CAHOW RECOVERY PROGRAM

For Bermuda's Endangered National Bird

2020 – 2021 Breeding Season Report

BERMUDA GOVERNMENT

Compiled by: Jeremy Madeiros, Principle Scientist
Terrestrial Conservation Division
Department of Environment and Natural Resources

"To conserve and restore Bermuda's natural heritage"

RECOVERY PROGRAM FOR THE CAHOW (Bermuda Petrel) *Pterodroma cahow*

BREEDING SEASON REPORT
For the Nesting Season (October 2020 to June 2021)
Of Bermuda's Endangered National Bird

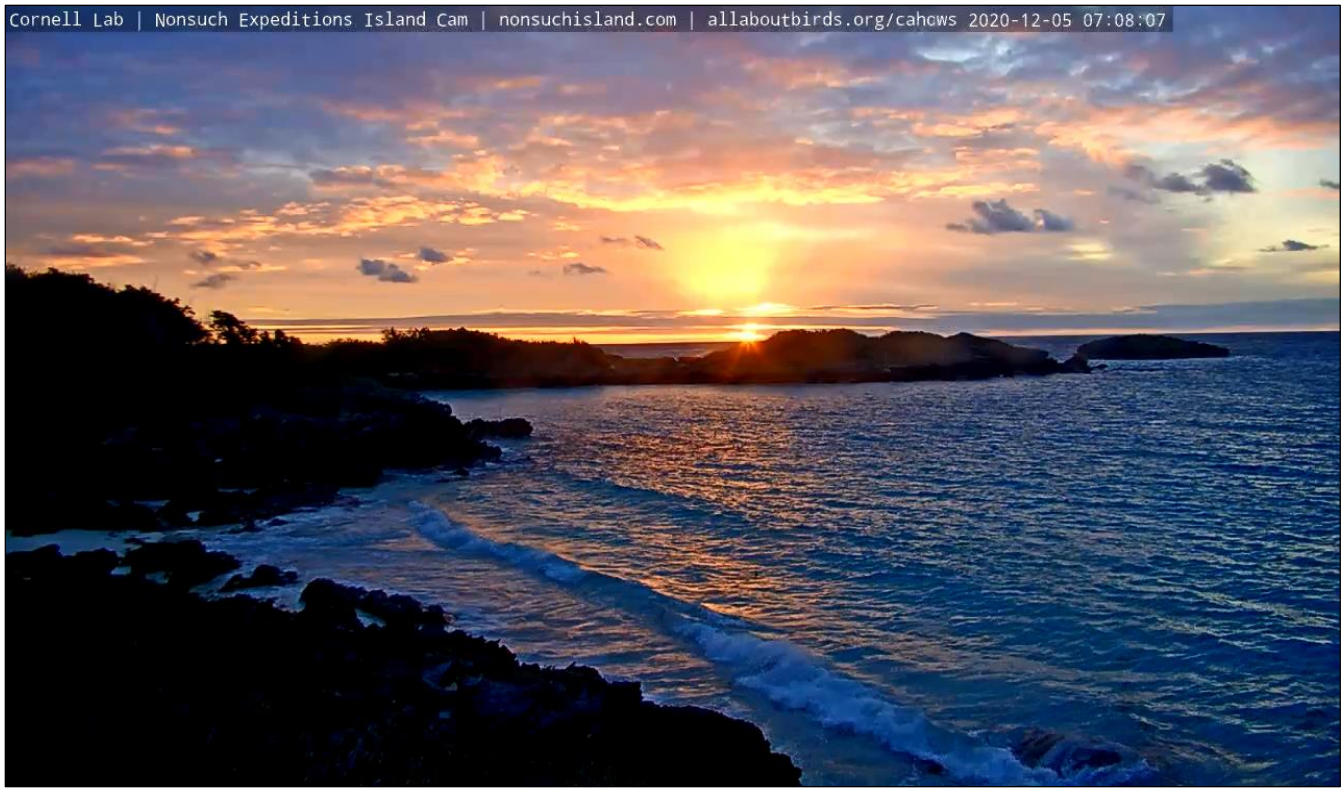

Fig. 1: Sunrise from Surface Live-Cam at (A) Cahow nesting colony on Nonsuch Island

Cover Photo: Pair of adult Cahows from Nonsuch Island R831 nest held by Recovery Project Manager J. Madeiros

CONTENTS:

Page No.

List of Figures Page no.

- Cover photo: J.P. Rouja; Fig. 1: Jeremy Madeiros; Figs 2,7 & 8: Mandy Shailer; Fig. 3: Leila Madeiros; Figs. 4, 5, 9 & 10: JP Rouja; Fig. 6: Letizia Campioni; Fig. 7: Monica Silva.

SECTION 1:
1(a): EXECUTIVE SUMMARY:

Key Words: Burrow-cam, Cahow, New Colony, Nonsuch Island, Translocation.

2021 marks a special highlight for the Cahow Recovery Project, as it is the 70th Anniversary of the Rediscovery of Bermuda's National Bird, the Cahow, or Bermuda petrel (*Pterodroma cahow*). The Cahow is endemic or unique to Bermuda, nesting no-where else on Earth, and is listed as endangered, being one of the rarest seabirds on Earth.

The Cahow Recovery Program is a long-term management, research and recovery program with **a primary objective** being the recovery of the Cahow's breeding population through: (a) the control of threats to the species, (b) the construction of artificial nesting burrows, and (c) the establishment of entirely new nesting colonies. **A secondary objective** is to promote public education and understanding of the importance of the Cahow to the cultural history and unique natural environment of Bermuda.

The Recovery Program is managed by the Principle Scientist – Terrestrial Conservation Division, through the Department of Environment and Natural Resources (DENR). As a critically endangered species, the Cahow and its nesting habitat are completely protected under the Protection of Species Act 2003 and **public access to all nesting islands is restricted by law,** except in the company of a member of the Recovery Team.

The Cahow is endemic to the Islands of Bermuda, and was originally abundant, possibly numbering as many as half a million breeding pairs. **It was catastrophically affected by the colonization of the island by English settlers in the early 1600s,** due to direct hunting by the settlers for food and by their introduction of mammal predators such as Rats, Cats, Dogs and Pigs. After less than 12 years of settlement, the Cahow by the 1620s was thought to be extinct, a belief that persisted for 330 years until the rediscovery in 1951 of a tiny remnant population on four small half-acre offshore islets (**Murphy & Mowbray, 1951**).

The Recovery Program has been in place since 1960 and was originally administered by Dr. David Wingate between 1960 and 2000. It has been successful in addressing most of the threats affecting the Cahow on the breeding islands on Bermuda, enabling the population to increase from only 18 pairs producing a total of 7 to 8 chicks annually in the early 1960s to a record number of 143 breeding pairs in 2021, producing a total of 71 fledged chicks (see Fig. 3).

The Cahow continues to face a number of threats, which include:

1) erosion and flooding of the original nesting islets from hurricane activity and sea-level rise;
2) predation by invasive Rats swimming from mainland Bermuda to the islets;
3) insufficient safe nesting habitat and suitable deep nest burrows or rock crevices;
4) nest-site competition with the Longtail or White-tailed Tropicbird *Phaethon lepturus catsbyii*;
5) human disturbance through illegal landings on the nesting islets, and interference with and vandalism of the nest burrows;

6) light pollution from the main islands of Bermuda, in particular from the area of the Bermuda International Airport, which can disrupt courtship activity of the nocturnal Cahow and the nighttime fledging of the chicks.

Following are some highlights of the 2020-2021 Cahow nesting season:

- **Two new nesting colonies of Cahows established on Nonsuch Island** by the translocation of chicks from the original small islets are continuing to grow, with 21 breeding pairs now at the "A" colony, and 7 new breeding pairs at the "B" colony site (see Fig. 7).

- **The third field season of a 3-year collaborative research project with international partners was partly carried out, although the deployment of tracking tags was delayed due to the Covid-19 pandemic.** Between Jan 22nd and Feb 13th , 2020, 24 GPS tags were attached to breeding adult Cahows during the egg incubation period, to investigate the oceanic movements and foraging areas of the adult birds during these periods. In addition, more feather samples were taken from 37 adult Cahows, to investigate toxicology, stable isotope analysis and sexing.

- **The infrared "Cahow-cam"** developed by project partner J.P. Rouja with financial assistance from the Ascendant Group of Companies has been a resounding public outreach success, and was further improved through **a new partnership with the Cornell Bird Lab.** This included the installation of new cameras which give improved views of the nesting birds, enabling school groups and the public to follow the nesting activity of Cahows in underground burrows on Nonsuch Island. **In 2021, a chick hatched and fledged successfully at burrow-cams No. 2**, providing detailed viewing of Cahow breeding activity, including courtship and chick-rearing activities. **In addition, a new "surface cam" was installed** which gives an external view of part of the nesting colony and the south coastline of Nonsuch Island. This website can be accessed at **www.nonsuchisland.com**

Full details on the 2020 to 2021 breeding season are given in the following report, in addition to research and management proposals for the next two seasons.

