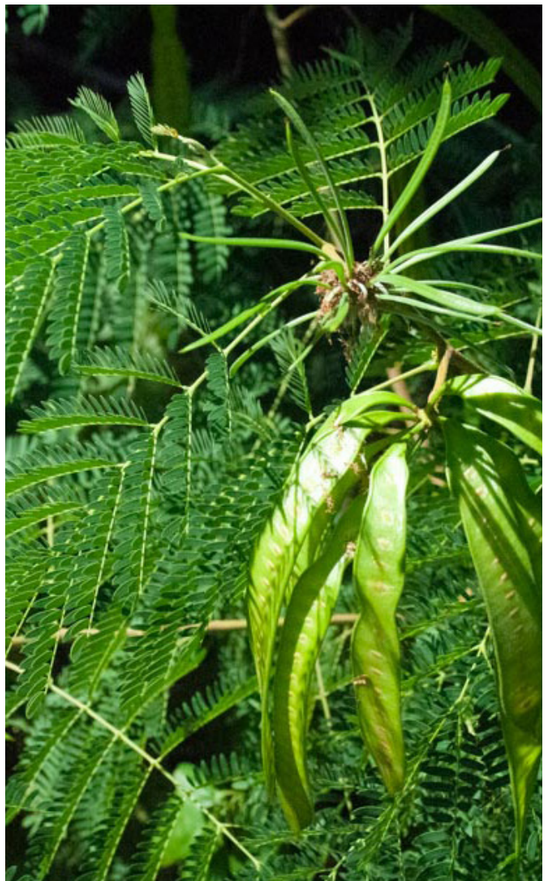
Droning on Diego Garcia © Sara Bárrios

Mature Pisonia grandis woodland, Moresby Island © Colin Clubbe

the Diego Garcia map was completed in 2018 by Sara Bárrios and Tim Wilkinson. We hope for more opportunities in the future to refine the maps for the outer islands.

Several recent expeditions have focused on increasing the number of plant records on Diego Garcia, including increasing the number of records for invasive non-native species. These include the Darwin Plus funded project, 'DPLUS151 Building knowledge of invasive non-native species on Diego Garcia (2021-2024)' and an expedition in 2023 by Meise Botanic Garden. DPLUS151's main focus was updating inventories for plants and invertebrates (see separate article in this issue, p10). These expeditions have increased the number of plant records on the island by more than 1,500 including approximately 142 new non-native taxa being recorded, raising possible implications for biosecurity.

Pressing specimens in the field in Diego Garcia © Sara Bárrios



Leucaena leucocephala, Diego Garcia © Sara Bárrios

Notable invasive non-native plants recorded in 2021 and 2022 include two significant grasses: bushy bluestem (*Andropogon glomeratus*) and Southern sandbur (*Cenchrus echinatus*), plus reconfirmation of the highly invasive leucaena tree (*Leucaena leucocephala*). These species were recommended for immediate removal due to their invasive impacts on native wildlife and plants, fire-promoting tendencies, and/or ease of spread by animals and machinery, combined with their currently limited distribution on the island.

It has been 15 years since the last complete plant checklist for the Chagos Archipelago was compiled (Hamilton & Topp, 2009). With lots of new plant records since then, and new non-native species recorded, as well as changes in taxonomy and reconciling taxonomic uncertainty of some collections, we are now working to bring all this new botanical information and revised taxonomy together to publish a new comprehensive checklist. We hope to complete this in the next few months.

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New Invertebrate Discoveries on Diego Garcia

Jodey Peyton, UK Overseas Territories Conservation Forum; Dr Rhian Guillem, Gibraltar Botanic Garden; Dr Chris Malumphy, Fera Science; Dr Ben Price and Dr Greg Edgecombe, Natural History Museum; Dr Wolfgang Rabitsch, Environment Agency Australia

Erecting a malaise trap © Jodey Peyton, UKOTCF

Invasive non-native species (INNS), their establishment and spread are a leading cause of biodiversity loss around the world and are well known for their negative impacts on native biodiversity, human health and the economy. These impacts are often greater on islands, therefore mitigating the detrimental effects of INNS is critical for conservation efforts for endemic and native species.

Information is needed on what species are already present, and what potential impacts they might have in order to protect native species. Unfortunately, significant knowledge gaps of native and invasive non-native species distributions and their impacts can lead to uncertainty in the prioritisation of management actions, biosecurity, and conservation planning.

Of the well-known invertebrate INNS, many tramp (species that are found around the world) ant species are a particular concern given their impacts to other plants and animals. Working with the British Indian Ocean Territory Administration (BIOTA), and a large expert team from around the world, led by the UK Centre for Ecology & Hydrology and funded by Defra Darwin Plus, we undertook invertebrate and plant surveys to address some of these gaps on Diego Garcia – the largest of the Chagos islands. Here we share some of the highlights and key findings of the invertebrate work.

Physical and online records were collected from 31 fixed sampling locations on Diego Garcia, as well as opportunistic sampling efforts from around the island. A variety of different methods were used for sampling invertebrates such as hoovering up invertebrates or catching them in light traps. With support of both field, lab and taxonomic identification, our project recorded over 50 invertebrate species new to Diego Garcia, adding to the approximately 400 species recorded before.

This data will be made openly accessible via the Global Biodiversity Information Facility. Data from more than 1,300 invertebrate specimens found during the 2022 surveys were analysed and uploaded on the Open Access database. The starting list of invertebrates, collated by the Zoological Society London can be found on the Chagos Conservation Trust Portal.

Of the identified samples, the vast majority were ants, many of which are invasive, including red fire ant (*Solenopsis invicta*), which can give a nasty bite), the woolly ant (*Tetramorium lanuginosum*) which is recognised as a widespread tramp species dispersed through human commerce and is particularly common on small tropical islands, and other invasive ants such as the ghost ant (*Tapinoma melanocephalum*). These invertebrate data are still being worked on and will be for some time to come, given the challenges around the identifications.

Along with finding 24 ant species on Diego Garcia (more than half of which were new to the island), the project was particularly excited to

Clonal raider ant (*Ooceraea biroi*) © Gibraltar Botanic Garden

Keith Bensusan collecting leaf samples © Jodey Peyton, UKOTCF

Transverse ladybird (*Coccinella transversalis*) © Jodey Peyton, UKOTCF

discover a new species of centipede to science. This species was formally described as *Australobius chagosensis* by experts at the Natural History Museum in London (Popovici et al. 2024). In addition, some species known for the Archipelago were found on Diego Garcia for the first time, including the endemic Chagos ground cricket (*Scottiola chagosensis*).

