Management Plan for the White-tailed Tropicbird (*Phaethon lepturus catesbyi*) in Bermuda

Government of Bermuda
Ministry of the Environment
Department of Environment and Natural Resources

Management Plan for the White-tailed Tropicbird (*Phaethon lepturus catesbyi*) in Bermuda

Prepared in Accordance with the Bermuda Protected Species Act 2003

Author

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Cover photo: Adult tropicbird on water
Photo credit: Miguel Mejías

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"To conserve and restore Bermuda's natural heritage"

CONTENTS

LIST OF FIGURES & TABLES

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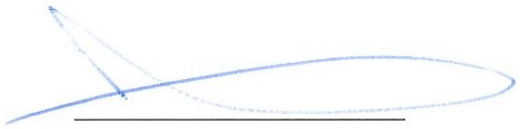

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Director
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Date

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EXECUTIVE SUMMARY

This management plan addresses the need for actions to conserve the subspecies of White-tailed Tropicbird (*Phaethon lepturus catesbyi*) across the Bermuda archipelago.

Current Species Status:
This subspecies was first granted legal protection under the Protection of Birds Act in 1975, followed by the Protected Species Act in 2003. Bermuda's White-tailed Tropicbirds are currently listed as 'Vulnerable' under the Protected Species Amendment Order (2016). Although a thorough, island-wide census has yet to be conducted on this population, it is estimated that at least 3,500 pairs breed on the island (Mejías et al. 2017a).

Habitat Requirements and Threats:
The White-tailed Tropicbird is a seabird species that only associates with land during the breeding season and is strictly pelagic during the non-breeding period. In Bermuda, they nest in cavities, caves, and fissures along the rocky coast. Artificial structures that provide cavities on the coast, like defunct forts, artificial "igloo" nest-cavities, and holes within solid, human debris, are also used. At a minimum, coastal cavities with a sandy substrate, a roof to shield occupants from the elements, and unobstructed entrances for easy arrival and departure on the wing are generally accepted by breeding pairs. Cavities too close (i.e., 1-5 feet) to the water level are prone to flooding and are generally unsuitable for nesting. During the mornings of spring and early summer, tropicbirds conspicuously chase and court with one another along coastlines island wide, especially south shore. They hunt almost exclusively offshore in tropical (subtropical in Bermuda) oceans, where they plunge dive for fish and squid. Currently, this subspecies maintains a relatively large (~3,500 nesting pairs) and stable population on Bermuda. Despite their high numbers on the island, there are several notable threats to breeders. For example, nest-cavities can be destroyed by hurricanes, coastal development, and the root system of invasive vegetation. Feral Pigeons (*Columba livia domestica*) inhabit and fowl coastal cavities, deterring nesting tropicbirds. Several introduced species predate tropicbird adults, eggs, and nestlings. These include rats (*Rattus sp.*), Argentine ants (*Linepithema humile*), American Crow (*Corvus brachyrhynchos*), cats (*Felis catus*), and dogs (*Canis lupus familiaris*) (Wingate and Talbot, 2003, Mejías et al. 2017a). While not a significant threat, adults may also be predated from large, migratory raptors that spend the spring and summer months on the island. Adult tropicbirds, which are site-faithful to nest-cavities, can also be stung to death by Western Honeybees (*Apis mellifera*) that have established a hive inside nest-cavities between nesting seasons (M. Mejías, pers. obvs). Nest-cavity entrances can also be blocked by discarded litter or thick foliage.

Management Objective: The purpose of this management plan is to highlight the breeding ecology and nesting threats faced by Bermudian tropicbirds, and provide essential guidelines needed to preserve, protect, and facilitate population growth of this seabird. It is by far the most abundant breeding seabird on the archipelago; Bermuda's population might be the largest in the entire Atlantic basin. Of the four breeding seabirds present in Bermuda, the White-tailed Tropicbird is one of three species that has survived

human settlement (the others are the Bermuda Petrel (*Pterodroma cahow*) and the Common Tern (*Sterna hirundo*)). Collectively, this makes Bermuda's tropicbird population of extreme conservation importance. It is with hope that this document will also encourage additional research and monitoring, mitigation of threats, and make the public aware of the practices they can adopt that will be beneficial to our "longtail."

Management Criteria: A positive conservation status for the Bermudian White-tailed Tropicbird can be maintained with:

- Evidence that the breeding population remains stable or increases in abundance.
- Controlling invasive species that threaten tropicbird breeding success.
- Advocating the installation of additional artificial "igloo" nest-cavities at suitable, coastal locations.
- Conducting additional tracking studies to understand pelagic movements of nesting adults and fledglings.
- Data to quantify the risk of plastic ingestion by foraging tropicbirds at-sea.

Actions Needed:

1. Estimate the size of Bermuda's breeding population.
2. Identify and map the relative nesting densities of tropicbirds along the Bermuda coastline.
3. Undertake and promote rat, pigeon, and invasive tree control, as well as litter cleanups, on coastal sites where tropicbirds breed.
4. Install more artificial "igloo" nest-cavities for tropicbirds in suitable locations across the island.
5. Fit small tracking devices onto tropicbird adults and near-fledged chicks to determine feeding and post-fledging movements.
6. Begin an active necropsying program on dead tropicbirds to check for evidence of plastic ingestion.

Management Costs:
The total cost of management actions cannot be defined at this point. Funding needs to be secured through non-governmental organizations (NGO's), overseas agencies, and other interested parties for implementing the necessary research and monitoring studies. Developing budgets for each action are the responsibility of the leading party as outlined in the work plan.

PART I: INTRODUCTION

A. Brief Overview

Three species comprise the genus *Phaethon*, all of which breed on remote, oceanic islands; Red-tailed Tropicbirds (*Phaethon rubricauda*) are restricted to the Pacific and Indian Ocean, whereas Red-billed Tropicbirds (*P. aethereus*) and White-tailed Tropicbirds (*P. lepturus*) are pantropical (del Hoyo 1992, Corre and Cebc 1999). *Phaethon* originates from the Ancient Greek word "*phaethōn*" which translates to "sun" (Jobling 2010); this might be reference to the gleaming white plumage of these species on sunny days. All tropicbirds have predominately white plumage with varying degrees of black markings on their back, wings, and face. The most defining trait of Phaethontidae are two long central tail feathers or "streamers" which are used during noisy aerial courtship (Veit and Jones 2003). Tail streamers vary from all red (*P. rubricauda*) to all white (*P. aethereus* and *P. lepturus*). This document will focus on *P. lepturus*, the smallest tropicbird species.