SECTION 2 (a):
Impacts of Hurricanes “Paulette”, “Teddy” and “Epsilon” on the Cahow Nesting Islands – September/October 2020

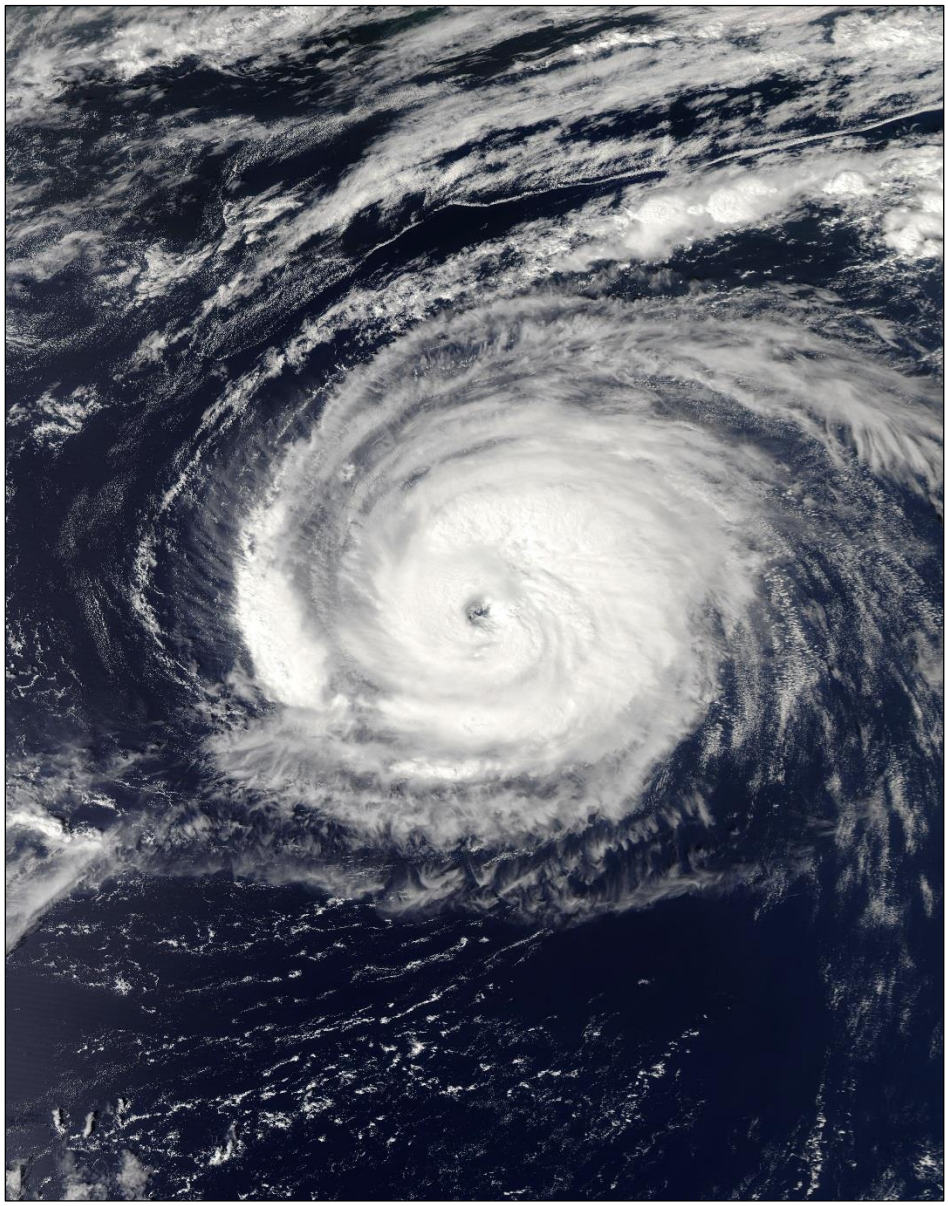

Fig 2: Hurricane “Paulette” the day after direct hit on Bermuda, 14th Sept 2020

The 2020 Atlantic hurricane season proved to be the most active on record, with 31 Tropical or Subtropical cyclones developing. Although Bermuda was spared during the early part of the season, it was perhaps inevitable that eventually we would be affected, and by the middle of September a number of storms directly or indirectly caused impacts on the island, mainly in the form of serious erosion from large, damaging storm waves and surge along the southern and eastern coastlines of Bermuda. The first of these storms was Hurricane “Paulette,”

which started as a tropical wave off the African coast, slowly strengthening as it moved westwards over the Atlantic, and developing into a hurricane to the southeast of the island. It approached and moved directly over the island as it strengthened into a Category 2 hurricane on the 14th September, producing winds gusting from 85-105 mph over the island. The calm, 40-mile diameter eye of the hurricane then moved directly over the island, taking almost 3 hours to pass, followed by another period of hurricane-force winds at 80-100 mph, before the storm finally moved away to the north (Fig. 2).

Hurricanes approaching Bermuda from the southeast always produce the largest ground swell waves and storm surge events, compared to storms approaching from any other direction, and Paulette lived up to this, with 15' to 20'+ waves hammering the southern and eastern-facing coastlines of Bermuda, causing considerable damage and erosion to the South Shore of Bermuda, and the Castle Harbour Islands in particular.

Following closely behind the first hurricane, the much more powerful Hurricane "Teddy" also approached Bermuda from the southeast, attaining Category 4 strength with 150 mph (241 kph) sustained winds on the 17th September when some 930 miles southeast of Bermuda. This storm weakened as it neared Bermuda and veered at the last minute, passing 130 miles east of the island on the 21st September, sparing the island the worst of its winds but hammering the southern coastline for three days with waves reaching 21' to 28' in height.

Damage in most of the island's Nature Reserves following the two September hurricanes was fairly limited, consisting mainly of downed trees and branches and considerable tidal flooding and erosion in coastal nature reserves such as Spittal Pond and Coopers Island. Spittal Pond Nature Reserve was extensively flooded by hurricane waves surging in through the low points at each end of the pond, raising water levels by over five feet for a couple of days and flooding portions of the walking trails and the woodland fresh water pond with sea water.

The Castle Harbour Islands are Bermuda's most important Nature Reserve, containing many of Bermuda's most endangered and unique species and habitats. This Reserve suffered substantial impacts, being much more exposed near the edge of the reef line and facing towards the southeast, the direction that all of this year's hurricanes approached from.

Preliminary assessments were carried out on the 16th and 23rd September, after each hurricane had passed. Most of the Castle Harbour Islands showed considerable erosion, showing numerous white scars where sections of weathered gray limestone were wrenched off. Cliff damage and erosion was particularly noticeable on Castle Island, Southampton Island, the east and south coastlines of Nonsuch Island, Coopers Island Point and Inner Pear Rock. A 30-foot section of the rampart wall fortifications on Castle Island, dating from the mid-1600s, was undermined and collapsed from the heavy surf coming through the Castle Roads channel.

The buildings on Nonsuch Island had been fully secured and boarded up by both conservation officers before the hurricane and suffered little damage. The stairway from the dock was blocked by two large, uprooted Bay Grape trees, otherwise there was almost no damage to the restored native vegetation on the island. The coastal areas on Nonsuch suffered the worst impacts, with the smaller beaches on the island being washed away and considerable erosion damage caused to

the island's coastal cliffs. About 12 of Nonsuch's nearly 200 Tropicbird (Longtail) nests were damaged or destroyed, but the two Cahow nesting colonies established over the last 10 years on Nonsuch Island were untouched, as they were specifically placed high enough to be above the erosion zone of severe hurricanes. However, the same could not be said for the four original smaller Castle Harbour islands on which most of the population of Bermuda's Endangered National Bird still nests.

A full assessment was made after the seas calmed down from the passage of hurricane "Teddy" on the 21st September, which produced even larger, more damaging ground swell than Paulette. Damage on the smaller nesting islands was severe, and the worst since hurricane "Igor" in 2010. Green Island and Long Rock were completely submerged under the 20-28 foot waves of Paulette and Teddy, and checks made on both revealed that two-thirds of the concrete nest burrows used by Bermuda's endangered Cahow were made unusable by the waves sweeping across these islands, rolling boulders weighing hundreds of pounds over nest burrows on Long Rock and washing the heavy concrete nest lids, through which the birds are observed and removed for banding and measurement, off the islands.

