CAHOW RECOVERY PROGRAM
For Bermuda's Endangered National Bird
2015 – 2016 Breeding Season Report

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"To conserve and restore Bermuda's natural heritage"

BERMUDA GOVERNMENT

RECOVERY PROGRAM FOR THE CAHOW (BERMUDA PETREL)

Pterodroma cahow

BREEDING SEASON REPORT

For the Nesting Season (October 2015 to June 2016) Of Bermuda's Endangered National Bird

Fig. 1: Cahow fledgling removed from nest burrow for measurement (Tim White)

Cover photo: 12-week old Cahow fledgling on Nonsuch Island (Tim White)

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- Cover photo & Fig.1 = Tim White; Fig. 4 = Leila Madeiros; Figs. 5 & 9 = Kate Sutherland; Fig. 6 & 7: = JP Rouja; Other photos: Jeremy Madeiros

SECTION 1:
1(a): EXECUTIVE SUMMARY:

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

The Cahow Recovery Program is a long-term management, research and recovery program for Bermuda's National Bird, the critically endangered Cahow, or Bermuda petrel (*Pterodroma cahow*). This program focuses on encouraging the increase of the breeding population through control of threats to the species, construction of artificial nesting burrows, and the establishment of entirely new nesting colonies.

The Cahow is endemic or unique to the Islands of Bermuda and was originally abundant, possibly numbering more than half a million birds. It was catastrophically affected by the colonization of the island by English settlers in the early 1600s. This was due both to direct hunting by the settlers and by invasive predators introduced by man, such as Rats, Cats, Dogs and Pigs. After less than 12 years of settlement, the Cahow by the 1620s had declined to the point where it was thought to be extinct, a belief that persisted for almost 350 years until the rediscovery in 1951 of a tiny remnant population on four small offshore islets (**Murphy & Mowbray, 1951**).

Since 1960, a conservation and recovery program has been in place that has addressed and controlled most threats to the Cahow. This program was administered by Dr. David Wingate until his retirement in 2000, since which it has been administered by the author of this report. This program has enabled the breeding population to begin a slow, but accelerating increase from only 18 pairs producing a combined 8 chicks annually in the 1960s to a new record number of 115 breeding pairs in 2016, producing a total of 56 successfully fledged chicks. Increased knowledge and public interest in the Cahow has been brought about from several films, documentaries and books that have highlighted the conservation and recovery work being carried out on the species.

The main threats to the Cahow include erosion and flooding of the original nesting islets from hurricane activity and continuing sea-level rise, predation by invasive Rats swimming to the islets, a lack of sufficient numbers of suitable nest burrows or rock crevices, and nest-site competition with the Longtail or White-tailed Tropicbird *Phaethon lepturus catsbyii.*

Following are some of the highlights for the 2016 Cahow nesting season:

- The new nesting colony of Cahows established on Nonsuch Island by the translocation of chicks between 2004 and 2008 has continued to grow, with 15 pairs established in nest burrows and laying eggs. From these, a record number (for Nonsuch) of ten chicks hatched and successfully fledged out to sea.

- **The total breeding population of the Cahow has increased to a record number of 115 nesting pairs** (pairs that produced an egg, whether it hatched or not), compared to 111 pairs in the 2014-2015 breeding season. This is despite the loss of 5 established breeding pairs in hurricane "Gonzalo" in late October, 2014.

- The number of successfully fledging chicks in 2016 increased to 56, compared to 53 during the 2015 nesting season. This represents continued recovery from the loss of established breeding pairs and damage to nest burrows during hurricane "Gonzalo" on October 17th, 2014.

- **The second translocation of Cahow chicks to Nonsuch continued at the 'B' translocation site,** approximately 200m east of the 'A' colony site. A total of 8 Cahow chicks were translocated from three of the original nesting islets to artificial nest burrows at the B site and hand-fed on fresh Anchovies and Squid. **All 8 of these chicks fledged successfully out to sea.** Coupled with 43 Cahow chicks already translocated to this site between 2013 and 2015, a total of 51 Cahow chicks have now fledged successfully from this site after being translocated to Nonsuch Island.