White-tailed Tropicbirds hunt on the wing, mostly offshore, where they plunge dive from a height of about 50 feet to acquire fish and squid (M. Mejías, pers. obvs). Globally, White-tailed Tropicbirds differ in nest-site selection. For example, in Chapéu Island, Brazil and Seychelles, they are known to nest on sparsely vegetated scrapes on the open ground (Hart et al. 2016, Leal et al. 2016) whereas in Culebra, Puerto Rico, they favour deep, rocky crevices under boulders or coastal cliffs (Pennycuick et al. 1990). In the tropics, the species nest asynchronously, where breeders are present year-round (Ramos et al. 2005). In contrast, their breeding is more synchronous in subtropical Bermuda, occurring between February-October (Mejías et al. 2017b). The return of tropicbirds in February is a sign of the warmer weather to come, and for this reason, they are considered the island's "Heralds of Spring." In Bermuda, they are fondly known as "Longtails" because of their long tail streamers. Globally, the International Union for the Conservation of Nature (IUCN) considers the extinction risk of White-tailed Tropicbirds to be "Least Concern" (i.e. unlikely in the near future), although the population trend is considered to be "decreasing." While an official population estimate of Bermuda's White-tailed Tropicbirds is unavailable, the subspecies remains abundant along the coastlines, with evidence suggesting it might even be increasing in Bermuda (J. L. Madeiros, pers. comm.).

This management plan discusses the ecology and natural history of Bermudian White-tailed Tropicbirds (*Phaethon lepturus catesbyi*), and outlines necessary steps needed to protect and conserve this native seabird. More specifically, Part I briefly outlines information on taxonomy, distribution, habitat requirements, biology, and local threats towards this subspecies. Part II presents the proposed management objectives and gives specific work plan actions in a step-down narrative form. Part III concludes the management plan with a summary table which lists the priority tasks required to complete the management objectives.

B. Taxonomy and Description of Species

Kingdom: Animalia
Phylum: Chordata
Class: Aves
Family: Phaethontidae
Genus: *Phaethon*
Species: *lepturus*
Subspecies: *catesbyi*
Common name: White-tailed Tropicbird; long known colloquially as "*Longtail*." Additional historical nicknames include "*boatswain bird*" and "*yellow-billed tropicbird*" (Gross 1912).

On account of their gular pouch, four-webbed toes, and lack of a brood patch, tropicbirds were once considered members of the order Pelecaniformes. However, phylogenetic research has found that tropicbirds are not closely related to any member of this order (Kennedy and Spencer 2004); all three species have since been placed into their own order, Phaethontiformes (Clements et al., 2021). In fact, the closest relatives to the Phaethontidae appears to be the Sunbittern (Eurypygidae; McCormack et al. 2013). This sister relationship is surprising, because tropicbirds forage on the open ocean and have stubby, feeble legs that render them practically immobile on land, whereas the Sunbittern is a long-legged, terrestrial, heron-like bird of lowland and foothill Neotropical forests, that forages along rivers and streams (McCormack et al. 2013). Within Phaethontidae, the White-tailed Tropicbird and Red-tailed Tropicbird are sister species (Kennedy and Spencer 2004). Six subspecies of White-tailed Tropicbirds are recognized: *catesbyi* (North Atlantic Ocean), *ascensionis* (South Atlantic Ocean), *europae* (Southern Mozambique Channel, Indian Ocean), *lepturus* (West Indian Ocean), *fulvus* (East Indian Ocean), and *dorotheae* (Pacific Ocean) (Humeau et al., 2020).

Bermudian White-tailed Tropicbirds (hereafter, "longtails" or "tropicbirds"), are of the *catesbyi* race, and named after English naturalist and artist, Mark Catesby. Physically, longtails are medium-sized seabirds. Table 1 shows the morphology measurements of 18 adult birds; mean body was mass 343 g (range 247–495 g, SD 61 g,), mean wing chord length was 274 mm (range 265–288 mm, SD 7 mm), and mean bill length was 51 mm (range 47–55 mm, SD 2 mm). The adult tail streamer length averaged 406 mm (range 278-508 mm, SD 51 mm) (Mejías, unpubl. data). Adults can be recognized by their white plumage, with black wing tips, diagonal black wing bars, black "comma" around eyes, and two long central white tail feathers (Fig. 1). The tail streamers of spring arrivals are usually an apricot hue from feeding on marine life beyond Bermuda's waters during the non-breeding period. The streamers gradually return to white throughout their summer residency on the island. Occasionally, some adults show a roseate tinge on breast. Longtails have thick, slightly decurved, serrated bills that range from lemon yellow to orangey-red. Airborne birds sometimes tuck their black, stubby legs and webbed feet into their plumage, especially on overcast, cooler days (Mejías, pers. obvs.). Humeau et al. 2020 noted that the Bermuda population have significantly larger tarsi than other subspecies of *lepturus*. Longtails do not exhibit any significant sexual dimorphism in size or colour (Mejías, unpubl. data).

Table 1. Morphology measurements taken from 18 adult longtail specimens in the Bermuda Natural History Museum collection. Note, tarsus length was not recorded due to desiccation of specimen legs.

Specimen ID	Sex	Body Mass (g)	Wing Chord (mm)	Bill Length (mm)
WRC5044	Male	NA	280	52.8
SRF-3918	Female	354	276	51.9
WRC5525	Unknown	NA	274	51.1
10/Mar/2012	Female	410	265	48.8
27/Apr/1989	Male	330	265	50.6
7/July/1996	Male	247	272	47.3
28/Apr/1994	Male	400	265	50.7
WRC4006	Male	300	288	51.2
17/?/1987	Unknown	270	267	51.0
Prep. by S. De Silva	Unknown	NA	276	52.8
1988-016-005	Male	265	283	49.2
27/April/1989	Male	330	268	49.7
22/Jun/1989	Female	360	272	52.5
4/July/2005	Female	320	277	53.9
22/June/1989	Female	360	271	52.4
SRF-580	Male	NA	273	50.7
?/July/1993	Female	NA	275	49.6
SP-579	Male	350	271	52.5
1988-016-006	Male	350	288	55.3
SRF-1193	Female	495	274	50.1

Figure 1. An adult White-tailed Tropicbird flying in Bermuda.
(Note the blue ocean hue reflecting off white underparts). Photograph by Miguel Mejías.