Fig. 3: R. Vincent and H. Wakeley after diving up some of the concrete nest lids Washed overboard by hurricanes "Paulette" and "Teddy"

Two volunteer scuba divers from the Grotto Bay Beach Hotel, Robyn Vincent and Holly Wakeley, came out on 29th September to dive up the heavy concrete nest lids, that had been swept off Green Island and Long Rock (Fig. 3). They were successful in retrieving almost all of the concrete lids, which can weigh up to 30lbs, greatly shortening the repair time to make the nest burrows ready for the return of the Cahows for their nesting season in late October. Some nests needed repairs with fresh concrete to repair sections that were broken away, and almost all burrows needed rocks and debris washed into the nests to be cleared out. Most work was finished in time by mid-October, until word was received of yet another Hurricane headed for Bermuda.

Despite hopes that Bermuda would suffer no more hurricane impacts, the high tropical activity of 2020 continued, and on the 21st October, hurricane "Epsilon" formed to the southeast of the island, rapidly strengthening to Category 3 strength and passing about 165 miles to the east of Bermuda during the 23rd October. Although this storm passed far enough away that the island experienced only Tropical Storm-force winds, the south and eastern coastlines were again pounded by 18' to 20' storm waves for two days as Epsilon moved by, affecting the same areas that suffered erosion during the September hurricanes.

Once again, Long Rock and Green Island were inundated by large storm swells and surge. Many of the concrete nest lids just recently recovered were swept off again (these were subsequently recovered by Conservation Officer Peter Drew), and nest burrows filled with rocks again, rendering them unusable. Many of the Islands in the Castle Islands Nature Reserve suffered significant additional erosion. Inner Pear Rock (Outer), which is one of the original four nesting islets and the location of the Cahow's rediscovery in 1951, suffered particularly heavy erosion and almost all of the huge collapsed boulders that enabled access from the western half of the island to the eastern half, (where a number of Cahow burrows are located in an isolated burrow complex), had been swept away. An extension ladder will now be required to safely access this area. Luckily, despite the erosion, only one inactive Cahow burrow was damaged, but continuing erosion to most of the original nesting islets is making them increasingly hazardous as nesting sites for this species. This is in contrast to the newly established, growing Nonsuch nesting colonies, which were unaffected by all three hurricanes.

Fig. 4: Coastal erosion damage on Nonsuch Island following the 2020 Hurricane events.

Section 2 (b): Management actions for the 2020-2021 nesting season:

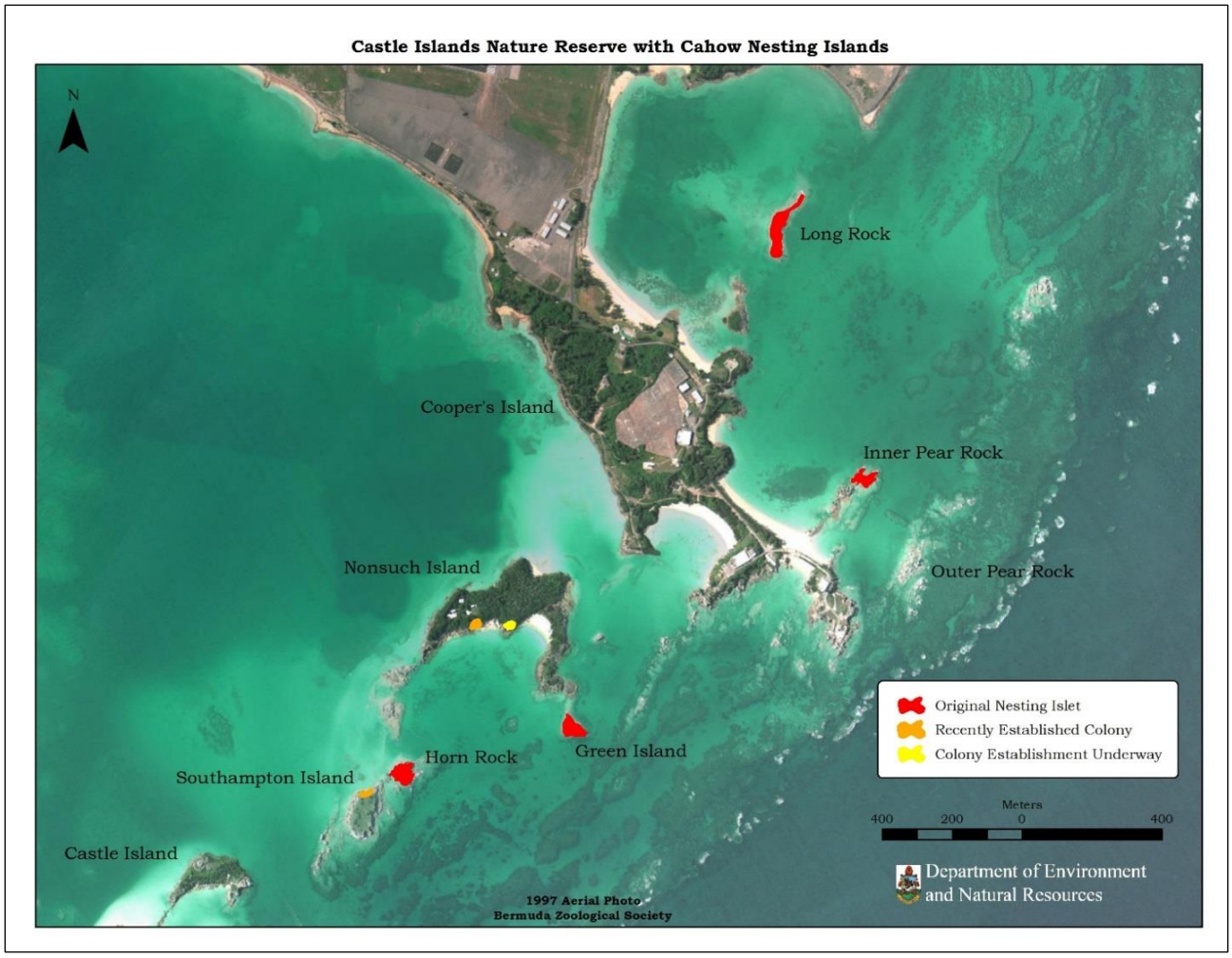

Fig. 5: Castle Harbour Islands Nature Reserve with Cahow nesting islands and new colony sites

Following is a review of the events and management / research work carried out for the 2020-2021 Cahow breeding season:

(1) As described in section 2(a), considerable repair work was necessary following the impacts of three separate Hurricanes, which affected Bermuda with damaging winds and extremely high waves and storm surges during September and October 2020. This work included retrieving nest lids (Fig. 3) washed overboard from some of the smaller nesting islands, as well as removing rocks and debris washed into the burrows and making new wood entrance baffles to replace those swept away by the surf.

(2) The first Cahows were recorded returning from the open ocean to their nesting burrows by the 24th October 2020, with all back by the second week of November. During late October and November 2020, a total of 112 adult Cahows were removed briefly from nests to check band numbers, body condition and weight.

(3) The first Cahows returned to the nesting islands from a one-month pre-egg laying exodus by early January 2021, with the first eggs confirmed on the 5th January. During the egg incubation period, which lasts about 53 days, an additional 55 of the incubating adults were checked to determine sex, weight and band numbers. Candling of eggs was carried out by Carla Marquardt to identify fertile eggs and follow embryo development.

(4) Some of the smaller Cahow nesting islets were severely impacted by an intense winter storm on the 28th – 29th January, 2021, which produced winds gusting to 65-85 knots (75-97 mph) and waves to almost 20'. Some nest burrows on low-lying Green Island and Long Rock were flooded out by waves during this storm, which caused confirmed breeding failure in at least 4 nests (see Fig. 6).

Fig. 6: Green Island during a severe winter storm on 28/Jan/21, which flooded burrows, causing failure in 4 nests

(5) Due to the continuing Covid-19 pandemic and ensuing travel restrictions, researchers Letizia Campioni, from Italy, and Monica Silva (U.K. Birdlife International) were again unable to travel to Bermuda for the 3rd year of the 3-year collaborative research program for the Cahow. Despite this, they were able to mail 24 GLS geolocator tags to me to investigate at-sea movements of the birds through an entire year in their life, encompassing both the breeding and non-breeding periods, to investigate dispersal patterns and foraging ranges during the non-breeding period in particular. These tags were successfully fitted on the birds between 7th Feb and 24th April 2021.

(6) The first Cahow chick hatched by the 22nd February 2021, with the last confirmed by the end of March. Once all chicks had hatched, 53 chicks in accessible nests were checked about once a week, weather conditions permitting, for weight, wing chord length, and

plumage development. This information is essential in identifying when chicks chosen for translocation, are at optimal development to be moved to new nest sites. It can also be used to estimate the fledge dates of chicks and whether chicks are being fed normally.

(7) All accessible chicks were fitted with identification bands on their left legs once their adult plumage covered more than half their body, usually at 70 days of age or older (adult birds whose ages are not known have their bands fitted to their right legs). During the 2020-2021 Cahow nesting season, a total of 49 chicks were fitted with identification bands, out of a total of 71 chicks which successfully fledged (69.0 % of all chicks).