- **The infrared "burrow-cam"** developed by JP Rouja of LookTV with financial assistance from the Ascendant Group of Companies was installed in one of the Cahow nest burrows on Nonsuch Island and "live-streamed" video on a website for the entire nesting season. This enabled school groups and the public to follow the courtship and nest-building activities of a pair of Cahows, including the hatching of a Cahow chick on the 5th March, 2016. The burrow-cam then followed the development of the chick, including feeding visits by both parents, until it fledged out to sea around June 6th. This website at **www.nonsuchisland.com** included weekly checks of the chicks, as well as images of additional terrestrial and marine plant and animal species from Nonsuch and the surrounding marine habitats.

To summarize, the Cahow Recovery Program has continued to achieve both its primary objective of increasing the Cahow breeding population, and secondary objectives of establishing new nesting colonies and increasing public outreach and education. This is despite several threats to the breeding population during the 2015-2016 nesting season, including the invasion of several nesting islands by rats, a known predator on Cahow chicks. Regular monitoring of the entire breeding population has proved to be indispensable for rapid identification and management of threats as they arise.

Full details on the 2015 – 2016 breeding season are given in the following report, in addition to research and management proposals for the next two seasons.

SECTION 2:
2 (a): Introduction - Effects of Hurricanes "Joaquin" and "Nicole"