From hatching to fledging, the appearance of nestling longtails undergo significant changes (see "Reproduction" below for more details). Just prior to fledging, immature longtails are nearly the same size as adults, albeit heavier. Like adults, their plumage also comprises mostly white feathers with some black markings, but the entire back and inner wing is covered with black chevron marks, as opposed to the diagonal bars (Fig. 2.). The most notable difference is the absence of the two long tail "streamers", which are acquired during adulthood while at sea. The bills of juveniles are a horn colour and are less serrated than adults. Their legs and feet, however, are entirely black, like adults.

Longtails exhibit various kinds of vocalizations. Their most common vocal displays are short, metallic "*tick*" or "*tick-keck*" notes emitted during aerial courtship and chasing at nest colonies. Adults may sometimes emit the occasional "*shhrreeaah!*" when apparently startled in mid-flight. When disturbed at nest-sites, adults and nestlings produce a long, deafening shriek and sometimes pig-like whines, given either as a long, drawn-out note, or short notes uttered rapidly.

Figure 2. A near-fledging White-tailed Tropicbird in Bermuda.
(Note the heavy black chevron markings, horn-coloured bill, and lack of a "long tail").
Photograph by Miguel Mejías.

C. Current Status

Subspecies Range

The *catesbyi* race of tropicbirds is endemic to the North Atlantic Ocean (Humeau et al. 2020). They breed throughout the Caribbean Islands and Bermuda (Humeau et al., 2020). Mejías et al. (2017b) found that post-breeding, Bermudian longtails never crossed the equator, providing further evidence that northern and southern Atlantic White-tailed Tropicbirds (*ascensionis*) are reproductively isolated.

Local Distribution

Historical Distribution

Historical records suggests longtails were abundant island-wide. Jones (1859) saw many longtails among the Castle Harbour Islands, Harrington Sound, and the stretch of southern coastline from Gibb's Hill Lighthouse to the northwestern limits of Somerset. A further testament of their high numbers was again given by Jones (1859, p 90): "*I sent word to sergeant's party, stationed at Gibb's Hill telegraph, (which is close to the lighthouse), that I would give a shilling each for a few of those birds in full and perfect plumage. I soon received a message in reply, requesting me to go up and select from a number which had been captured. On my arrival at the station, I found between forty and fifty of these birds confined in a small room, the whole of which, with a number of eggs, had been taken in one day."* Gross (1912) also noted their high abundance across Bermuda, with nests being found along the cliffs of Ely's Harbor, Hungry Bay, Tucker's Town, Harrington Sound, Castle Harbor, Spanish Point, and at least nine islands in the Great Sound. At Ely's Harbour and Tucker's Town; concentrations of 50-75 nesting pairs within a range of less than 100 yards was not unusual (Gross 1912).

Contemporary Distribution

Longtails can be readily found nesting and flocking in virtually all rocky coastal habitats surrounding the main island and satellite islands of Bermuda (Fig. 3). The Castle Harbour Islands supports the highest concentration (at least 500 breeding pairs) across the archipelago (Mejías et al. 2017b). Their second stronghold is still the southwestern "elbow" of Bermuda, stretching from Warwick to Daniel's Head, Sandys. Longtails are by far the most abundant native seabird on the island. Both Castle Harbour and south shore have some of the tallest coastal cliffs in Bermuda (up to ca. 40 meters in elevation), which are riddled with rocky cavities that are attractive to prospecting tropicbirds. Albeit not as tall, the northern coastline stretching from Shelly Bay to Coney Island is also inhabited by many nesting pairs.

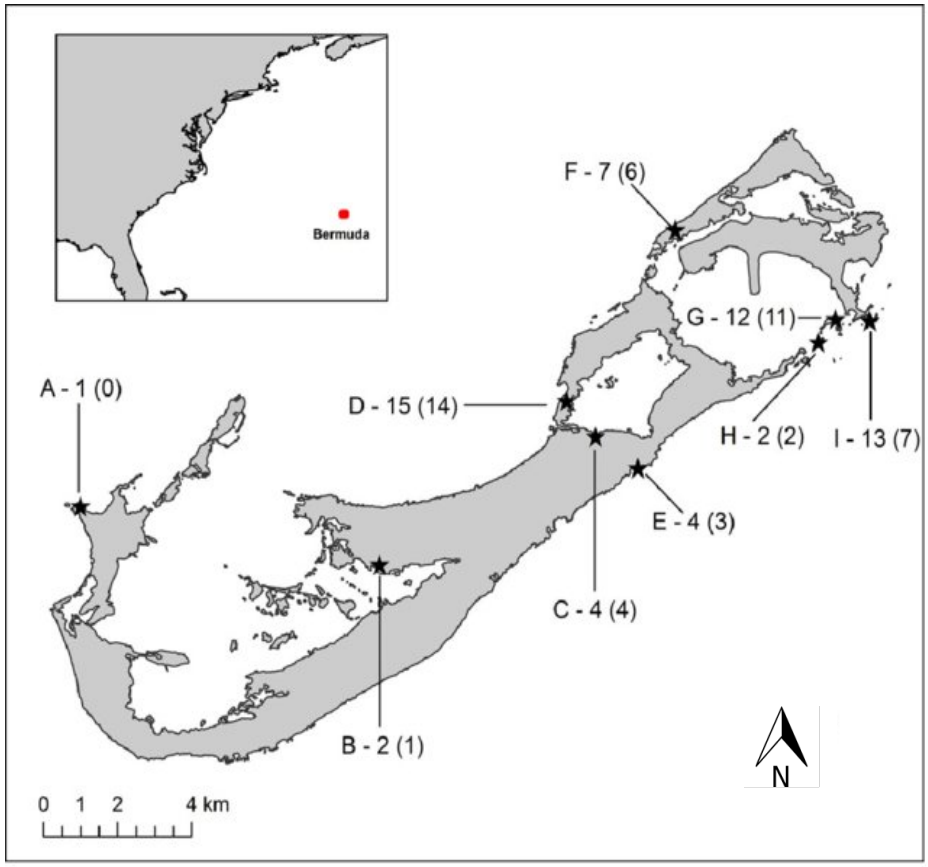

Figure 3. Sites where White-tailed Tropicbirds were captured and fitted with GLS loggers across Bermuda in 2014 and 2015. (A) Daniel's Head, (B) Bay House, (C) Bermuda Aquarium, (D) Shelly Bay, (E) Spittal Pond, (F) Ferry Reach, (G) Nonsuch Island, (H) Horn Rock, and (I) Cooper's Island. Numbers represent the number of tagged and recaptured (in parentheses) birds at each site. Figure adopted from Mejías et al. (2017b).