(8) The total number of **confirmed breeding pairs of Cahows increased to a record high of 143 pairs during the 2020/2021 nesting season, compared to 135 pairs in 2019/2020.** A total of 71 chicks successfully fledged from all nesting islands, compared to 69 chicks fledged during 2020 (**See Fig. 3**).

(9) At the new nesting colonies on Nonsuch Island, established by the translocation of near-fledged chicks between 2004 and 2017, the numbers of breeding pairs have continued to grow. For the 2020-2021 breeding season, 21 nesting pairs laid eggs at the original "A" colony, with 7 more pairs at the second, "B" colony; from these, a total of 13 chicks hatched (**See Tables 1 & 2**), all of which fledged successfully to sea, while 7 new pairs of prospecting Cahows are establishing in burrows at both colonies **(See section 3(a)** for full details).

The 2020/2021 nesting season also reached another important milestone concerning the new Cahow nesting colonies on Nonsuch Island:

As of this year, the breeding colonies on Nonsuch Island have produced a total of 102 successfully fledged chicks. The final stage in the establishment of a new, self-sustaining seabird colony is for fledged chicks produced by the colony to return when mature, establish nest sites and choose mates to make new breeding pairs at the new site. The new colony can then be considered to be self-sustaining at this point.

In the 2016/2017 season, the first 3 confirmed returning chicks were recaptured, including two male birds choosing empty burrows (R838 and R839) at the original translocation site on Nonsuch, and 1 female Cahow pairing up with a male bird on Green Island (#12 nest).

By the 2020/2021 season, the number of confirmed returning Cahows that had originally hatched and fledged from Nonsuch increased to 16, including 12 recorded in new nests on Nonsuch, and 4 in nests on other islands (Green Island # 12, Horn Rock F6, and Long Rock D9 and D10 nests). Of these, three pairs on Nonsuch (in the R822, R838 and R839 nests) have so far produced successfully fledging chicks, **fulfilling the final criteria needed for the establishment of a new, self-sustaining nesting colony.**

SECTION 2 (c):
Overall summary of 2020 / 2021 Cahow nesting season:

During the 2020-2021 Cahow nesting season, the Cahow population increased to a record high number of 143 breeding pairs, of which 71 produced successfully fledging chicks. This represents a breeding success rate of 49.25 %, compared to 55.7% recorded in the 2018-2019 season. In addition, new prospecting or pre-breeding activity was recorded at 12 additional new nest sites, including 7 new nest sites on Nonsuch Island.

Following is a summary of the 2020-2021 nesting season results:

Total number of nest burrows with confirmed nesting activity: 143*

Number of new nest sites with prospecting activity: 12*

Total number of confirmed successfully fledged chicks: 71

Total number of active nest sites with unsuccessful nesting: 72

Number of failures from nest sites with observable nest chambers: 57

Number of failures from nest sites with non-observable nest chambers: 15

* Indicates record high numbers

Breakdown for causes of breeding failure from observable nest burrows:

Chick died in 1st month of development: 2
Chick died later in development: 0
Chick died hatching: 2
Embryo died in egg at 0-30 days development: 8
Embryo died in egg at 30+ days development: 6
Eggs broken or pipped: 14
Non-hatching / infertile eggs: 8
Egg buried or knocked off nest: 4
Egg disappeared (Land Hermit Crab predation?): 2
Tropicbird nest competition/disruption: 2
Failure from unknown causes: 5
Egg washed out or nest flooded by waves from winter storm: 4

SECTION 2 (d):
Breakdown of Breeding Season Results by Nesting Island:

Following is a breakdown of breeding results on all Cahow nesting islands for the 2020/2021 nesting season. Out of all nesting islets, Inner Pear Rock had the highest breeding success rate at 57.1%. Green Island and Nonsuch Island, which normally enjoys high breeding success, had relatively poor breeding success in 2021 at only 46.2% and 46.4% respectively. Long Rock, Horn Rock and Southampton Island had average breeding success rates of 53.3%, 50% and 50% respectively.

LONG ROCK: (53.3 % breeding success)

Active nest burrows with nesting confirmed (eggs laid and/or chick hatched): ……..... 15
New nest burrow prospected by confirmed pair: ……..... 1
Nest burrows w/successfully fledged chicks (B; D1; D2; D4; D5; D8; D9; E1): 8
Nest burrows with confirmed failed nesting: 7
(A – cause unknown; C – cause unknown; D3 - egg pipped/cracked; D7 – egg disappeared, Land Hermit Crab predation? D10 – egg cracked; E4 – egg infertile; # 12 – nest flooded by storm waves

INNER PEAR ROCK: (57.1 % breeding success)

Active nest burrows with nesting confirmed: ……..... 21
New nest burrows prospected by confirmed pairs: ……..... 0
Nest burrows with successfully fledged chicks: ……..... 12
(B1; B2; B5, B7, B8; C2; C3; C6; D2; D3; D4, E1)
Nest burrows with confirmed failed nesting: ……..... 9
(A1- Tropicbird nest invasion; B3-unknown causes; B4-egg broken; B6-egg cracked/broken; B9-embryo died in egg in late development (30+ days); B10 – unknown causes; C1-unknown causes; C4-egg broken; D1-egg knocked off nest.

GREEN ISLAND: (46.2 % breeding success)

Active nest burrows with nesting confirmed: 26
New nest burrow prospected by confirmed pair: 1
Nest burrows with successfully fledged chicks: 12
(A1; D1; F1; F2; # 4; # 5; # 6; # 8; # 12; # 13; # 14; # 16)
Nest burrows with confirmed failed nesting: 14
(A2 – nest flooded by storm waves; E1 – nest flooded by storm waves; F3 – cause unknown; # 2 – egg broken; # 3 – embryo died in egg at 30+ days development; # 3/4 – egg buried in nest; # 4/5 - egg infertile; # 5-6 – egg broken;# 7 – storm flooding; # 9-possible storm flooding; # 10 – egg infertile; # 11 – egg knocked off nest; # 15-egg buried in nest; # 17 – chick died hatching; .)

HORN ROCK: (50 % breeding success)

Active nest burrows with nesting confirmed: ……..... 47
New nest burrows prospected by confirmed pairs: ……..... 1
Nest burrows with confirmed successfully fledged chicks: 23
(B6; B7; C4; C5; C7; C8; C10; C16; C17; C18; C20; C21; C22; C23; C26; C30; D1; E2; F3; F6; F7; F8; G3)
Nest burrows with confirmed failed nesting: ……..... 23
(B3-egg infertile; B8–unknown causes; C6–embryo died in late development; C9–chick died at 3 weeks of age; C11-egg cracked/broken; C12–disruption due to loss of female; C13 – egg cracked/broken; C14–egg cracked/broken; C15–chick died shortly after hatching; C19– egg knocked off nest/disappeared; C24-egg infertile; C25-egg infertile; C27 – Tropicbird disruption; C28–egg cracked/broken; C29 - embryo died 0-30 days in egg; C31 – egg knocked off nest; D3–unknown causes; D4-unknown causes; E1 – unknown causes; F1- cause unknown, egg disappeared; F2 – egg infertile; F4–egg infertile; F5-embryo died in late development)

NONSUCH ISLAND: (46.4 % breeding success)

Active nest burrows with nesting confirmed: 28
New nest burrows prospected by confirmed pairs: 6
Nest burrows with confirmed successfully fledged chicks: 13
(R816; R817; R818; R820; R821; R830; R832; R834; R835; R836; R839; B1; B8)
Nest burrows with confirmed failed nesting: 15
(R819–embryo died at 0-30 days in egg; R822- egg cracked/broken; R823-embryo died at 0-30 days in egg; R824 – embryo died at 0-30 days in egg; R825 – egg cracked/broken; R831 – embryo died 30+ days in egg; R833-embryo died 0-30 days in egg; R837-small, undersized egg, embryo died at 0-30 days; R838-egg buried in sandy cave-in in nest; R840-embryo died at 0-30 days in egg; R841- egg cracked/broken; B2-egg infertile; B5 – embryo died at 0-30 days in egg; B9 – embryo died at 30+ days in egg; B12- egg cracked/broken; B14 – unknown causes)

***** See Section 3(a), page 18 for a complete summary of breeding results at the 2 breeding colonies on Nonsuch Island.

SOUTHAMPTON ISLAND: (50 % breeding success)

Active nest burrows with nesting confirmed: 6
New nest burrows prospected: 1
Nest burrows with successfully fledged chicks: 3
(S2; S6; S7)
Nest burrows with failed nesting: 3
(S1-cause unknown; S3-cause unknown, S4-egg buried by sand collapse)

* Overall breeding success for entire breeding population: ..... 49.6 %

SECTION 3 (a): Update on New Nonsuch Translocation Colonies:

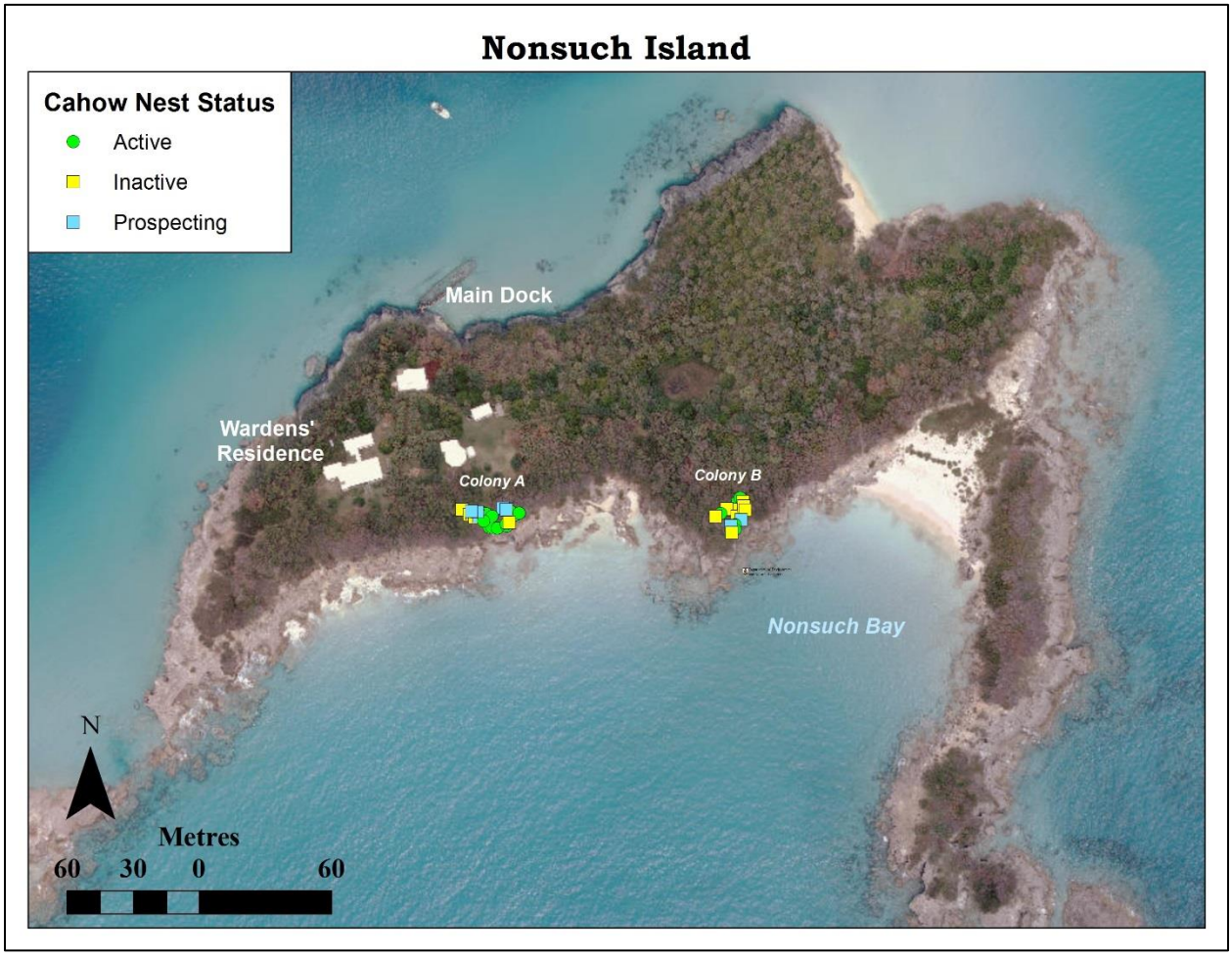

Fig. 7: Location of new Cahow nesting colonies on Nonsuch Island in 2021

A primary objective of the Cahow Recovery project has been the establishment of new nesting colonies on larger, more elevated islands with suitable habitat, that are less at risk from hurricane flooding and erosion, and safer from ongoing sea-level rise, than the original tiny nesting islets. It has involved moving (translocating) Cahow chicks approximately 18-21days before fledging, from nests on the original nesting islets, to artificial burrows constructed on the much larger and higher elevation Nonsuch Island.

Gadfly petrels such as the Cahow **usually return when mature to the same area that they originally departed from as fledglings, a trait known as *site faithfulness***. Taking advantage of this tendency, a total of 105 Cahow chicks selected from all 4 of the original nesting islets were moved to artificial nest burrows on Nonsuch Island over a five-year period between 2004 and 2008. On Nonsuch, they were hand-fed daily for 2 to 3 weeks on imported squid and locally sourced Anchovies, until they were fully developed. The chicks were then fitted with bands, and monitored through their exercise period, during which they emerge at night to exercise and imprint on their surroundings.

At the end of this period, they fledged to sea on their own, hopefully to return when mature to the translocation site. **A total of 102 translocated Cahow chicks fledged successfully from Nonsuch between 2004 - 2008** (**Carlile et al. 2012**). **By 2008**, the first four translocated Cahows were recaptured back at the translocation site on Nonsuch (**now called the "A" colony site**), and their identities confirmed from their band numbers. The first real evidence that the effort to establish a new Cahow breeding colony on Nonsuch was succeeding occurred in **2009,** with the first pairs of Cahows nesting in burrows. **In March, 2009, this resulted in the first chick known to have hatched on Nonsuch Island since the 1620s.**

Between 2010 and 2020, the number of established breeding pairs carrying out nesting activity at the new Nonsuch Island "A" nesting colony rose from 4 to 24, with the number of successfully fledged chicks produced annually by this colony increasing from 1 chick in 2010 to 13 chicks by 2018. The total number of returning adult Cahows on Nonsuch that had been translocated to the island as chicks rose to 28, one from the 2004 translocation cohort, eight from the 2005 cohort, eight from the 2006 cohort, six from the 2007 cohort and five from the 2008 cohort (**Madeiros 2010, 2012, 2013 & 2014**). In addition, another 21 translocated chicks eventually returned to the four original nesting islets (Long Rock, Inner Pear Rock, Green Island and Horn Rock). The total number of returning Cahow chicks from the first translocation was therefore 49, out of 102 that originally fledged from Nonsuch (representing a 48.0 % return rate).

For the most recent, 2020/2021 breeding season, the total number of breeding pairs on Nonsuch was 28, of which 13 produced successfully fledging chicks (46.4 % breeding success). This is down notably on preceding years, such as the 72.2% breeding success achieved in 2018. **The total number of Cahow chicks that have hatched and successfully fledged from the new Nonsuch nesting colonies since 2009 increased to a total of 102 by 2021** (**See Tables 1 & 2**).

TABLE 1: Breeding results at new translocation colonies on Nonsuch Island 2008/2009 to 2020/2021 breeding seasons

Breeding season	No. of Breeding pairs	No. of fledged chicks
2008-2009	3	1
2009-2010	5	1
2010-2011	7	4
2011-2012	12	7
2012-2013	13	5
2013-2014	13	9
2014-2015	14	9
2015-2016	15	10
2016-2017	15	8
2017-2018	18	13
2018-2019	21	12
2019-2020	24	10
2020-2021	28	13

Table 1: Total annual numbers of breeding pairs & fledged chicks at translocation colonies on Nonsuch Island.

Table 2: Table showing annual breeding success of active Cahow nest burrows at the Nonsuch "A" and "B" nesting colonies from 2009, when the first pair of translocated birds returned to breed successfully, to 2021, when the number of breeding pairs increased to 28.

NONSUCH ISLAND	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
"A" Colony No. of Nests	(Chick fledged = 1, failed = 0)												
R816			0	1	1	1	1	1	0	1	0	0	1
R817			1	1	0	1	0	0	1	1	0	0	1
R818	1	1	1	1	0	1	1	0	1	1	1	1	1
R819						1	1	1	0	1	1	0	0
R820					0	0	1	1	1	1	1	1	1
R821							1	1	1	1	1	1	1
R822											0	1	0
R823												0	0
R824													0
R825													0
R830				1	0	0	0	1	0	1	1	0	1
R831		0	0	0	0	1	1	1	1	1	0	1	0
R832		0	1	1	1	0	1	1	1	1	1	1	1
R833				0	0	1	0	1	0	1	0	0	0
R834		0	0	0	0	1	0	0	0	0	0	0	1
R835					1	1	1	1	1	0	1	0	1
R836				1	1	1	1	1	1	1	1	1	1
R837			1	1	1	0	0	0	0	1	1	1	0
R838								0	0	1	0	0	0
R839										0	1	0	1
R840												0	0
Nonsuch B Colony													
B1												0	1
B2											0	0	0
B5													0
B8											1	1	1
B9										0	1	1	0
B12										0	0	0	0
B14													0
Total no. of chicks/year	1	1	4	7	5	9	9	10	8	13	12	10	13

SECTION 3 (b):
Results and Update for 2nd Nonsuch Translocation Project (B Colony)

Fig. 8: Fledgling Cahow exercising at night at "B" translocation colony on Nonsuch Island

Following the success of the first translocation project, **a second translocation project** was carried out, **for the purpose of establishing a second (B) nesting colony site** at a different location on Nonsuch. This would ensure that the Cahow would have two separate footholds on this much larger island, which offers improved nesting habitat and safety from hurricane erosion and flooding. To accomplish this, a new complex of 10 artificial concrete nest burrows was constructed and 4 artificial plastic burrows installed in 2012 – 2014 about 250 meters to the east of the original colony site. A total of 70 fledgling Cahows were moved over a 5-year period from nest burrows on the original nesting islets to these new burrows, where they were fed and monitored daily until they fledged out to sea. This was done so they could imprint on the new site, returning when mature to choose their own nest burrows. The new burrow complex is located on top of a promontory formed by the south hill of Nonsuch, situated at 35' to 45' above sea level, beyond the reach of hurricane waves, storm surge and predicted future sea-level rise.