It was interesting to see that relatively few plant pest species were recorded on Diego Garcia during the surveys than would be expected for an island of this size and location. This relatively 'pristine' status is likely due to the history of the island and its relative shelter from commercial enterprise and no tourism.

Together with the sources listed above, it is possible to view many of the new records from this project and from other research on the island through the open access iNaturalist site, which was set up by the Royal Botanic Gardens, Kew in 2018.

There is still more work to be done in identifying other invertebrate groups we collected, eg the diverse and abundant spider species. However, this project made great strides in identifying species of conservation importance such as the endemic species, including mapping their distribution on Diego Garcia, that can be used in assessing their global red list status in the future.

We would like to thank the British Indian Ocean Territory Administration, Mark Spalding, the US Naval Facility, the Chagos Conservation Trust, the Zoological Society London, the Royal Botanic Gardens Kew, and the project team for ensuring the successful delivery of this project. We would also like to thank the Defra Darwin Plus funding scheme for funding our project DPLUS151 'Building knowledge of invasive species on Diego Garcia'.

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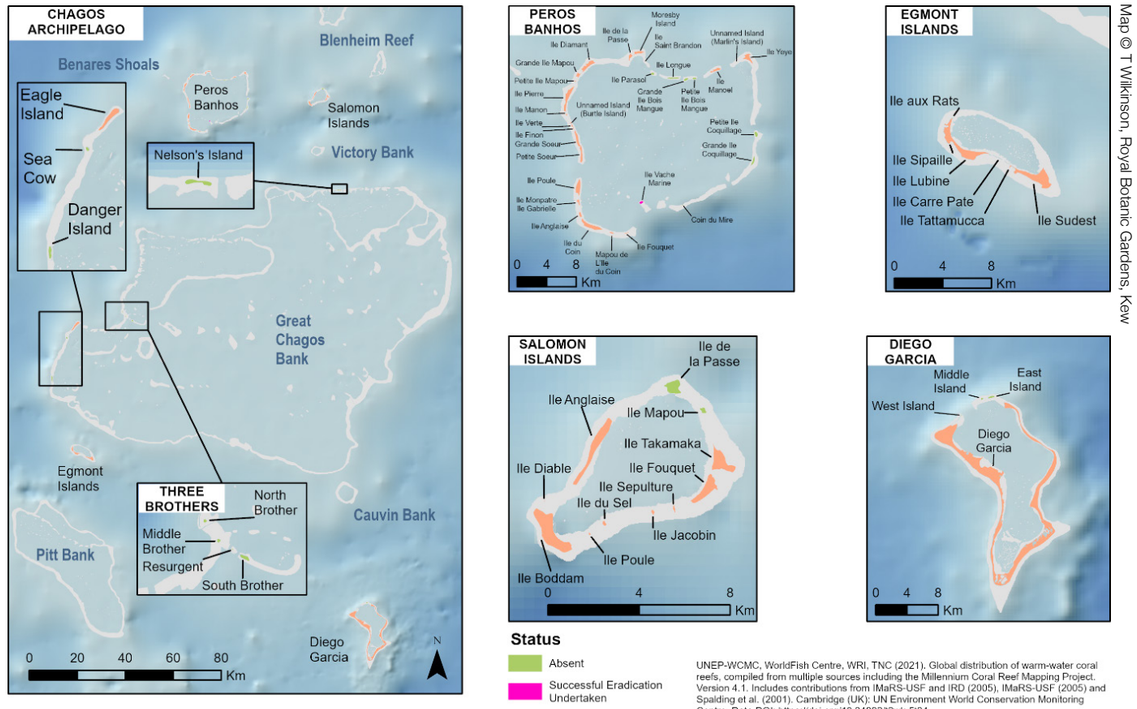
Vache Marine – 10 Years After

By Dr Peter Carr, Chagos Conservation Trust

In 2014, the Chagos Conservation Trust (CCT) led an eradication operation for black rats (*Rattus rattus*) hereafter referred to as rats, on the small (12.4 hectares, 2 metres above sea level) island of Vache Marine in the south of the Peros Banhos atoll, Chagos Archipelago (Figure 1). The operation was funded by the UK Government's Darwin Plus grant scheme (project DPLUS011), and conducted with significant assistance from the UK military based on Diego Garcia, plus the captain and crew of the BIOT Patrol Vessel (BPV). Declared in 2017, the operation was the first successful rodent eradication in the central Indian Ocean. The full story of this venture is contained in Harper, Carr and Pitman (2019).



Map © T Wilkinson, Royal Botanic Gardens, Kew

Figure 1: Black rat (*Rattus rattus*) distribution in the Chagos Archipelago showing Vache Marine in southern Peros Banhos, the site of a successful rat eradication operation in 2014 led by the Chagos Conservation Trust.

In October and November 2024, as part of the Bertarelli Programme in Marine Science (BPMS), I assisted Hayley McClennan, a PhD student from St Andrews University. Her thesis looks at associations between trophic levels, from subsurface to aerial, and the research was conducted at sea from the bridge of the BPV, which had to dovetail into the ship's programme. Fortunately, this occasionally gave us the opportunity to visit islands. On 1 November 2024, we visited Vache Marine, some 10 years after the successful eradication of rats.

It was my first time back on Vache Marine since January 2018. Although the island had been declared rat-free by an internationally recognised expert in 2017, on approaching the island by small craft, I still felt a slight nervousness. What if a tiny

Figure 2: Dr Peter Carr and St Andrews University PhD student Hayley McClennan on Vache Marine in November 2024, censusing breeding seabirds and checking for the presence of rats. Photo © McClennan

rat population was missed in 2017 and 2018? Highly unlikely, but what if a pregnant female rat had rafted over to Vache Marine from the rat-infested islands of western Peros Banhos? Along with conducting a full ornithological census, I was taking this opportunity to check again that rats had been eradicated and had not reinvaded. After swimming ashore with the Fisheries Protection Officer (FPO), we set off to circumnavigate the island – two of us counting breeding seabirds and looking for signs of rat presence (Figure 2), whilst the FPO conducted his island tasks, which included monitoring breeding turtles.