Species Protection

Using IUCN criteria, the White-tailed Tropicbird is listed under Level 1 as 'Vulnerable" (D1 + 2) on the Protected Species Order (2016). Current legal protection is provided by the Protected Species Act (2003) which considers the willful destruction, damage, removal or obstruction of habitats, and the taking, importing, exporting, selling, purchasing, or transporting this species an offence. Offenders are liable to a fine of up to $25,000 or two years imprisonment.

Habitat Protection

Some of the rocky coastal habitats where longtails breed are within parklands and nature reserves and are therefore protected under the National Parks Act (1986) and the National Parks Regulations (1988), both of which provide protection by prohibiting the destruction and collection of any plants and animals found within protected areas. Much of the remaining nesting habitat on Bermuda is classified as Coastal Reserve which restricts development under current Planning Regulations.

D. Ecology

Habitat Requirements

Being a pelagic seabird species, longtails are dependent on land strictly for breeding purposes. Their desire to nest in pre-existing cavities near the ocean makes the rocky coastal habitat important to longtails. Both flat, gently sloping rocky terrain, to steep cliffs (≥30 feet), can attract longtails, if either formation provides ample cavities for them to explore and nest in. Each nesting pair is only reliant on one nest-cavity per season. Longtails do not collect materials for nest construction, they simply lay their eggs in nest-cavities alongside whatever detritus is already present inside nest-cavity, including *Sargassum* seaweed and anthropogenic litter (Gross 1912, M. A. Mejías, pers. obvs.). Mejías et al. (2017a) thoroughly summarized nest-cavity traits that are desirable to Bermudian tropicbirds and that increased their nesting success. In short, for natural nest-cavities, breeders typically selected holes with a sandy flooring, smaller entrances, and on steeper terrains. Longtails prefer cavities with sandy flooring, over bare rocks, likely because the former offer cushioning for their eggs during incubation (Mejías et al. 2017). Smaller entrances may reduce detectability and accessibility by predators (Mejías et al. 2017a). Natural cavities on steeper terrain may be selected because they permit easier arrival and departure on the wing; longtails have poor ground mobility because of their short tarsi (Clark et al. 1983). For this reason, vegetation that blocks nest-cavity entrances can render nest-cavities inaccessible. While tropicbirds accept both shallow and deep nest-cavities, they had higher breeding success in the latter, due in part because some predators, such as American Crows, are unable to predate the nest contents of deeper nest-cavities (Mejías et al. 2017a). The rocky coast is a high-energy environment, exposed to over-washing and high winds during adverse weather. Thus, nest-cavities that are further up from the high-water mark are less prone to nest failure from flooding (M. A. Mejías, pers. obvs.). The implications for the installation of artificial "igloo" nest-cavities are as follows: they should be installed on top of high (≥ 30 feet) coastal cliffs or inside a coastal wall, have a small entrance, a sandy floor, and an entrance tunnel deep enough to protect nest contents from potential predators, such as cats and crows (see "Tools Available for Strategy" below for more details). Although nest success was similar between natural and artificial nest-cavities (Mejías et al. 2017a), the installation and occupancy of the latter clearly increased the number of nest-sites for tropicbirds.

Reproduction

The tropicbird nesting season spans March — September, with some breeders departing as late as November (Mejías et al. 2017b). During spring and summer mornings, large flocks of tropicbirds can usually be seen chasing and courting above coastlines island-wide. During courtship, adults will meet in the sky, fly in synch, one directly above the other, and touch tail streamers while soaring (Fig. 4). Once a pair-bond is formed, the breeders return to and copulate inside a nest-cavity. Recaptures of ringed birds showed that established breeding pairs reuse the same nest-cavity for several years (Mejías, unpubl. data). Longtails have a clutch size of one egg, although a second can be laid if nest failure occurs early in the nesting stage or season (Mejías et al. 2017a). They are not known to lay a third egg. Gross (1912) noted a variety of egg colour morphs, although mottled maroon is most common in Bermuda (Fig. 5).

Figure 4. Two adult White-tailed Tropicbirds from Bermuda engaged in aerial courtship. The top bird in this photograph has moulted its tail streamers. Photograph by Miguel Mejías.

Figure 5. A Bermudian White-tailed Tropicbird egg. Photograph by Miguel Mejías.

Figure 6. (Left) An adult White-tailed Tropicbird in Bermuda brooding a downy chick (small grey fluff on lower right side); (right) a newly hatched Bermuda tropicbird. Photographs by Choy Aming and Miguel Mejías, respectively.

Both sexes participate with incubation (mean ± SD = 42 ± 1 day, range: 41– 44 days, n = 7 clutches), making changeovers about every 5-6 days (Mejías, unpubl. data). Tropicbirds

lack a brood patch therefore they induce hatching by transferring heat from their feet to the egg, a process known as "hot footing" (Hart et al. 2016). See Gross (1912) for photographs depicting different age classes of tropicbird nestlings in Bermuda. Hatchlings are blind for the first few days of life and covered by soft, grey down and are brooded by the parent (Fig. 6). Although downy chicks are capable of thermoregulation, at least one adult is usually present with young until about 3 weeks old. Both parents partake in the chick rearing period (67 ± 3 days, 61– 69 days, n = 7 broods) when the chick increases in size and the grey down is replaced by immature plumage, just prior to fledging. Peak nestling weight can surpass 500 g towards the end of development, which is nearly double the weight of adults during chick rearing (Mejías, unpubl. data). After fledging, the chicks are totally independent, presumably dispersing to waters across the Atlantic basin, but return to Bermuda after 3 or 4 years as adults to breed. Similarly, after their young fledge, adults become strictly pelagic during the fall and winter months; data from tracked birds revealed that non-breeding adults remained in the North Atlantic, occupying waters from eastern seaboard of the United States, to as far east as the Azores, before returning to their Bermuda nest-cavities the following spring (Mejías et al. 2017b).