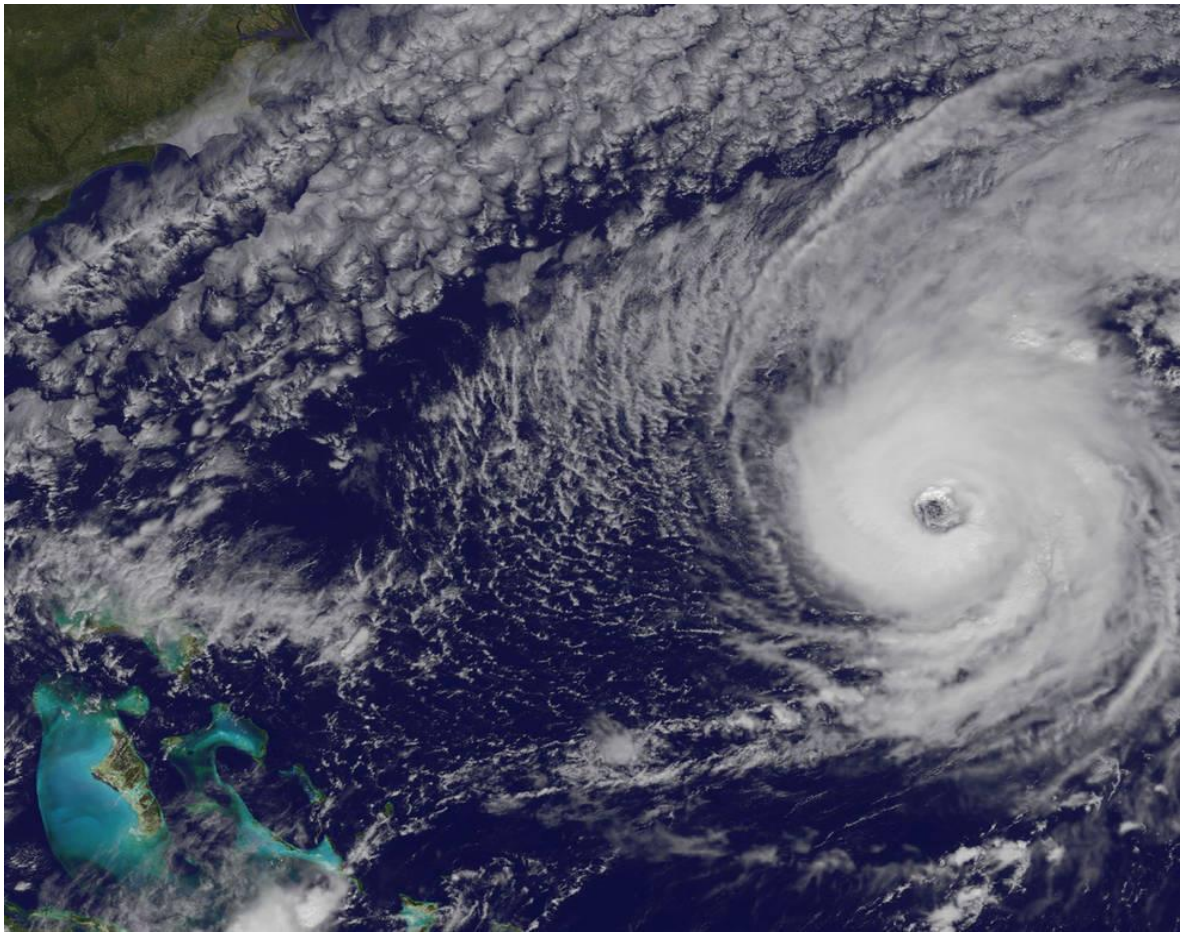

Fig. 2: Hurricane "Nicole" approaching Bermuda on 13th October, 2016

Two hurricanes directly affected Bermuda just before the start of the last two Cahow breeding seasons in October 2015 and again in October 2016. **Hurricane "Joaquin"** formed south of Bermuda and affected the central Bahamas as a Category 4 storm in October 2015, before moving northwards and passing just 85 miles to the west of Bermuda on October 3rd as a Category 2 hurricane, giving sustained 92mph winds gusting to 115mph on the island. With the hurricane passing to the west of the island, the Cahow nesting islets on the east side were sheltered from the worst of the storm and suffered little damage. In October 2016, **Hurricane "Nicole"** also formed well to the south of Bermuda, strengthened briefly to a Cat 4 storm, and then tracked north-northeast towards the island, with the calm eye of the hurricane passing directly over the island at midday on October 13th, 2016. Hurricane "Nicole" struck the island with Category 2 winds sustained at 103mph with gusts to 136mph, but passed over during extreme low tide, minimizing the storm surge. Although two of the Cahow nesting islands were partly submerged during this hurricane, the point of closest approach was at low tide and only relatively minor damage occurred to the nest burrows and breeding colonies.

These hurricanes once again illustrate that **damage and major erosion to the nesting islets from severe hurricanes and storms, coupled with accelerating sea-level rise, is the single most important threat to the Cahow.** After thirty-five years (early 1950s to late 1980s) with few to no major impacts from hurricane waves and storm surge, in the last 27 years there have been no fewer than thirteen significant hurricane events impacting the nesting islands. These have caused major erosion to these small, low-lying islets and damage to and destruction of Cahow nest burrows.

In the past three-year period 2014 - 2016, there have been four significant hurricane events affecting Bermuda, including three direct hits, with the eye, or center of the storms passing right over the island, which is only 21 miles in length.

The most severe damage to the original nesting islets during this active period have been caused by hurricanes "Felix" in 1995, "Gert" in 1999, "Fabian" in 2003 and "Igor" in 2010. These hurricanes, although causing severe damage to the islets and Cahow nesting burrows, were early enough in the season to avoid direct impact on Cahows returning to nest. However, all four hurricanes that have struck Bermuda in the last three years (2014/2016) have occurred in October, with hurricane "Gonzalo" (Oct, 17th 2014) being the first hurricane in the history of the Recovery Program to kill nesting Cahows that had already returned to their burrows **(see Cahow Recovery Program 2014-2015 Breeding Season Report**).

To address this threat, **a major component of the recent recovery program has been the establishment of new nesting colonies** on islands that are larger and of greater elevation than the original tiny nesting islets, which average only half an acre (0.2 Ha) in area each **(See Fig. 5).** This has already been accomplished on Nonsuch Island, which at 16.5 acres is the largest isolated island in the Castle Harbour area. **A new colony has been established on Nonsuch** with 15 active nesting pairs of returned Cahows which had been translocated as chicks from the original nesting islets to Nonsuch Island **(Carlile et al 2012).**

Building on the success of the first translocation project, **work is now underway in establishing a second colony site at another location on Nonsuch Island (see Section 3(b),** so that the Cahow has a second foothold on this much larger, more elevated island. During the last four years, a total of 56 near-fledged Cahow chicks have been translocated to this second colony site, of which 51 have fledged successfully out to sea.

Ironically, the only other offshore island in Bermuda that was determined to be suitable for the establishment of a new Cahow nesting colony was Southampton Island, which was re-colonized naturally by the 2012-2013 breeding season by the expanding Cahow population. In the 2015-2016 breeding season, four breeding pairs of Cahows on this island produced one successfully fledging chick. All other islands around Bermuda are too closely situated to the main populated islands to control invasion by rats or are subject to uncontrolled human disturbance.

2(b): Management actions for 2016 Cahow breeding season:

Fig. 3: 2/3 fledged chick translocated from Long Rock D3 nest to Nonsuch Island, May 2016

Following is a review of the events and management / research work carried out for the Cahow Recovery Program through the 2015-2016 breeding season:

(1) The breeding season began with preparatory work for the upcoming Cahow nesting season in early October, including the setting out of rat bait on all nesting islands, unblocking of nest burrows, removal of entrance Tropicbird baffles etc. In addition, replacement of several nest lids washed off nests by large waves from hurricane "Joaquin", and clearing out of debris washed into burrows by the storm had to be carried out on some of the nesting islets.