After walking the perimeter coast with no signs of rat presence, we pushed our way into the interior of the island where any signs of rats would be more evident if they were present. I am pleased to report that after a comprehensive check of the island, no signs of rat presence were detected. On the ornithological side, 25 pairs of great crested tern (*Thalasseus bergii*) (Figure 3), 10 pairs of white tern (*Gygis alba*) and eight pairs of brown noddy (*Anous stolidus*) were recorded as breeding, along with some 15 pairs of the introduced, finch-like red fody (*Foudia madagascariensis*), which have colonised all islands of the archipelago.

After swimming out to the craft waiting to pick us up, and as we headed back to the BPV across the calm seas of the atoll lagoon, I pondered the results of our visit; certainly, no rats, but also no significant increase in breeding seabirds since the successful eradication 10 years ago. Why was that? Later, as I sat on the bow of the BPV hoping to see the 'green flash', I came to some simple conclusions:

- Vache Marine was selected for a rat eradication operation due to its isolation – being distant from other islands it was highly unlikely to ever be 'naturally' reinvaded. The nearest rat-free 'seabird islands' are the Coquillages in eastern Peros Banhos (Figure 1), some 16km away. Whilst not far as the breeding seabird flies, it takes time for founding breeding populations to discover that an island is rat-free.
- Most breeding seabirds do not tolerate disturbance by humans. Vache Marine is located in the Strict Nature Reserve half of the Peros Banhos atoll. However, despite visiting yacht crews being prohibited from landing on the island, in the early 21st century it was a favourite spot for beach BBQs, overnight camps and unlicensed visits (Carr, pers. obs.). As witnessed elsewhere in the Chagos Archipelago, it has taken up to 80 years before seabirds returned to some now, undisturbed islands, such as the red-footed booby recolonisation of the Egmont Islands.
- The vegetation communities on Vache Marine are not conducive to most breeding seabirds. Recent scientific research in the Chagos Archipelago has demonstrated that when an island has had its natural vegetation cleared and monospecific stands of coconut (*Cocos nucifera*) dominate and there are rats present, both of these breeding seabird inhibitors must be managed before true seabird island status can be regained (Carr et al. 2021). While Vache Marine is not a 'coconut chaos' island, there are no open fayres for ground-nesting seabirds, and none of the classic lowland rainforest trees that arboreal breeding seabirds favour are present (Carr 2013).

Figure 3: Great crested tern (*Thalasseus bergii*). 25 pairs were breeding on Vache Marine in November 2024. Photo © P Carr

Restoring seabird driven ecosystems to environmentally degraded islands often takes decades and depends upon a multitude of factors. In the Chagos Archipelago, some seabird species, such as the red-footed and brown booby are naturally expanding their distribution. But, their range expansions are limited by the number of rat-free islands that are available (brown booby) and the vegetation communities available (both species). For seabird islands to be restored successfully in the Chagos Archipelago, three essential ingredients are needed: rat eradication, vegetation management and time. Time for the founding populations of breeding seabirds to discover where successful conservation interventions, such as those being championed by the Chagos Conservation Trust, have occurred.

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Discovering the Whales and Dolphins of the Chagos Archipelago

By Dr Clare Embling, University of Plymouth, UK

Cetaceans (whales, dolphins and porpoises) are key components of the marine ecosystem, playing an important role in food web regulation, nutrient cycling, and carbon capture. They are also charismatic and capture the public's imagination. Cetaceans are very wide ranging, migrating across ocean basins, between inshore and offshore waters, and vertically through the water column, circulating nutrients on both a small and large scale (Gilbert et al. 2023).

Bottlenose dolphin © Istock

Additionally, they are important for carbon sequestration, with large whales sequestering carbon as they sink into the deep at the end of their lives (Pearson et al. 2023).

However, cetaceans have been severely threatened over the past century through human activities. Large whale populations were decimated by industrial whaling, causing the extinction of some populations, and the severe depletion of many others (Rocha et al. 2014). The impacts of this level of exploitation are still poorly understood, but are likely to have been considerable, impacting whole ecosystems from the pelagic to the deep sea (Croll et al. 2006).

A recent publication based on historic whaling data and modern sightings data of sperm whales in the Western Indian Ocean (WIO), showed a redistribution of sperm whales as a result of whaling, with whales now found further from shore in deeper waters than during the whaling times (Letessier et al. 2022). The discovery of humpback whale song by Roger Payne in the 1970s inspired the general public, resulting in an outcry over industrial whaling, and resulting in a moratorium on whaling in 1986. Released from this threat, many large whale populations are now recovering, though it takes many decades for these long-lived, slow breeding populations to recover. Only recently have we begun to see clear and measurable recoveries (Calderan et al. 2020).

Cetaceans are also threatened by other human impacts, the most significant of which, for all large marine vertebrate species, is bycatch and entanglement: the incidental catch of individuals in fishing nets and fishing gear. In the Indian Ocean alone, the tuna gillnet fishery has resulted in the peak bycatch of almost 100,000 cetaceans per year during 2004-2006 (Anderson et al. 2020). This has been estimated to have resulted in a population reduction of around 13% since pre-fishery levels. While bycatch of cetaceans in the Indian Ocean is highest in the gillnet fishery, it is recorded in all fisheries. This is likely having a similar impact on smaller cetaceans as whaling had on the larger whales and remains an ongoing threat to these populations.

The Chagos Archipelago Marine Protected Area (MPA), as a no-take MPA, could be a refuge from this threat – creating a safe haven away from fishing pressure and bycatch. However, until 2022, very little was known about the cetaceans in the Chagos Archipelago, other than an occasional