Diet and Feeding

Tropicbirds prey on fish and squid captured by plunge diving (M. Mejías, pers. obvs). While hunting, tropicbirds look downward, scanning the ocean surface from above. They also commonly follow moving boats, presumably because vessels can flush prey at the surface. During the breeding season, most tropicbirds appear to forage several kilometers south of Bermuda (M. Mejías, unpubl. data). Foraging White-tailed Tropicbirds tagged in Fernando de Noronha Archipelago also made southerly trips of 20 kilometers, before returning to their nesting colony (Campos et al. 2017). Once longtails have visual on their prey, they plunge dive headfirst while slowly spiraling, from a height of about 50 feet, directly on top of prey, and capture them near the surface with their bill (M. Mejías, pers. obvs). Their prey is either digested or stored in their gular pouch; the latter food is later fed to chicks. When threatened, tropicbirds can regurgitate their catch (Fig. 7). During handling, longtails have regurgitated Caribbean reef squid (*Sepioteuthis sepioidea*), Atlantic flyingfish (*Cheilopogon melanurus*), and pufferfish (Tetraodontidae). Adults are at their heaviest (400-470g; Mejías, unpubl. data) at the beginning of the breeding season, but drop ~100 g throughout incubation and chick rearing (Mejías et al. 2017b).

Figure 7. Regurgitated fish (*Decapterus sp*.) and squid from a Bermuda White-tailed Tropicbird. Photograph by Miguel Mejías.

E. Current Threats

Local

Several factors threaten tropicbirds at nesting sites, most of which are anthropogenic in nature. For example, feral cats and dogs attack and kill adult and nestling tropicbirds (D. B. Wingate, pers. comm.). Rats and crows have been documented consuming tropicbird eggs and chicks (Figs. 8, 9). The introduced Argentine ant also swarm and devour nestlings (Mejías et al. 2017a). While uncommon, visiting raptors that overlap with the longtail breeding season may prey upon adults (Fig. 10). Feral Pigeons are present year-round on the archipelago, and can inhabit and fowl nest-cavities, rendering them unusable by longtails. Nest-cavities are also lost through coastal erosion during hurricanes. In 2003, Hurricane Fabian destroyed approximately 300 nest-cavities throughout Castle Harbour, with some islands losing more than half of all nest sites (Madeiros 2011, P. Talbot unpubl. data). Coastal development may destroy nest cavities and alter the profile of the rocky coast making it unfavourable to nesting longtails.

Furthermore, the roots of introduced plants, especially the casuarina (*Casuarina equisetifolia*), penetrates into and erodes the rocky coast, which further degrades tropicbird nesting habitat. At sea tropicbirds are harassed (and occasionally killed) by avian kleptoparasites (e.g. Skuas and Jaegers from the Family Stercorariidae). These pelagic, transient seabirds cause tropicbirds to regurgitate food items and then consume the items afterwards.

Figure 8. (Left) An introduced black rat; (right) rat prints and a devoured tropicbird egg inside an artificial nest-cavity. Photographs by Miguel Mejías.

Figure 9. (Left) an introduced American Crow; (right) a crow-predated tropicbird egg from Bermuda. Photographs by Miguel Mejías.

Figure 10. An immature Bald Eagle with an adult White-tailed Tropicbird in its talons. (Note this could be the first published record of a Bald Eagle preying on a member of the Family Phaethontidae). Photograph by Chris Burville on Bermuda (April 27, 2022).

F. Current Conservation Actions

Installing artificial nest-cavities

Arguably the most significant conservation action taken for the benefit of breeding tropicbirds was the creation of artificial "igloo" nest-cavities (see "Tools Available for Strategy" for more details). Invented by Dr. David Wingate in the 1960s, "igloo" nest-cavities are mass-produced Styrofoam domes coated with a fiber bond and cement mixture that are cemented over a sandy depression on the tops of stable cliff edges (Mejías et al. 2017a). These artificial "igloos" are approximately 15" high, with an internal length and width of 22" and 24", respectively (Mejías et al. 2017a). The "igloos" were intended to compensate for natural nest-cavity loss, either by destruction (i.e., hurricanes, coastal development, and invasive trees) or competition with pest species (i.e., Feral Pigeons). Their installation proved successful; tropicbirds have accepted and fledged offspring inside them for decades (Mejías et al. 2017a). Field observations have suggested that they are, to some degree, more resilient to hurricane damage than natural nest-cavities (P. Talbot, unpubl. data). Over the past two decades over 100 artificial nest-cavities have been installed by the Department of Environment and Natural Resources throughout Castle Harbour and Cooper's Island Nature Reserves. Additionally, a series of volunteer work parties run by the Bermuda Audubon Society and the Bermuda Zoological Society have led to successful "igloo" installations island-wide. Today, they can be found across rocky shorelines of nature reserves, parks, and private residences, although there is ample space on Bermuda's coasts for many more.

Invasive species control

Several nature reserves, parks, and private properties across the island receive varying degrees of invasive species control, procedures that ultimately benefit nesting tropicbirds. Rats are permanently removed from the environment using poison baited feeding stations, live walk-in traps, and, most recently, mounted "A24 goodnature" captive-bolt traps. Over a three year period, these methodologies have proven effective in total rat eradication on Nonsuch Island (16 acres), following episodic infestations (Madeiros, 2017). Feral Pigeons have been culled using a combination of baited walk-in traps and targeted shooting. From 2004 and 2015, a total of 11,727 pigeons were permanently removed from the environment island-wide, of which 45% came from livestock farms (Outerbridge, 2016a). During this same time period, a total of 717 American Crows were culled island-wide, of which 31% were from the Peak on Town Hill (Outerbridge, 2016b). Invasive casurinas are routinely removed from coastal habitats via cutting, girdling, and application of herbicides, most notably within the Castle Harbour islands and Coopers Island nature reserves, where the highest concentrations of breeding longtails occur.

Banding nesting tropicbirds and tracking their post-breeding movements

Beginning in 2006, the Senior Terrestrial Conservation Officer from the Department of Environment and Natural Resources began banding tropicbirds at 10 nest-sites on the eastern end of Bermuda (Madeiros, 2011). Avian banding involves fitting individuals with uniquely numbered metal bands (incoloy in Bermuda), so that individuals can be recognized from afar or in the hand. As 2022, over 1,700 tropicbirds have been banded, ~75% of which were nestlings (J. Madeiros, pers. comm). While results of these banding efforts are currently unavailable, a subset of band recoveries from the Shelly Bay tropicbird colony, annually recorded by the author since 2015, revealed that the same breeding pairs return to the same nest-cavities, year after year, until one or both members disappear (Mejías unpubl. data). Some of the adults banded in 2015 were recaptured at the same nest-site in 2022, showing site-fidelity for at least seven years (Mejías unpubl. data). In addition to comparing their nest success between natural and artificial nest-cavities and their vulnerability of nest contents to introduced predators (Mejías et al. 2017a), adults were also fitted with small (0.5 g) light-based geolocators to map the non-breeding movements of post-breeding longtails, highlighting areas where the species might be vulnerable when off island (Mejías et al. (2017b).