(2) The first Cahows were recorded returning from the open ocean to their nesting burrows on the 21st October 2015, with all back by the second week of November. During late October and November, 2015, a total of 100 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 in January 2016, with the first eggs confirmed on the 5th January. During the egg incubation period, which lasts about 53 days, an additional 57 of the incubating adults were checked to determine sex, weight and band numbers.

(4) Checks to the nesting islands could not be carried out at times, especially during the period between January and March 2016, by gale-force winds on a nearly weekly basis as winter storm systems passed over the Bermuda area. A regular occurrence at this time of the year, strong to gale-force winds occurred on over 30 days between January and March 2016.

(5) The first Cahow chick hatched by the 22nd February, 2016, with the last confirmed by the end of March. Some of these had to be confirmed in deeper natural nests by using an infra-red "burrow-scope." Once all chicks had hatched, a sub-sample of 40 chicks were chosen which were then checked at least twice weekly, weather conditions permitting, for weight, wing chord length, and plumage development. This information is essential in identifying when chicks chosen for translocation, are at the optimal stage of development to be moved to their new nest sites.

(6) 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 2015-2016 Cahow nesting season, a total of 39 chicks were fitted with identification bands, out of a total of 56 chicks which successfully fledged (70 % of all chicks). ***See section 3(e)** for complete information on the Cahow Banding Program.

(7) The total number of active nesting pairs of Cahows increased to a record high of 115 pairs during the 2015/2016 nesting season, compared to 111 nesting pairs in the 2014/201 season and 55 pairs in 2000/2001. A total of 56 chicks successfully fledged from all nesting islands, slightly less than the record number of 59 chicks that were fledged in the 2013 – 2014 nesting season (**See Fig. 5**).

(8) The new nesting colony on Nonsuch Island, which was established by the translocation of near-fledged chicks and sound attraction techniques between 2004 and 2009, has continued to grow. For the 2015-2016 breeding season, 15 nesting pairs laid eggs at the Nonsuch colony; from these, a record number of ten chicks hatched, all of which fledged successfully out to sea, while a new pair of prospecting adult Cahows has established themselves in one additional nest **(See section 3(a)** for full details).

(9) During May and June, a total of eight Cahow chicks were translocated from three of the original nesting islets to a second site on Nonsuch Island (**See Fig. 6**). All eight of these chicks eventually fledged successfully from this new site, termed the 'B' site. This makes a total of 51 translocated chicks that have fledged to sea successfully over the last four breeding seasons from the 'B' translocation site, out

of 56 chicks that have been translocated (91.1% fledging success rate). This new translocation effort started five years after the first translocation project, which has been successful in establishing a new breeding colony on Nonsuch. It is planned to eventually move 80-90 chicks to this new location over a 6-year period **(See section 3(b).** The last Cahow chick to depart from Nonsuch fledged on 19th June, 2016.