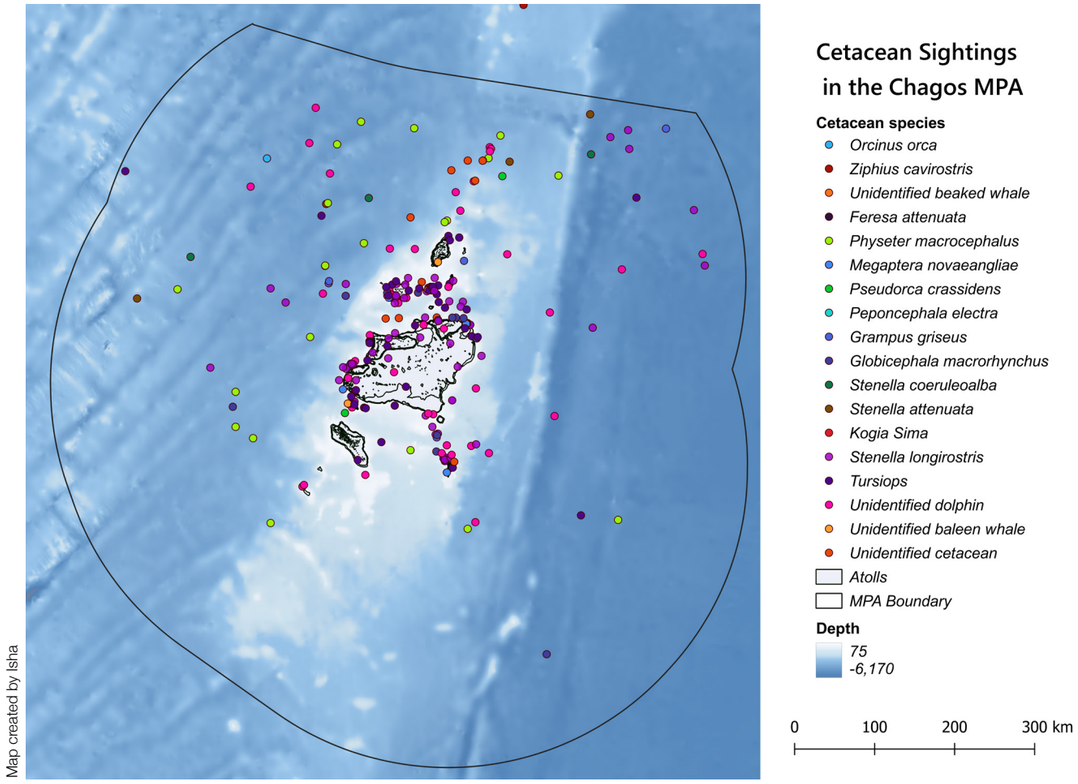
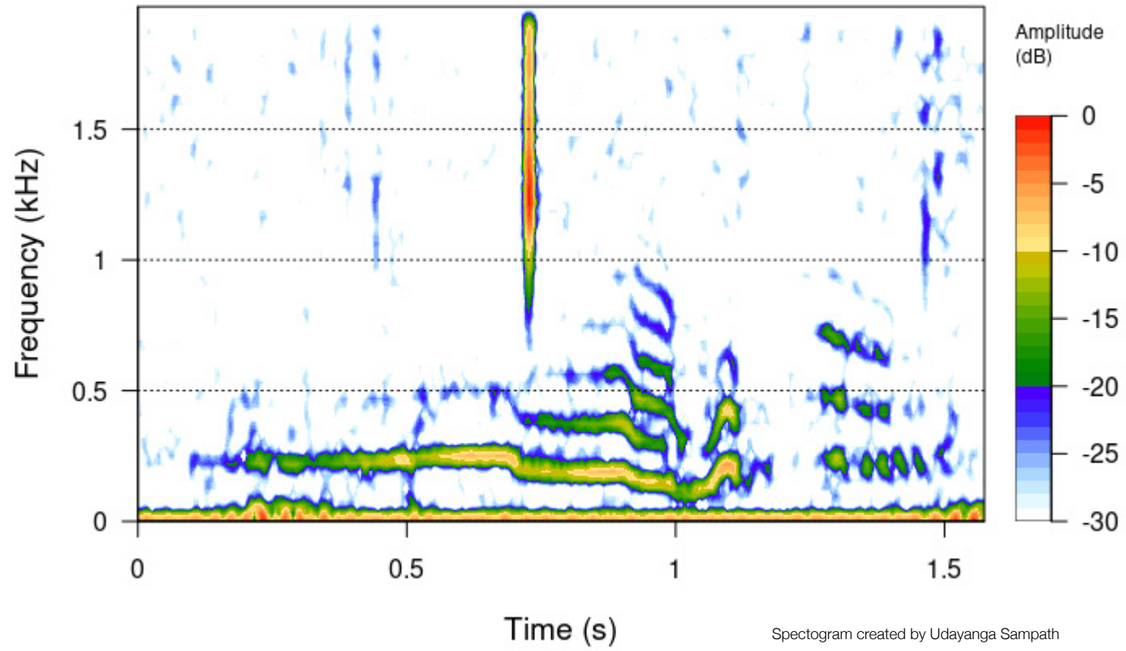


Figure 1 (above): Cetacean sightings data collected in the Chagos Archipelago MPA from the patrol vessel between November 2022 and June 2024.



Spectogram created by Udayanga Sampath

Figure 2 (top right): Humpback whale call (likely non-song vocalisation) recorded from Egmont Atoll.

incidental sightings from the patrol vessel. The International Union for Conservation of Nature's (IUCN) Marine Mammal Protected Area Task Force (MMPATF) identified the Chagos Archipelago as an 'Area of Interest', but data-deficient, requiring 'enhanced effort for monitoring species of marine mammals', due to its location and high abundances in the surrounding archipelagos, such as the Maldives and Seychelles.

Our study, generously funded by the Bertarelli Foundation, is the first dedicated study of cetaceans in the Chagos Archipelago, with the aim of determining whether the Chagos Archipelago is the last tropical refuge for cetaceans in the Indian Ocean. Therefore, our aims are to determine the distribution, abundance, habitat use and acoustics of cetaceans within the Chagos Archipelago to feed into management plans for the MPA. Our project started in 2022, and since then has been collecting cetacean sightings data from the patrol vessel through a wildlife observer* (who have been so far: Sharmin Rouf, Isha and most recently Chris Robson), and acoustic data through moored hydrophones (underwater sound recorders).

Cetacean sightings data are collected using a standard methodology that allows us to compensate for the fact that more animals will be seen close to the vessel and fewer are seen with increasing distance. This technique is called line-transect methodology and requires the wildlife observer to record not only species and group size, but also to estimate the distance to sightings and their bearing (Buckland et al. 2015). Using this information, we can estimate the abundance of cetacean species if there are sufficient sightings (Buckland et al. 2004). This is the task of our PhD student Isha, who is estimating the abundance of cetaceans as well as their distribution and habitat use across the entire Chagos Archipelago.