Wildlife Rehabilitation at the Bermuda Aquarium Museum and Zoo

The Bermuda Aquarium Museum and Zoo (BAMZ) runs a tropicbird rehabilitation program, where injured, lost, and distressed birds are received, rehabilitated and, more recently, banded prior to release. At least five circumstances result in tropicbirds being accessioned into the wildlife rehabilitation program:

(1) nestling abandonment,
(2) nestlings being washed out of nest cavities (especially during peak hurricane months),
(3) fledglings departing before their flight feathers have fully grown in,
(4) fledglings being too heavy or light at first flight, and
(5) birds sustaining injuries (this applies mostly to adult tropicbirds).

Most of the longtails brought into the wildlife rehabilitation program are juveniles. Since 2004, a total of 575 longtails have been received, 346 (60%) of which have been successfully released back into the wild.

PART II: MANAGEMENT

A. Management Goal

The primary goal of this management plan is to promote the persistence and population growth of one of the few remaining breeding seabirds on Bermuda, and quite possibility the largest population of its kind in the entire Atlantic basin. This plan presents important information on the ecology, natural history, and threats relevant to the Bermuda Longtail as well as activities which will promote long-term conservation. This can be achieved by conducting a population estimate for the Bermuda breeding colony, mapping their nesting density across the island, continued management of invasive species which threaten their survival, and litter on the rocky coast, encouraging the installation of more artificial "igloo" nest-cavities across Bermuda , use tracking devices to study adult foraging patterns and the pelagic movements of fledglings, and begin a long-term necropsy program to find evidence of, and monitor rates of, plastic ingestion in foraging longtails.

The short-term (5 years): Measure tropicbird population viability by modelling survivorship of recaptured, banded tropicbirds. Initiate a census along Bermuda's coastlines during tropicbird breeding season to estimate nesting density. In addition to continued invasive species control throughout managed nature reserves, similar practices and coastal litter removal needs to be done on neglected nature reserves. Furthermore, coastal homeowners should also be encouraged to adopt these practices. Identify additional coastal sites, both on government owned nature reserves and private properties, suitable for artificial "igloo" nest-cavity installation. Purchase tracking devices, through funding obtained by interested parties, on adult and near-fledgling tropicbirds, to map foraging trips and fledgling dispersal patterns. Finally, begin necropsying longtail carcasses for any signs of plastic ingestion.

Long-term (20 year): Monitor and publish findings on the stability, size, distribution, and health of Bermuda's tropicbird population. Monitor a subset of the additional artificial "igloo" nest-cavities mentioned in the short-term goals for signs of occupancy and productivity. Also publish papers on the foraging and post-fledging movements of tagged adults and fledglings, respectively, as well the extent tropicbirds in Bermuda are vulnerable to plastic ingestion. Finally, present data pertaining to the ecology, population status, threats, and conservation efforts to members of the public, in order to raise additional awareness of this subspecies.

B. Management Objective and Criteria

Management Criteria: A positive conservation status for the Bermudian White-tailed Tropicbird can be maintained with:

- Evidence that the breeding population remains stable or increases in abundance.
- Controlling invasive species that threaten tropicbird breeding success.
- Advocating the installation of additional artificial "igloo" nest-cavities at suitable, coastal locations.
- Conducting additional tracking studies to understand pelagic movements of nesting adults and fledglings.
- Data to quantify the risk of plastic ingestion by foraging tropicbirds at-sea.

Actions Needed:

1. Estimate the size of Bermuda's breeding population.
2. Identify and map the relative nesting densities of tropicbirds along the Bermuda coastline.
3. Undertake and promote rat, pigeon, and invasive tree control, as well as litter cleanups, on coastal sites where tropicbirds breed.
4. Install more artificial "igloo" nest-cavities for tropicbirds in suitable locations across the island.
5. Fit small tracking devices onto tropicbird adults and near-fledged chicks to determine feeding and post-fledging movements.
6. Begin an active necropsying program on dead tropicbirds to check for evidence of plastic ingestion.

This management plan acknowledges both the straightforward and difficult activities deemed necessary for population stability and growth of the Bermuda White-tailed Tropicbird population. Traits that favour management include their present-day island-wide abundance, catchability within nest-cavities, willingness to breed in artificial nest-cavities, nest site fidelity, and availability of carcasses for study brought to the Bermuda Natural History Museum every year. In contrast, several aspects of their behaviour present significant management obstacles. More specifically, individuals can only be observed and handled inside or close to nest sites and become virtually unobservable away from nest colonies. They are prone to human-induced abandonment if handled for too long, particularly during pre-laying or early incubation; nest contents are also vulnerable to introduced predators that hunt within breeding sites. Unlike small, offshore islets, total eradication of pest species is improbable on mainland sites, with constant suppression being the primary focus on latter sites. Finally, most longtails are quite aggressive and can bite and cut fingers with their serrated bills.

C. Tools Available for Strategy

Artificial "igloo" nest-cavities

Bermudian artificial nest-cavities are a mass producible SKB and fiber bond coated Styrofoam hemisphere ''igloo'' which can be cemented over sandy depressions excavated into level cliff top ledges, human-made terraces, and seawalls (Fig. 11). The initial SKB roofing fiberbond mix painted on top of the dome increases its durability. Painted domes are fairly light in weight. Detailed instructions on optimal installation and "igloo" purchases can be found on the webpages of the Bermuda Audubon Society and the Department of Environment and Natural Resources. Artificial nest-cavities can also be fitted with an entrance tunnel (~1-2 feet) with a flared entrance (8 X 6'') at the cliff edge; the tunnel length protects nest contents from cats/dogs and crows, whereas the large entrance creates a dark hole that is attractive to prospecting adults. While longtails are highly territorial over their nest-cavities, aggression is reserved for intrusions inside nesting chambers. Therefore, "igloo" nest-cavities can be installed in high densities, with as little as 1 foot between nest-cavities. It is imperative that nearby vegetation be pruned to prevent entrance obstruction.