These new nest burrows were built with the assistance of **volunteer groups from the Ascendant Group of Companies**. Groups of volunteers from Ascendant came out to Nonsuch Island in 2012 and 2013 to assist in digging out mixing and pouring concrete to make new Cahow nest burrows at the "B" translocation site. Additional nest burrows have since been constructed at this site by the terrestrial conservation crew and conservation officer. Both the traditional concrete artificial burrows and a new design of plastic burrows installed at this site have been readily accepted by the translocated chicks.

Out of the 70 Cahow chicks translocated to the "B" site over the 5-year translocation period, a total of 64 chicks fledged successfully out to sea, representing a 91.43 % success rate. Six of the chicks did not fledge successfully, due to the following reasons:

1 chick died just before fledging after its nest burrow was colonized by a wild swarm of European Honeybees (*Apis meliofolia*) which stung the chick to death;
2 chicks died from eating food that had spoiled due to the freezer being opened repeatedly by a work crew installing a new solar panel array on the island;
3 chicks died from undetermined gastric problems, rejecting or regurgitating all food fed to them.

At their translocation burrows, the chicks were hand-fed either every other day, or daily if the chick was considered below optimum weight. Food provided to the chicks in 2013 and 2017 consisted primarily of oil-rich and highly nutritious Anchovy *Sardinella anchovia*. The availability of Anchovies during those years made it unnecessary to include imported unfrozen squid, simplifying feeding and saving money. However, in 2014, 2015 and 2016, Anchovies were generally unavailable locally, making it necessary to use Threadfin Herring or Pilchards, which have a lower nutritional value. During these years, imported squid and supplemental vitamins were included to ensure that translocated chicks were receiving the necessary nutrition.

All Anchovies, Herrings and Pilchards used in the 2013-2017 translocation were netted locally and **provided by Mr. Chris Flook, who had also provided fish for the original translocation project from 2004 to 2008.** His contribution and assistance is greatly appreciated and has been instrumental in the success of these two projects.

In 2017, the first of the translocated Cahow chicks from the 2nd translocation project had begun to return as adults; during the 2017/2018 breeding season, **2 new breeding pairs produced the first eggs recorded at this new colony site**. Although both eggs failed, this was a major milestone in the establishment of the 2nd Nonsuch colony. Another returned Cahow was recorded prospecting in a new nest at the (A) Nonsuch colony, and yet another was found in a nest burrow on Horn Rock. The first two chicks successfully fledged from the "B" site in 2019.

By the 2020/2021 breeding season, a total of 9 Cahows translocated to the "B" site as chicks were recorded returning as adults, 5 at the B site, 2 at nests at the "A" site, and 2 on Horn Rock. Of these, 3 were translocated in 2013, 3 in 2014, 2 in 2015, and 1 in 2017. Seven breeding pairs produced eggs at the "B" site, **two of which (in the B1 and B8 nest burrows) produced successfully fledging chicks at this new translocation nesting colony.**

SECTION 3 (c):
Collaborative International GPS / GLS Tagging and Toxicology Project:

Fig. 9: Local and Overseas Researchers & collaborators involved with Cahow Research And Public Outreach Projects (left to right; C. Eldermire, L. Campioni, J. Madeiros, M. Silva, J.P. Rouja)

In the 2018-2019 Cahow breeding season, a collaborative research project was initiated with a number of overseas researchers. This project, which was originally scheduled to extend over a 3-year period, had the following primary objectives:

- To investigate at-sea movements and routes taken by adult Bermuda petrels during the egg incubation and early chick-rearing periods. Specific objectives are to identify any regularly used foraging areas, and to determine whether BPs regularly forage in Canadian territorial waters along the edge of the Nova Scotia Continental Shelf.

- To collect blood and feather samples, as well as hatched eggshells and failed eggs when possible, to investigate a number of factors, including a) identifying the tropic niche of adult Cahows during the breeding season; b) to investigate whether birds are being exposed to Persistent Organic Pollutants integrated with diet, by analyzing blood samples to determine levels of DDT, DDE, PFOs, PCPs etc. c) to understand whether the relatively high percentage of infertile and failed eggs is related to the concentration of bioaccumulated contaminants / POPs.

- To confirm the sex of adult Cahows using sex chromosomes in blood samples; this will confirm whether the present free & easy method of sexing by external cloacal examination after egg-laying is an effective & accurate way of sexing Cahows.

Following is a breakdown of this project over the last 3 years:

YEAR 1: 2019
Jan/Feb 2019 – Letizia Campioni (MARE IPSA) and Maria Silva (CE3C-FCUL) deploy 22 X 3.1g GPS tags on tail feathers of adult birds to investigate incubation "off-shift" foraging trips by birds when their partners take over incubation duties.

March 26th to April 10th - L. Campioni and M. Silva deploy 11 GPS tags on adult birds to investigate oceanic range and foraging areas during early chick provisioning. Also collected 67 blood samples and 57 feather samples for analysis.
March 26th to April 10th – C. Gjerdrum and A. Raine deploy 6 X 10g GPS tags on adult Cahows on Nonsuch Island and Horn Rock only to investigate oceanic range and foraging areas during early chick provisioning, to see whether Cahows utilize Canadian Territorial Waters during this critical time. This team also set out motion-activated infrared trail cameras at the entrances of nest burrows where adult Cahows had been fitted with GPS tags. These cameras recorded feeding visits by adult birds as well as numerous visits by the endemic and critically endangered Bermuda Skink (*Eumeces longirostris*).

YEAR 2: 2020
L. Campioni and M. Diaz returned to Bermuda between Jan 22nd and Feb. 13th 2020 to continue research work started the previous year. They worked with the Terrestrial Conservation Officer fitting a total of 26 X 3.1g GPS tags to the tail feathers of adult Cahows incubating eggs on 4 of the nesting islands, as follows:
NONSUCH ISLAND ..... 6 Cahows fitted with GPS tags
HORN ROCK ..... 11 Cahows fitted with GPS tags
GREEN ISLAND ..... 5 Cahows fitted with GPS tags
LONG ROCK ..... 4 Cahows fitted with GPS tags

All of these GPG tags were eventually recovered from the birds after deployment periods ranging from 10 days to 25 days. 18 of the tags were recovered by L. Campioni and M. Diaz before they departed Bermuda on 13th Feb, with the remaining 8 tags recovered by myself by the 25th Feb. The data downloaded from these tags showed that the Cahows generally foraged closer to Bermuda during the egg incubation period than was the case in the 2019 breeding season.

- In addition to GPS tag deployment, a total of 38 additional blood and feather samples were collected from adult Cahows, 18 from male birds and 20 from female birds. Several eggshells from failed or hatched eggs were also collected. All samples were taken back to Portugal, where Monica Silva oversaw their analysis for the presence of Persistent Organic Pesticides, sex chromosomes, genealogy etc.

*The 2nd field trip to Bermuda planned by L. Campioni for late March/April was cancelled due to the worldwide outbreak of the Covid-19 pandemic.

YEAR 3: 2021

No overseas research collaborators were able to travel to and work on Bermuda during this nesting season, due to continuing lockdowns, travel restrictions and other disruptions in most countries caused by new outbreaks and variants of the continuing Covid-19 pandemic.