So far, the wildlife observer has recorded over 100 sightings of at least 15 species, with sightings spanning the entire MPA (Figure 1). The most commonly sighted species is the spinner dolphin (*Stenella longirostris*), predominantly found around atolls such as Peros Banhos, Salomon and Diego Garcia. They exhibited a diurnal pattern at Peros Banhos based on visual and acoustic data: they are found resting in the lagoon during the day, but are assumed to travel offshore to feed at night (Letessier et al. 2022). Using energetic calculations, this study was able to infer that dolphins are likely to have a similar effect to bird guano in bringing nutrients into the shallow waters, which enhances reef diversity and resilience, thereby highlighting the importance of these atoll-associated dolphin populations.

Other frequent species include bottlenose dolphins,of which there are two species: *Tursiops truncatus* which tends to be found further offshore, and *Tursiops aduncus* which is more atoll-associated. Also present are more enigmatic, deep-diving species, such as sperm whales and beaked whales. For example, sperm whales (*Physeter macrocephalus*) have been found off Speakers Bank and further offshore, towards the boundaries of the MPA, whereas beaked whales, such as Longman's beaked whale (*Indopacetus pacificus*) and Cuvier's beaked whales (*Ziphius cavirostris*) have been seen on the outer edges of Great Chagos Bank. By analysing this data, Isha will be able to estimate abundance and identify important areas and habitats for key species.

Alongside the sightings data, we have been deploying underwater sound recorders (hydrophones) to listen for cetaceans around the shallow-water atolls. The benefits of moored hydrophones are that they give us a long-term picture of the cetaceans within an area, something that a passing patrol vessel cannot provide. Most cetaceans are highly vocal animals, producing a range of sounds, from the low-frequency moans of blue whales to the long songs of humpback whales, and the higher frequency whistles and echolocation clicks of odontocetes (toothed whales), such as dolphins.

Hydrophones deployed near the seabed record these sounds over several months (up to 6 months at a time), giving us a longer term understanding of cetacean habitat use in the area. However, there are challenges with acoustic data: while we can determine species from some of the baleen whale calls (eg the distinctive song of a humpback whale), this is much more difficult for most dolphin species. In addition, many cetaceans do not vocalise continuously. Some species, like the sperm whale, produce metronome-like clicks continuously, except when breathing at the surface.

Other species are more variable in their vocalisation use; for example, humpback whales (*Megaptera novaeangliae*) only sing during the breeding season, while dolphin whistle use varies depending

Spinner dolphins © Isha

Isha cleaning the hydrophone for redeployment © Isha

Short-finned pilot whales © Isha

on behaviour, with different calls and frequency during feeding, socialising and travel. When they vocalise within range of the hydrophone, we can hear these vocalisations (along with fish calls and the sounds of the reef), allowing us to identify which cetaceans are within range and analyse their temporal patterns. So far, hydrophones have been deployed in seven locations, including Peros Banhos (two sites), Egmont Atoll, Sandes seamount, Middle Brother, and southwest and northwest Great Chagos Bank (GCB). This data is being analysed by PhD student Udayanga Sampath, who is based at Oceanswell and the Ocean University of Sri Lanka.

Udayanga has found that dolphins detected (likely spinner dolphins based on their whistle characteristics) outside Egmont Atoll have been recorded on 78% of the days monitored. These dolphins show an opposite diurnal pattern to the spinner dolphins detected inside Perhos Banhos lagoon, with vocalisations peaking around dawn and dusk (paper coming soon!). This suggests that dolphins are using the area between Egmont and GCB to transit between day and night feeding areas within the MPA. Additionally, Udayanga has detected humpback whale calls on all the hydrophones during both the northwest and southeast monsoon seasons (Figure 2), including song.

These vocalisations are currently being shared with other humpback whale researchers in the Indian Ocean to help determine which population these humpback whales belong to. But these findings already highlight the importance of the Chagos Archipelago for cetaceans, whether spinner and bottlenose dolphins associated with the atolls or larger breeding humpback whales.

Our project still has another 15 months until its conclusion in March 2026, during which we will continue to collect both visual and acoustic data, and analyse it. The findings so far suggest that the Chagos Archipelago MPA is an important refuge for cetaceans in the Indian Ocean, largely protected from the impacts of fishery bycatch. Additionally, these cetaceans likely provide a crucial role in the Chagos ecosystem by transporting nutrients, which is critical in these oligotrophic, nutrient-poor tropical oceans. This project provides the first essential step in understanding the importance of the area for cetaceans. It is incredible to think that we still know so little about our cetacean populations in some of these remote locations, yet their importance cannot be underestimated.

*The Wildlife Observer is also collecting data to support a wide range of projects, from seabird surveys and nesting counts, to turtle nesting surveys, illegal shark catches, and much more. If you are interested in the WO supporting your data collection, then contact: tom.letessier@plymouth.ac.uk or clare.embling@plymouth.ac.uk.

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Lives of Coconut Crabs: From Sea to Land

By Mark E. Laidre, Dartmouth College, USA

The coconut crab (*Birgus latro*) is an iconic species of Chagos Archipelago. These crabs play important ecological roles on atolls and islands across their entire Indo-Pacific distribution (Laidre 2017a). As the world's largest terrestrial invertebrate (Laidre 2018), coconut crabs grow to what Charles Darwin described as "a monstrous size" (Darwin 1845), reaching over one metre in leg span and weighing up to four kg.

Yet often overlooked is the fact that these large adults, which vary considerably in size, initially arise from the tiniest of shell-dwelling juveniles (Figure 1). Furthermore, the lives of coconut crabs are deeply intertwined with both sea and land: individuals must obligately pass through an oceanic larval dispersal stage of about a month at sea, followed by a juvenile stage spent inhabiting seashells on land for up to several years. Only once an individual reaches a critical size can it outgrow and abandon its final seashell, ultimately becoming a shell-free adult and then spending the rest of its multi-decade life exclusively on land.

Figure 1. Coconut crab (*Birgus latro*) juvenile life stage: shell-dwelling juvenile, smaller than a fingernail. Photo © Mark Laidre

Little is known about coconut crabs' life-history transition from sea to land, particularly the factors influencing successful recruitment from shell-dwelling juveniles to shell-free adults. Consequently, the Biodiversity Action Plan for coconut crabs in Chagos Archipelago (Laidre 2020) highlighted a lack of fundamental knowledge about life-history transitions as one of the most "critical gaps in knowledge for making sound conservation management decisions about this species." Acquiring this knowledge is vital, not only for effective management, but also for conserving the species across its broader Indo-Pacific distribution, where it faces major worldwide conservation concerns (Laidre 2017b), recently being reclassified on the IUCN Red List from 'Data Deficient' to 'Vulnerable'.