While the foam igloos are readily accepted by nesting tropicbirds, they are an environmental hazard if and when they are destroyed by storms, given that they are made of (polystyrene) foam. As a form of plastic, this is an ingestion risk and possesses a wider environmental hazard. On way to remedy this is to construct 'igloos' out of limestone slate using the same dimensions as the foam ones.

Figure 11. Artificial "igloo" nest-cavity with an adult tropicbird sitting inside. Photograph by Miguel Mejías.

Morphometric, banding, and tagging equipment

The Protected Species Amendment Order (2016) lists Bermudian White-tailed Tropicbirds as a "Level 1" species. To work with them requires a local research license from the Department of Environment and Natural Resources, which can also be used to purchase leg band supplies from an overseas supplier. Tropicbirds are readily hand-caught inside their nest-cavities, but birds must be carefully removed. Captured birds should immediately be placed inside an appropriately sized breathable cloth bag in order to minimize stress, injury to bird or handler, and reduce the likelihood of nest-cavity abandonment. It is imperative that handling time be no more than 10 minutes. A pair of bird banding/ringing pliers should be used to fit a single metal (i.e., incoloy) identification ring on one leg. The uttermost care should be taken to ensure that closed leg bands do not overlap, in order to prevent tarsi irritation, chaffing, or wounds. Mejías et al. (2017b) describes specific tagging methodology for small, light-based geolocators (GLS tags) onto longtails, which were retrieved from birds the following year with no reported ill-effects. Additional tracking devices that could be suitable for adult and near-fledged birds are miniaturized, waterproof GPS archival tags; these have been successfully deployed on Bermuda Petrels (*Pterodroma cahow;* http://www.nonsuchisland.com/blog/gps-trackers). A wing chord ruler is essential for measuring wing length, and Vernier calipers for measuring bill and/or head length and tarsi length.

Invasive species control

In Bermuda, there is a fairly large list of invasive species that directly or indirectly hinder tropicbird nesting success. While these threats can be readily managed on small, offshore islands where longtails nest, their superabundant presence on mainland Bermuda makes total eradication highly improbable. Nonetheless, limited measures can be taken to ease predation pressure on mainland nesting pairs. For example, rats can be culled with a combination of live trapping, rodenticide bait stations, and the use of baited automatic traps. Argentine ant control requires the use of poison bait. Feral Pigeons and American crows can be culled by using a combination of walk-in traps and targeted shooting by licensed individuals. Coastal habitats with invasive vegetation, such as casuarina and Brazilian pepper trees (*Schinus terebinthifolia*), should be pruned or removed. For permanent removal, trees should be either cut to the stump or girdled, followed by a dose of appropriate herbicide painted on the stump/wound. Inquiries about the handling, distribution, and purchase of rodenticides should be directed to Bermuda Vector Control. Similarly, herbicides, and firearm services inquiries can be directed to the Department of Environment and Natural Resources. Ant poisons can be locally purchased from a variety of hardware stores.

Population census

Presently, no official census for the Bermuda longtail population has been conducted. This can be accomplished by using a combination of nest search surveys and aerial body counts via boat (Bright et al. 2014, Bollen et al. 2018). The former has already been done throughout one of Bermuda's tropicbird strongholds; Castle Harbour (Madeiros 2011). Nonetheless, additional surveys should be carried out in other areas of the island, especially along the southern shoreline. Accessible nest-sites should be surveyed by foot. Nest-cavities can be found throughout daylight hours by watching for signs of birds arriving and departing holes, the smell of guano, searching for moulted feathers and the

presence of hatched eggs, and listening for the shriek of startled birds (M. Mejías, pers. obvs.). Boat surveys should be conducted during peak flying activity, which in Bermuda is from 06:00 – 11:00 (Gross 1912).

Bermuda Audubon Society, Bermuda Aquarium, Museum, and Zoo

Additional information and live, close encounters of the White-tailed Tropicbird can be acquired through the Bermuda Audubon Society. This local charity hosts several birdwatching, photography walks, and lectures throughout the year, both of which provide ideal opportunities to observe longtails in their habitat. Experienced, local birders also routinely attend these events, serving as an additional source of information on the tropicbirds. The Bermuda Aquarium runs a wildlife rehabilitation program, where injured and/or distressed tropicbirds are brought in and hand reared on fish and squid. If rehabilitation is successful, these birds are banded and released back into the wild. All tropicbirds recovered in wild, live or dead, should be brought into the Bermuda Aquarium. Lastly, the Bermuda Natural History Museum is an excellent resource for local publications on longtails, as well as study skins available for research purposes. Tropicbird carcasses are brought to the Museum regularly throughout the spring and summer months and is the ideal place to perform necropsies for signs of plastic ingestion.

D. Step-down Narrative of Work Plan

Abbreviations used in Section E and Part III:

DENR – Department of Environment and Natural Resources
BAS – Bermuda Audubon Society
BVC – Bermuda Vector Control
PARKS – Department of Parks
MM – Miguel Mejías

The management actions are as follows:

1. Estimate the size of Bermuda's breeding population.

Actions proposed:

- Undertake a Capture-Mark-Recapture investigation of adult and nestling tropicbirds across the island.
- Visit all banding sites several times a month throughout the breeding season, across successive years, to band/recapture additional birds.
- Conduct a coastal census by boat of adult tropicbirds at several survey sites across consecutive years.
- Use appropriate statistical software (e.g. Program MARK), to estimate population size, as well as survivability and recruitment of banded birds.

Work Team: DENR, BAS, MM
Team Leader: DENR
Assistance: BAMZ, Volunteers, graduate students, visiting researchers
Outputs: A long term dataset comprised of recaptured, banded tropicbirds, as well as a total abundance of counted tropicbirds from boat counts, which can be statically analyzed for estimates of population abundance and individual rates of survival.
List of equipment required: Vehicle/boat to get to sites, incoloy rings, banding pliers, breathable, cotton bags to hold captured tropicbirds, binoculars, and a computer with appropriate statistical analysis software installed.

2. Identify and map the relative nesting densities of tropicbirds along the Bermuda coastline.

Actions proposed:

- Conduct a coastal census by boat of adult tropicbirds at chosen sites across the island.
- Use data to create a heat density map of tropicbirds along Bermuda's coastlines.