As it was again impractical for the overseas researchers to travel to Bermuda, a consignment of 22 Archival Geolocator (GLS) tags were mailed to Bermuda by L. Campioni. These GLS tags were fitted to the legs of breeding adult Cahows on Nonsuch Island (14 tags) and Horn Rock (8 tags) by the Principle Scientist – Terrestrial Conservation, between 07/Feb /2021 and 26/Mar/2021. It is planned to let these tags remain on the birds to gather locational data for a period of at least a year (to be recovered by January to March 2022), or for a small number of tags, to remain for up to 2 years, which is within the archival storage capacity of these tags

Nesting Island	Nest Number	Bird Band Number	Sex of Bird	GLS Tag No.	Date of Tag Deployment
Nonsuch Is.	B2	E0364	Female	BW 147	07/Feb/2021
Nonsuch Is.	B8	E0083	Female	BW 146	07/Feb/2021
Horn Rock	F1	E0330	Male	BW 154	09/Feb/2021
Horn Rock	F2	E0224	Male	BW 144	09/Feb/2021
Horn Rock	F7	E0385	Female	BW 149	09/Feb/2021
Horn Rock	C31	E0471	Male	BW 148	09/Feb/2021
Nonsuch Is.	R817	E0162	Male	BW 152	11/Feb/2021
Nonsuch Is.	R820	E0243	Male	BW 151	11/Feb/2021
Nonsuch Is.	R821	E0296	Male	BW 158	11/Feb/2021
Nonsuch Is.	R839	E0434	Male	BW 145	11 Feb/2021
Nonsuch Is.	B9	C0903	Male	BW 157	19/Feb/2021
Nonsuch Is.	R822	C1080	Male	BW 156	19/Feb/2021
Horn Rock	C18	E0351	Female	BW 160	25/Feb/2021
Horn Rock	C22	E0131	Female	BW 159	25/Feb/2021
Horn Rock	C30	E0265	Male	BW 150	25/Feb/2021
Nonsuch Is.	R834	E0161	Male	BW 171	25/Feb/2021
Nonsuch Is.	R840	C0917	Female	BW 999	25/Feb/2021
Nonsuch Is.	R831	E0197	Male	BW 170	28/Feb/2021
Nonsuch Is.	R820	E0487	Female	BW 351	28/Feb/2021
Nonsuch Is.	B2	C0910	Male	BW 184	09/Mar/2021
Nonsuch Is.	R837	E0196	Female	BU 348	14/Mar/2021
Horn Rock	C29	E0391	Male	BW 182	26/Mar/2021

TABLE 3: Summary of adult Cahows that were fitted with GLS Tags in early 2021 for periods of 1 to 2 years

In addition, the blood and feather samples that had been already collected from adult Cahows during the first 2 years of this project have now mostly been analyzed, with some of the results summarized as follows:

CAHOW BLOOD SAMPLE ANALYSIS
(Letizia Campioni – MARE IPSA and Maria Silva – CE3C-FCUL)

CONTAMINATION BY PERSISTANT ORGANIC PESTICIDES (POPs)

In addition to being tested for sex hormones and Stable Isotope Ratios, blood and feather samples collected from almost 90 adult, breeding Cahows were tested for the presence of a number of Persistent Organic Pesticides (POPs) and their many compounds.

The following were detected:

THE BAD NEWS:

ORGANOCHLORINATED PESTICIDES (OCPs); 25 different compounds were analyzed:
- DDE was confirmed in 100% of sampled Cahows (no. = 58).
- DDT was confirmed in the blood samples of less than 30% of sampled Cahows.

- DDE median value: ..... 1.60 ng/g/w.w.
- DDT median value: ..... 0.72 ng/g/w.w.

The presence of DDE and DDT in such a high percentage of sampled Cahows is a clear cause for concern, due to their well-documented effect on calcium uptake on various bird species, resulting in thin eggshells which are more easily broken during egg incubation. This also illustrates how long-lasting these compounds persist in the environment, despite being banned in North America since the 1970s. The only positive news in this regard is that the levels that were detected were considerably less than was the case in the late 1960s/early 1970s (Wingate & Wurster, 1968), which caused a severe decline in breeding success during that period.

In addition, the detection of Hexachlorobenzene in more than 50 % of sampled Cahows is of particular concern, for the following reasons:

HEXACHLOROBENZENE (HCB):
- Was detected in more than 50% of sampled Cahows.
- This compound is an organochloride, and was a fungicide formally used as a seed treatment, especially on wheat, to control the fungal disease “Bunt”.
- This compound was banned globally under the Stockholm Convention on PCPs since 2001.
- It is an animal carcinogen and is considered to be a probable human carcinogen.
- May cause embryo lethality and is teratogenic (causes birth defects via a toxic effect on an embryo or fetus).
- HCB is very toxic to marine organisms and is persistent in the environment. Ecological studies have found that biomagnification up the food chain does occur. The risk of bioaccumulation in aquatic species is high.

* The tendency of this compound to cause embryo death and that it can bioaccumulate in marine species is a cause of concern, and further studies will be carried out to determine whether this has a connection to the relatively high level of egg failure in Cahows.

THE GOOD NEWS:

Few traces of the following compounds were found in blood and feather samples of Cahows:

POLYCHLORINATED BIPHENYLS (PCBs)

(7 of these compounds were analyzed); these are the most abundant in terms of occurrence in the environment, especially the heavier compounds.
- Few traces of these contaminants were found in the sampled Cahows.

POLYBROMINATED DIPHENYL ETHERS (PBDEs)

(8 of these compounds were analyzed);
- We found few traces of these contaminants in the sampled Cahows.

Fig. 10: Letizia Campioni and Monica Silva taking blood sample from adult Cahow.

SECTION 3 (d):
Cahow Recovery Program – Public Outreach & Education:

One of the primary objectives of the Cahow recovery Program has been to increase public outreach and education about Bermuda's National Bird, and the broader conservation issues involved in its management. To help achieve this, a partnership was formed with Mr. J.P. Rouja of Look TV, who, funded by the Ascendant Group of Companies, developed an infrared "night vision" video camera. This was installed in a modified Cahow burrow, to provide video footage of the breeding activities of adult Cahows and the development of their single chicks. This footage was available on-line mainly to local viewers.

This system was used successfully from 2013 – 2016, but the view from directly overhead was not ideal, and there was a need to use a higher-quality camera with better distribution to international viewers. Accordingly, a new partnership was formed with the **Cornell Lab of Ornithology Bird Cams project**, with project manager Charles Eldermire visiting Bermuda in 2016 to help set up the new camera and work out the details of the live-streaming system.

Fig. 11: Adult Cahow incubating egg in nest burrow, viewed by infrared "CahowCam"

A new video camera, fitted with military-grade infrared lights that are completely undetectable by humans or animals, was installed for 2018, giving an improved vantage point to see the nesting Cahows (see Fig. 11). This camera then live-streams video to the internet through the Cornell network, where it is seen by viewers in over 100 countries. This new partnership between the Bermuda Department of Environment and Natural Resources, the Cornell lab of Ornithology and Nonsuch Expeditions has contributed greatly to the objective of increasing

public outreach and education over the last 3 years, resulting in 600,000 views for a total of 8.5 million minutes of video being viewed by scientists, students and followers from around the world, through the website www.nonsuchexpeditions.

In 2019, a second infrared video camera was set up in a 2nd nesting burrow on Nonsuch Island, and connected to the "CahowCam" network. This was done to provide an alternative in case one of the burrows suffered nesting failure, and study any differences between nesting pairs in adult courtship, egg incubation and chick rearing behavior. In addition, a pole-mounted "surface cam" was set up which overlooks the southern coastline of Nonsuch Island, as well as the western section of the "A" Cahow nesting colony. This gives views at night of Cahows flying in from the sea at night, landing and going in & out of several nest burrows, as well as views of Nonsuch Bay, present weather conditions and two of the offshore nesting islets.

These cameras in addition to allowing direct observations of in-nest behavior by the adults and the rearing of chicks, has also documented visits to the nests by some of the other species found on Nonsuch. These include the **Bermuda Skink** (*Eumeces longirostris*), a critically endangered ground lizard now only common on several of the Castle Harbour Islands, which has been filmed entering burrows both when Cahows were present, and during the summer non-nesting period. In addition, the native **Red Land Crab** (*Gecarcinus* lateralis) is also a regular visitor, although the birds will chase these from the nests as soon as they are detected. A **Leach's Storm-petrel** (*Oceanodroma leucorhoa*) prospected in the Nonsuch Island R831 nest burrow that the CahowCam was installed in, shortly after the Cahow chicks departed. This small seabird, although common offshore during the winter and spring months, had never been recorded on land before 2016 on Bermuda. Between 2018 and 2021, this bird again returned, this time to the adjacent R832 nest, at times sharing the nest nightly with the growing Cahow chick, which weighed up to 10 times as much as the Storm-petrel. Neither the adult Cahows nor the chick seemed unduly concerned with the presence of the Storm-petrel, with the chick in all cases fledging normally after nearly three weeks of this unusual co-habitation.

The infrared CahowCams have proven to be a valuable asset for the Recovery Program, revealing previously unknown behavior and enabling the public to follow the development and behavior of the chick and adult Cahows, revealing the private life of Bermuda's critically endangered National Bird to an international audience. It has promoted and used the concept of "citizen science", where members of the public provide 24-hour viewing coverage (which is impossible for the project researchers to maintain!), leading to a number of valuable observations which would otherwise have been missed. In addition, the new partnership with the Cornell Lab of Ornithology is proving to be successful in highlighting the management efforts of the Bermuda Dept. of Environment and natural resources to an international audience.