Figure 2. Two color morphs of coconut crab (*Birgus latro*): red (left) and purple (right). The two are competing over a dead rat, held by the purple crab. Photo © Mark Laidre

Notably, like their closest evolutionary relatives, the terrestrial hermit crabs (Laidre 2014; Valdes and Laidre 2019; Doherty and Laidre 2024; Steele and Laidre 2024), coconut crabs are highly vulnerable if lacking a shell early in life. Even if a coconut crab makes it onto land with a shell, its juvenile shell-dwelling stage can last years and requires transitioning to progressively larger shells while navigating a complex 'housing market' (Laidre 2021).

Our research, both on Chagos and across the Indo-Pacific, suggests that empty shells are rare: of tens of thousands of shells sampled, both on land and in the intertidal, nearly all were occupied. Moreover, few were occupied by juvenile coconut crabs, but rather by three competitor species of sympatric terrestrial hermit crab (*Coenobita brevimanus*, *C. rugosus*, and *C. perlatus*). These competitors are abundant, permanent residents of the shell 'housing market', using many sizes and species of seashells and even coconut shells (Laidre 2019), effectively monopolising housing resources needed by juvenile coconut crabs. Limited shell availability has therefore been hypothesised to be a major bottleneck for coconut crabs' population recruitment and life-history transition from juveniles to adults. Yet the shell 'housing shortage' hypothesis has yet to be rigorously tested in the field, where it matters most for this vulnerable species.

Our research on coconut crabs is now addressing these knowledge gaps with whole-island experiments, designed to elucidate the connections between sea-to-land life stages and rigorously test multifaceted ecological variables that may impact successful adult recruitment. For example, using control-experimental pairings of islands across the Indo-Pacific (with island pairs

matched in their baseline shell availability and other key variables), we are adding empty shells to experimental islands and leaving control islands unmanipulated. These whole-island experiments will therefore test the impacts on population recruitment of coconut crabs years down the line, thereby establishing key factors that shape recruitment, growth and molting, and the stability of healthy adult populations.

Alongside our whole-island experiments, we look forward to continued long-term collaboration with the Chagos Conservation Trust, particularly in its ongoing efforts to 'rewild' Chagos Archipelago by eradicating invasive rats (*Rattus rattus*) and by re-establishing native flora through the conversion of abandoned coconut plantations. Understanding the impacts of rewilding on land crab species, particularly on coconut crabs, is vital, given that many land crab species utilise coconuts as a food resource and also have complex interspecific interactions with rats (Laidre 2020). While invasive rats have well-documented negative impacts upon native seabirds, catastrophically affecting the birds' breeding populations, their full impacts on coconut crabs remain less clear.

Figure 3. Coconut crab (*Birgus latro*) dragging dead rat (*Rattus rattus*) up coconut tree (*Cocos nucifera*). Photo © Mark Laidre

Figure 4. Coconut crab (*Birgus latro*) adult life stage: full-grown reproductive adult (left) and smaller newly-recruited adult (right). Photo © Mark Laidre

Rats may act as predators, prey, competitors, or indeed all of the above to coconut crabs. For example, juvenile coconut crabs may fall prey to rats. But this relationship may reverse for full-grown adult coconut crabs, which can be observed fighting over (Figure 2) and feeding on (Figure 3) dead rats, potentially providing the crabs with a major source of protein. Adding to this already complex crab-rat relationship, adult coconut crabs may also compete directly with rats over challenging-to-open coconuts, with rats sometimes stealing opened coconuts from the crabs or vice versa. Hence, only with detailed individual-level monitoring, systematic comparisons across islands, and before-and-after measures of population densities on islands with targeted rat eradication will we fully disentangle the nuanced impacts of rats and rewilding on coconut crabs. Ultimately, the ecological outcomes may depend heavily on the life stage (Figure 4) of the coconut crabs.

To fully understand the lives of coconut crabs, it is essential to track unique individuals through space and time. We are therefore building a life-history database of thousands of uniquely RFID-tagged coconut crabs for permanent individual-based monitoring of growth and molting across their lives. In addition, we are deploying cutting-edge GPS tracking devices on full-grown adults to better understand their spatial movements on islands. Finally, we are also using genetic analyses to shed light on dispersal through the sea, which will offer insights into population connectivity across islands throughout the Indo-Pacific. Our multi-faceted approach – spanning from oceanic larval dispersal to shell-dwelling juveniles to fully terrestrial adults – will therefore connect all lifestages of coconut crabs, providing a foundation of knowledge to help conserve this fascinating species worldwide.

Acknowledgements

I am grateful to the National Geographic Society for funding my research on coconut crabs since 2016, including my current project (2025–2029) on whole-island experiments and shell housing markets. I thank Luisa Arnedo and Lindsay Anderson for their support, Pete Carr for helpful collaboration, and Sarah Puntan-Galea for the invitation to write this article.