Work Team: DENR, BAMZ, BAS, MM
Team Leader: DENR
Assistance: Volunteers, graduate students, visiting researchers
Outputs: A heat map showing the density of tropicbirds across sampled areas, across the archipelago.
List of equipment required: Vehicle/boat to get to sites, binoculars, physical or digital field notebook, and a computer with appropriate mapping software installed.

3. Undertake and promote rat, pigeon, and invasive tree control, as well as litter cleanups, on coastal sites where tropicbirds breed.

Actions proposed:

- Continue predator control activities on public lands where tropicbirds nest.
- Promote effective methods of predator control on private properties to reduce rat and ant abundance (e.g. poisons and trapping).
- Promote proper sanitation methods at home by reducing shelter and food sources available to rats and ants.
- Organize volunteer work parties on coastal habitats, either on Nature Reserves or Public Parks, to remove invasive trees and human debris.
- Spread awareness of nesting threats to tropicbirds with presentations to the general public, and how the above practices could be implemented on private properties.

Work Team: DENR, BAMZ, BAS, PARKS
Team Leader: DENR

Assistance: Volunteers, visiting scientists
Outputs: The extermination or reduction of invasive species on rocky coastal habitats on offshore islets and mainland Bermuda. A revitalized obligation and appreciation in the steps that local residents can take to protect our longtails, and other native species.
List of equipment required: Vehicle/boat to get to sites, landscaping equipment that is appropriate for targeted trees, rat/ant poison, and poison bait boxes, and walk-in traps.

4. Install more artificial "igloo" nest-cavities for tropicbirds in suitable locations across the island.

Actions proposed:

- Survey coastal sites across the island suitable for artificial "igloo" nest-cavity installation.
- Install artificial nest-cavities at appropriate coastal sites.
- Ensure responsible parties check these artificial nest-cavities in subsequent breeding seasons for signs of, and impediments to, nesting activity.

Work Team: BAS, BAMZ, DENR, MM
Team Leader: BAS
Assistance: Volunteers, graduate students, visiting researchers
Outputs: A significant increase in productive artificial nest-cavities for tropicbirds.

5. Fit small tracking devices onto tropicbird adults and near-fledged chicks to determine feeding and post-fledging movements.

Actions proposed:

- Reach out to potential overseas collaborative partners.
- Write a proposal to obtain funding for the appropriate tracking devices for adult and near-fledged tropicbirds.
- Capture and tag tropicbird adult and near-fledging birds at nest-sites.
- Analyze, publish, and make conservation recommendations based on retrieved tracking data.

Work Team: DENR, BAMZ, BAS, MM
Team Leader: DENR
Assistance: Collaborators from overseas, volunteers, graduate students, visiting researchers.
Outputs: A publishable, long-term movement dataset of foraging adults rearing chicks and the high-seas movements of immature White-tailed Tropicbirds.

6. Begin an active necropsying program on dead tropicbirds to check for evidence of plastic ingestion.

Actions proposed:

- Receive and store tropicbird carcasses.
- Dissect, study, and record the contents of the digestive tracts.
- Compile, analyze, and publish a paper, based on several years of examined specimens.
- Compile and present findings to members of the public in order to educate and increase awareness about the effects of plastic ingestion on seabirds.

Work Team: BAMZ, MM, DENR
Team Leader: DENR
Assistance: Collaborators from overseas, volunteers, graduate students, visiting researchers.
Outputs: A long term dataset on the prevalence of plastic ingestion in Bermuda's tropicbirds, as well as publishable paper(s) and presentations to the public.

E. Estimated Date of Down Listing

The White-tailed Tropicbird is currently listed as 'Vulnerable" (D1 + 2) under the Protected Species Amendment Order (2016). Despite its present-day island-wide distribution across the rocky coastal environment, an official estimate of their numbers is currently unknown. As proposed in this management plan, a series of capture, ringing, and monitoring programs is essential in obtaining a more accurate estimate of their abundance, so that strategic decisions can be made with respect to down listing. Their relative abundance, ubiquitous distribution, high catchability at nest-cavities, and nest-cavity fidelity, are all traits that favour feasible assessments. A population assessment study of at least 10 years should be sufficient to determine a reliable estimate of population size and health necessary to consider the Bermuda longtail as a suitable candidate for down listing.

PART III: IMPLEMENTATION

Priority 1: An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.
Priority 2: An action that must be taken to prevent a significant decline in the species population/habitat quality, or some other significant negative impact short of extinction.
Priority 3: All other action necessary to provide for full recovery of the species.

Priority #	Task #	Task description	Task Duration	Responsible Party
2		**Nest predator control**		
	1	Continue control activities on public lands	ongoing	DENR, BVC, PARKS
	2	Promote control activities on private lands	ongoing	DENR, BAS
	3	Give lectures to public	ongoing	MM, BAS
2		**Continued artificial "igloo" nest installations**		
	4	Survey additional coastlines suitable for "igloo" installations	ongoing	DENR, BAS
	5	Install "igloo" nest-cavities	ongoing	DENR, BAS, land owners
	6	Monitor "igloos" annually	ongoing	DENR, BAS, land owners
3		**Estimate abundance and survival rates**		
	7	Capture and band tropicbirds	ongoing	DENR, MM
	8	Compile and digitize band recoveries	ongoing	DENR, MM
	9	Run population and survival estimates using statistical software	5-6 months	DENR, MM
3		**Map nesting tropicbird hotspots across the island**		
	10	Conduct coastline surveys to count flying tropicbirds	6-7 months	MM, BAS, DENR
	11	Collate and analyze sighting data	5-7 months	MM
	12	Publish peer-reviewed paper	1 year	MM, DENR, BAS
3		**Track pelagic movements of adults and fledglings**		
	13	Capture and fit tropicbirds with tags	3-4 weeks	DENR, MM, BAS
	14	Collate and analyze tracking data	5-6 months	MM, DENR
	15	Publish peer-reviewed paper	1 year	MM, DENR
3		**Necropsy tropicbirds**		
	16	Receive tropicbird specimens from the public	ongoing	DENR

	17	Dissect and record evidence of plastic ingestion	ongoing	DENR
	18	Collate and analyze necropsy data	5-6 months	MM, DENR
	19	Publish peer-reviewed paper	5-6 months	MM, DENR
	20	Give presentations to the public	ongoing	MM, DENR

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