Other public outreach efforts relating to the Cahow Recovery Project have included guided tours and "Cahow encounters" at Nonsuch, in addition to PowerPoint presentations at schools and the Bermuda Zoological Society's Natural History Course. Warwick Academy and Saltus Cavendish School have included the Cahow in their curriculum, with the latter again giving a very generous donation to the Recovery Project. A total of 20 tour groups, mostly from local middle and secondary schools and the Bermuda College, and totaling 370 people, were allowed to see Cahows at close range on Nonsuch Island being assessed, measured and banded as part of the

research program (see Fig. 12). However, as of April 2020, all tours to Nonsuch Island were largely discontinued due to the developing world-wide Covid-19 pandemic, and lockdown measures put in place for some months by the Bermuda Government to contain and reduce the spread of the virus. These measures have been re-instated on two more occasions during 2021 as new strains of the coronavirus have emerged and continued to cause serious outbreaks, both on Bermuda and world-wide.

The ban of tours to Nonsuch Island has continued through the rest of the year, due to the risk of large groups crowded together onto boats to Nonsuch, and also due to uncertainly whether Covid-19 was transmissible between humans and critically endangered species such as the Cahow.

The Terrestrial Conservation Officer has received a special permit from the Government to continue travelling out to the nesting islands during the Covid-19 pandemic to carry out work. Out of an abundance of caution, he underwent frequent Covid testing and practiced basic anti-transmission guidelines (wearing surgical gloves, facial masks, and regularly washing hands, weighing bags and measurement equipment with an antiseptic wash).

Fig. 12: Cahow Chick health check with school tour group on Nonsuch island.

Section 4 (a): Future Management Actions and Research:

A number of the projects and proposals recommended in past yearly Nesting Season Reports have now either been successfully completed or are well underway; following are the most important recommendations for the continuation of projects and management work already underway, or that are newly proposed for the next two nesting seasons:

2021 – 2022 Breeding Season:

- Continue banding program for adult and fledgling Cahows;
- Continue monitoring of nesting islands for the presence of rats; set out rodenticides when necessary;
- Continue to monitor for the return of translocated birds as adults to the two translocation colony sites on Nonsuch Island as well as all other nesting islands;
- Continue installation of additional artificial nest burrows at nesting colonies, including at the new colony on Southampton Island;
- Continue to work with international partners to deploy extremely accurate GPS loggers on Cahows to more accurately determine oceanic range and important foraging areas for the species. Engage with international partners to carry out this project and analyze data and findings.
- Continue to engage with international partners to take & analyze blood and feather samples from adult breeding Cahows of varying ages to investigate bioaccumulation of man-made and natural chemicals and toxins, genetic and DNA variability and relationship of the Cahow to other North Atlantic Gadfly petrels, isotope analysis to look at prey items and tropic levels the birds are taking food from, etc.

2022 – 2023 Breeding Season:

- Switch from active translocation of chicks to monitoring of burrows for the return of birds at the two translocation colony sites;
- Continue monitoring, baiting and trapping program for continuing eradication of rats from Nonsuch and all nesting and adjacent islands in the Castle Harbour Reserve;
- Continue banding program for adult and fledgling Cahows;
- Continue the installation of additional artificial nest burrows for the Cahow on suitable nesting islands and locations;
- Working with international partners, to continue the deployment of extremely accurate GPS loggers on selected adult and fledgling Cahows, to determine major oceanic foraging areas and range.
- In partnership with international researchers, to continue to collect blood, feather and eggshell samples to analysis for Persistent Organic Pollutants and genetic factors etc.

Section 4 (b): Acknowledgements:

I would again like to acknowledge with thanks the following Departmental staff, volunteers, organizations, and members of the public for their assistance in the Cahow Recovery Project during the 20120– 2021 breeding season:

Mr. Peter Drew, Conservation Officer, and Bermuda Biodiversity Officer Alison Copeland (Dept. of Conservation Services) as well as Camilla Stringer of the Bermuda Zoological Society. Carla Marquardt and Lizzy Madeiros, for assistance in monitoring checks, egg candling etc.; Lynn Thorne, who provided electrolytes and equipment for rehabilitation of abandoned Cahow chicks, and Chris Flook, who once again provided fresh Anchovies for abandoned Cahow chicks. Also instrumental in furthering the project's objectives of public outreach & education are JP Rouja of Nonsuch expeditions, designer/installer of the infrared "Cahow burrow-cam," and Charles Eldermire, manager of the Cornell Bird Lab web cam project, to enable unobtrusive study of the behavior of the birds inside nest burrows and live-streaming video to schools and the general public.

The photos in this report were used with the kind permission of Kate Sutherland, J.P. Rouja, David Liittschwager, Letizia Campioni, Leila Madeiros, Monica Silva and Tim Smith.

As always, I am deeply thankful to the Terrestrial Conservation Crew for their hard work in building concrete nest burrows and assistance in managing nesting habitat for the Cahows on both Nonsuch Island and the original nesting islets. The Crew consists of Kiwon Furbert (Foreman), Llewellyn Rewan, Marvin Jones and new worker Marco Davis.

The research and management work carried out by the Cahow Recovery Program has been possible only because of donations by schools, businesses and members of the public. For example, the geolocational loggers which revolutionized understanding of the oceanic range of the Cahow were purchased entirely through public donations, notably by Saltus Cavendish School and Paget Primary School. Mr. Robert (Bob) Flood of Scilly Pelagics, who produced a series of multimedia seabird identification books in which the Cahow was prominently featured, and who also brings specialized birding groups to Bermuda specifically to see the Cahow, has also been an important supporter of the project. Special thanks also go out to the former Ascendant Group of Companies, who provided volunteers to construct new Cahow nest burrows and donated a new Boston Whaler boat and solar power system for the Cahow Recovery Project. We are deeply grateful for the interest and generosity shown by these and other essential donors.

Finally, I would like to thank Leila Madeiros and our children Seth and Elizabeth, whose support have made it possible for me to carry out this demanding project over the last 20 years.

Jeremy Madeiros,
Senior Terrestrial Conservation Officer
Dept. of Environment and Natural Resources

Section 4 (c): References:

Carlile, N., Priddel, D., & Madeiros, J. 2012. Establishment of a new, secure colony of Endangered Bermuda Petrel *Pterodroma cahow* by translocation of near-fledged nestlings. *Bird Conservation International,* available on Cambridge Journals Online Doi: 10.1017/S0959270911000372.

Flood, R., & Fisher, A. Multimedia Identification Guide to North Atlantic Seabirds; *Pterodroma* Petrels. 2013. Pelagic Birds & Birding Multimedia Identification Guides in association with www.scillypelagics.com ISBN 978-0-9568867-1-2. 4edge Ltd, Hockley, Essex

Madeiros, J. 2005. *Recovery Plan for the Bermuda Petrel (Cahow) Pterodroma cahow.* Department of Conservation Services, Bermuda.

Madeiros, J. 2010. Cahow Recovery Program. *Establishment of a New Breeding Colony of Bermuda Petrel Pterodroma cahow on Nonsuch Island, Bermuda, by the Translocation of Near-fledged Chicks and Social Attraction.* Department of Conservation Services, Bermuda.

Madeiros, J., Carlile, N., & Priddel, D. 2012. Breeding biology and population increase of the endangered Bermuda Petrel *Pterodroma cahow*. *Bird Conservation International* 22: pp. 34 – 45.

Madeiros, J., Flood, R., & Zufelt, K. 2014. *Conservation and At-sea Range of Bermuda Petrel (Pterodroma cahow).* *North American Birds,* pp. 546-557. Quarterly Journal of Ornithological Record Published by the American Birding Association. Volume 67: No. 4, 2014

Murphy, R. C., & Mowbray, L. S. 1951. *New Light on the Cahow (Pterodroma cahow)*. The Auk, Vol. 68, pp.

Wingate, D. & Wurster, C.F., DDT residues and declining reproduction in the Bermuda petrel, 1968. Science 159 (3818): 979 – 981.

Wingate, D. B. Excluding Competitors from Bermuda petrel Nesting Burrows. 1978. Endangered Birds: Management Techniques for Preserving Threatened Species. The University of Wisconsin Press.

Wingate, D. B. The restoration of Nonsuch Island as a living museum of Bermuda's pre-colonial terrestrial biome. 1985. In: Moors, P.J. (ed.), *Conservation of Island Birds*, pp. 225-238. ICBP Technical Publication No. 3. International Council for Bird Preservation, Cambridge.

Wingate, D.B., Hass, T., Brinkley, E. S., Patteson, J.B. Identification of Bermuda petrel. 1998. Birding 30 (1): 19-36. (BAMZ # 557)