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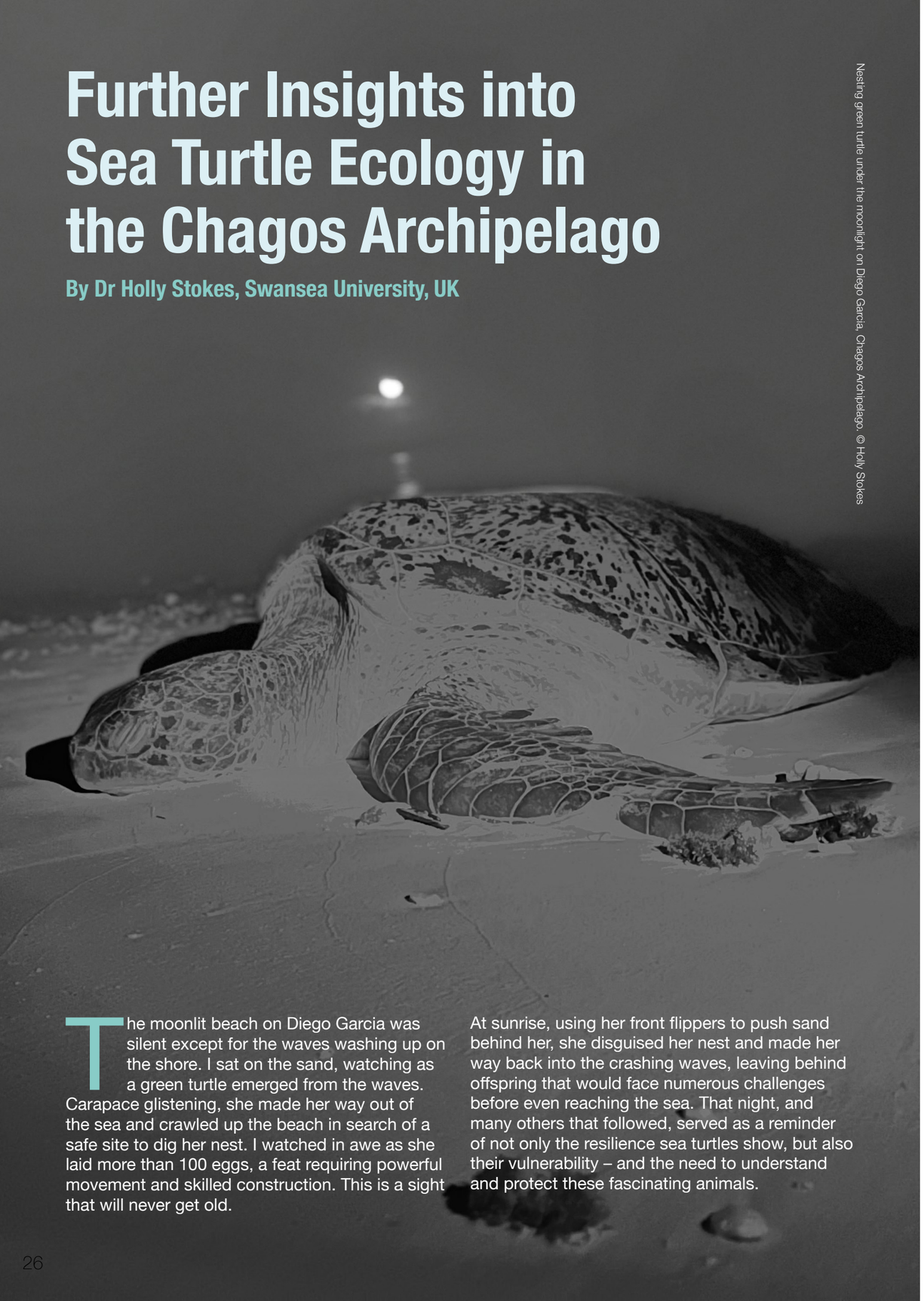
Further Insights into Sea Turtle Ecology in the Chagos Archipelago

By Dr Holly Stokes, Swansea University, UK



Nesting green turtle under the moonlight on Diego Garcia, Chagos Archipelago. © Holly Stokes

The moonlit beach on Diego Garcia was silent except for the waves washing up on the shore. I sat on the sand, watching as a green turtle emerged from the waves. Carapace glistening, she made her way out of the sea and crawled up the beach in search of a safe site to dig her nest. I watched in awe as she laid more than 100 eggs, a feat requiring powerful movement and skilled construction. This is a sight that will never get old.

At sunrise, using her front flippers to push sand behind her, she disguised her nest and made her way back into the crashing waves, leaving behind offspring that would face numerous challenges before even reaching the sea. That night, and many others that followed, served as a reminder of not only the resilience sea turtles show, but also their vulnerability – and the need to understand and protect these fascinating animals.

Sea turtles are a group of reptiles of great importance to the marine ecosystem. Although they spend most of their time at sea, females emerge onto beaches during the nesting season to lay multiple clutches of eggs[1]. In a process known as temperature-dependent sex determination, their sex is determined by sand temperature: warmer temperatures produce more females, while cooler temperatures produce more males.

The Chagos Archipelago is known as a nesting refuge for green and hawksbill turtles from across the whole southwest Indian Ocean region[2] and green turtles have undertaken remarkable migrations between their nesting and foraging sites, including a record-breaking 5,000km migration from Diego Garcia to Mozambique[3]. Nesting numbers have risen significantly in the archipelago, largely due to over 40 years of minimal human disturbance and the establishment of a 640,000 sq km no-take Marine Protected Area (MPA)[4]. The MPA encompasses nesting beaches across 55 islands and also safeguards key juvenile foraging habitats for green and hawksbill turtles, including Diego Garcia. Although extensive sea turtle research has been undertaken in the Chagos Archipelago, knowledge gaps remain, such as on nesting behaviour, hatching success and predation.

I was awarded my Doctorate in November 2024 and now, nearly two years since my last *Chagos News* article detailing my expeditions and initial findings (Sea Turtle Ecology in the Chagos Archipelago, No 60, February 2023), it is time to provide a roundup of the results from my PhD.

For the last four years, my aim has been to build on existing sea turtle research from the Chagos Archipelago, in particular on sea turtle nesting ecology. This topic has largely been understudied due to the remoteness of the archipelago and limitations on the duration of expeditions. To facilitate my research and increase temporal and spatial coverage, I used a combination of *in situ* and remote sensing technology (eg Unmanned Aerial Systems, satellite tracking and camera traps) alongside traditional techniques (eg foot patrols and capture-mark-recapture). Over two green turtle nesting seasons, I carried out clutch counts, nest inventories and nest monitoring, setting camera traps to monitor nesting activity (a novel technique) and deploying sand temperature loggers to assess nest conditions. A long-term mark-recapture study of immature turtles has been ongoing since 1996 at Turtle Cove on Diego Garcia. As part of the continuation of this study, satellite and flipper tags were attached to turtles, enabling the tracking of their movements, and morphometric data were collected to assess immature turtle growth rates.