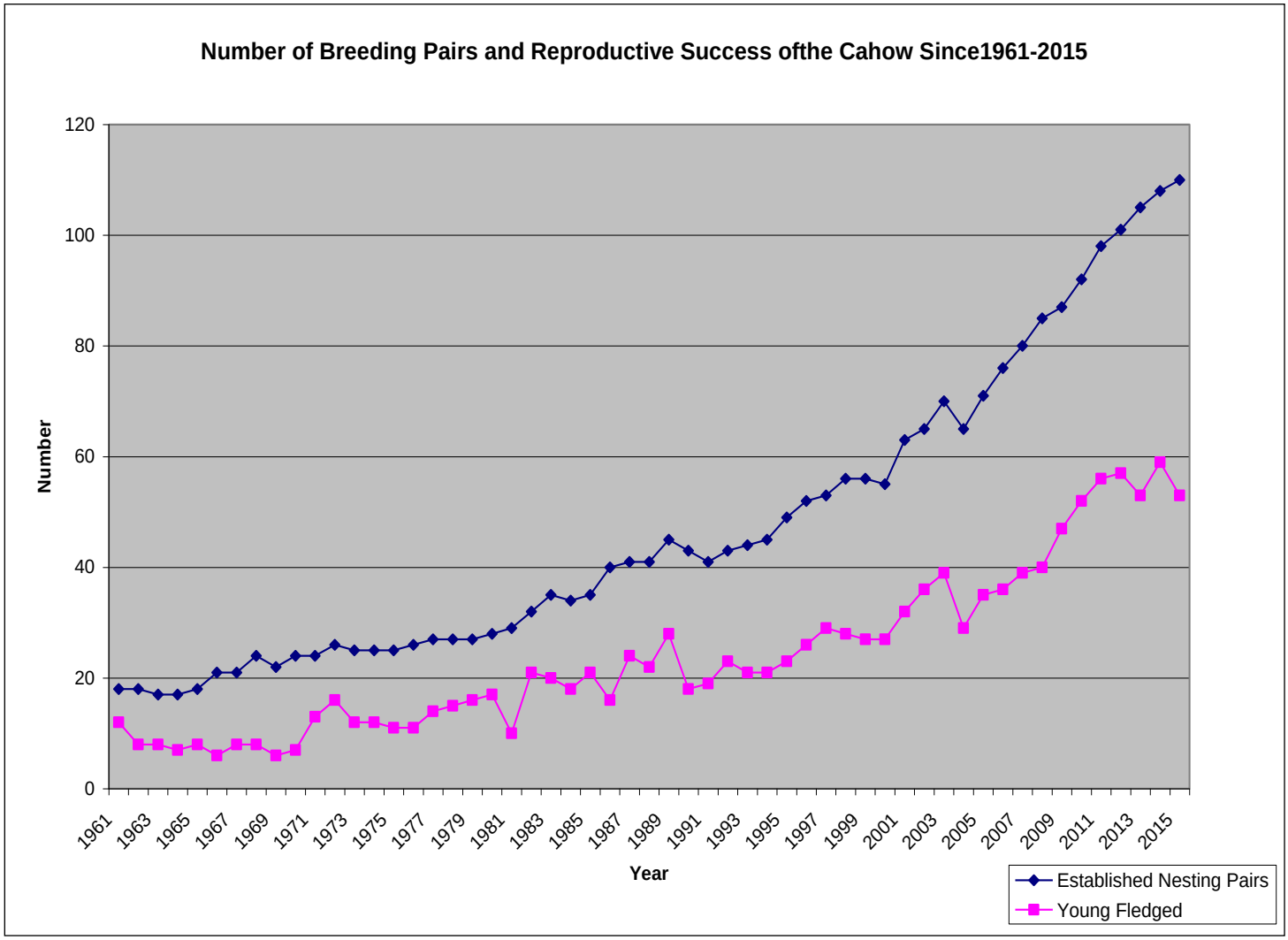

Fig. 4: Number of breeding pairs and fledged young Cahow over 55-year period (L. Madeiros)

2(c): Summary of 2015 - 2016 Cahow Nesting Season:

The 2015-2016 Cahow nesting season has been highlighted by (a): an increase in the number of breeding pairs; (b): successfully fledging chicks increased to 56 from last year's number of 53, and (c): by the continued growth of the new nesting colony that has been established on the Nonsuch Island Nature Reserve.

The Cahow population has increased to a new record high number of 115 breeding pairs, of which 56 produced successfully fledging chicks. This represents a breeding success rate of 48.7%, slightly more than the 47.7 % recorded in the 2014-2015 season, but still notably less than the 54.6 %, recorded in the 2013-2014 nesting season. In addition, new prospecting or pre-breeding activity was recorded at 7 additional nest sites, including 1 new nest site on Nonsuch Island.

Following is a summary of the 2015-2016 nesting season results:

Total number of nest burrows with confirmed nesting activity: …… 115*

Number of new nest sites with prospecting activity: …….. 7

Total number of confirmed successfully fledged chicks: ……. 56

Total number of active nest sites with unsuccessful nesting: ……. 59

Number of failures from nest sites with observable nest chambers: ……. 49

Number of failures from nest sites with non-observable nest chambers: ……..10

Breakdown for causes of breeding failure from observable nest burrows:

Chick died hatching: ……..…. 1
Chick died within one month of hatching: …… 1
Chick died later in development: ……... 2
Eggs broken or pipped: ……. 22
Non-hatching / infertile eggs: ……16
Egg buried or knocked off nest: ……..… 3
Egg washed off nest by storm waves: …… 0
Chick disappeared (Crab/rat predation?): ……..… 1
Tropicbird nest competition: …….. 0
Failure from unknown causes: ……... 3

* Indicates record high numbers

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

Following is a breakdown of breeding results on all offshore Cahow nesting islands for the 2015/2016 nesting season. For the second consecutive year, some of the nesting islets had abnormally low breeding success. These included Inner Pear Rock and Green Island, at 45 % and 38.1 % breeding success respectively. This may be due to heavy impacts to these particular islands from recent hurricanes. In contrast, other islands, such as Long Rock, Horn Rock and Nonsuch Island had much higher breeding success rates of 50.0 %, 51.2 % and 66.6 % respectively.