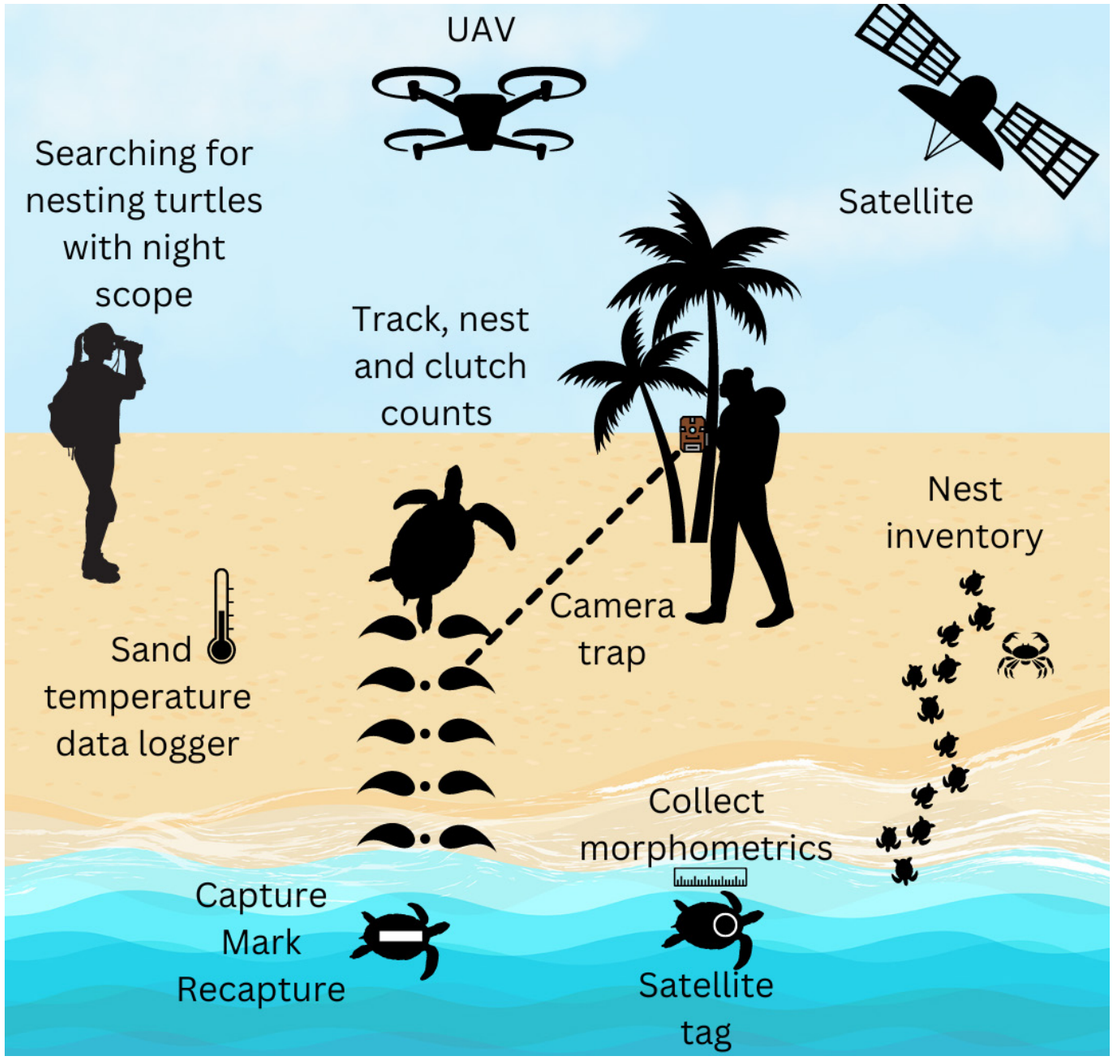
Research highlights

Green turtle nesting ecology:

- *Predators of green turtle eggs:* Green turtle eggs in the Chagos Archipelago face predation from native coconut crabs, ghost crabs and invasive black rats, adding to the extensive list of predators documented globally. Our findings support the Chagos Conservation Trust's Healthy Islands, Healthy Reefs project, particularly the eradication of invasive rats to enhance sea turtle nesting success[5].
- *Nesting behaviour:* Green turtles mainly nest within the vegetation (90%) on Diego Garcia, a pattern that aligns with those observed at other rookeries around the world, where turtles choose sites further away from the sea to minimise nest inundation. As these turtles already nest within and towards the back of the vegetation, there is concern that sea level rise may lead to the loss of available nesting habitat, particularly on low-lying atolls[6].
- *Sand temperature variation:* A wide range of sand temperatures has been recorded across the archipelago over the last decade, mainly driven by seasonal and inter-annual changes but also inter-beach and intra-beach variations. Our findings suggest both male-biased and female-biased clutches are likely produced across the nesting season[7].

Immature hawksbills:

- *High hawksbill densities:* Turtle Cove in the Chagos Archipelago has the highest recorded density of immature hawksbill turtles globally, compared with 17 other foraging sites. This likely reflects the effectiveness of long-term turtle protection efforts in the archipelago[8].
- *Ethics of satellite tagging:* Post-removal examinations of satellite-tagged turtles showed no carapace damage, and growth rate measurements were not significantly different between tagged and untagged individuals. This finding addresses a common ethical concern regarding the effect of satellite tagging on sea turtles[9].



With the support of my supervisory team at Swansea University (Dr Nicole Esteban) and Deakin University (Professor Graeme Hays) along with co-authors and the Bertarelli Foundation, we have resolved knowledge gaps in nesting ecology and developed our understanding of various life stages of both green and hawksbill sea turtles in the Chagos Archipelago.

More specifically, this work has uncovered key aspects of the nesting behaviour, as well as previously unknown threats to reproductive success at this significant nesting site. Our findings provide a baseline for assessing the impacts of climate change, sea level rise and predation on sea turtles in the Chagos Archipelago. We also highlight a positive outlook for these protected sea turtle populations. Moreover, the research offers a template for similar studies (UAV surveys, remote cameras) at other remote sites around the world.

Image p28: Nesting green turtle under the moonlight on Diego Garcia, Chagos Archipelago. © Holly Stokes

Image above: The combination of methods used to survey and monitor sea turtles in the Chagos Archipelago, including traditional ground surveys and remote and in situ sensing techniques.

Image right: Holly Stokes giving a brief to volunteers before carrying out surveys in Turtle Cove, Diego Garcia.

With thanks to the Bertarelli Foundation, BIOT administration, Grampian Frontier, and countless volunteers on Diego Garcia for support and logistical guidance during my PhD research.

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The Chagos Archipelago is a rare haven of beautiful reefs, diverse wildlife and clean waters, located in the midst of the Indian Ocean. The Chagos Conservation Trust is the only UK-based charity dedicated to protecting and conserving it.

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