LONG ROCK:

Active nest burrows with nesting confirmed (eggs laid and/or chick hatched): ……..… 12
New nest burrow prospected by confirmed pair: ……..... 2
Nest burrows with successfully fledged chicks: ……..…… 6
(B, C, D1, D2, D3, D7)
Nest burrows with confirmed failed nesting: ……..…. 6
(A (cause unknown), D4-egg broken, D5–egg crushed, D8- chick disappeared at 7 weeks of age – rat predation? E4-egg infertile and undersized, nest # 14-egg broken)

INNER PEAR ROCK:

Active nest burrows with nesting confirmed: ……. 20
New nest burrows prospected by confirmed pairs: ……. 2
Nest burrows with successfully fledged chicks: …….. 9
(A1, B1, B3, B6, B8, C3, D1, D4, E1)
Nest burrows with confirmed failed nesting: …….. 11
(B2-egg broken, B4-egg broken, B7-egg infertile, B9-egg broken, B10 (unknown causes), C2-egg buried, C4-egg infertile, C6-egg broken, C7-chick died from insufficient provisioning, D2-egg infertile, D3-egg infertile.

GREEN ISLAND:

Active nest burrows with nesting confirmed: ……. 21
New nest burrow prospected by confirmed pair: ……..... 1
Nest burrows with successfully fledged chicks: ……. 8
(A1, # 3-4, # 4, # 4/5, # 5, # 6, # 8, # 13,)
Nest burrows with confirmed failed nesting: ……..15
(E1- cause of failure unknown; F1 – cause of failure unknown, F2-egg broken, F3 – cause of failure unknown, # 3-egg broken, # 5-6-egg infertile, # 7-egg broken, # 9-chick died while fledging, # 10-egg infertile, # 11-egg broken, # 12-egg broken, # 14-egg broken, # 15-egg infertile)

HORN ROCK:

Active nest burrows with nesting confirmed: …… 43
New nest burrows prospected by confirmed pairs: …… 3
Nest burrows with confirmed successfully fledged chicks: …… 22
(B5, B6, C4, C6, C7, C8, C9, C10, C11, C13, C14, C16, C19, C23, C24, C25, C28, D1, F3, F7, F8, G3)
Nest burrows with confirmed failed nesting: ……...19
(B3-egg knocked off nest/buried, C5-infertile egg, C12-chick died when fledging, C15-chick died shortly after hatching, C17-broken egg, C18-broken egg, C20-infertile egg, C21-infertile egg, C22-broken egg, C26-broken egg, C27-egg crushed, C29-egg crushed, D3-unknown causes, D4-egg buried on nest, E1-unknown causes, E2-nest invasion by Tropicbird, F2-egg infertile, F4-egg infertile, F5-chick died at 2 weeks, F6-egg infertile)

NONSUCH ISLAND:

Active nest burrows with nesting confirmed: …… 15
New nest burrows prospected by confirmed pairs: …… 1
Nest burrows with confirmed successfully fledged chicks: …… 10
(R816, R819, R820, R821, R830, R831, R832, R833, R835, R836)
Nest burrows with confirmed failed nesting: …….. 5
(R817-infertile egg, R818-broken egg, R834-infertile egg, R837-egg broken, R838-egg broken)

SOUTHAMPTON ISLAND:

Active nest burrows with nesting confirmed: ……...… 4
New nest burrows prospected: ……..…. 1
Nest burrows with successfully fledged chicks: ……..….. 1
(S3)
Nest burrows with failed nesting: ……...….. 3
(S1, S2, -cause unknown, S4-egg buried by sand collapse)

SECTION 3(a): Update on New Nonsuch Nesting Colony:

Fig. 5: New pair of Cahows being measured on Nonsuch Island (Kate Sutherland)

The Cahow Translocation Project is aimed at establishing new nesting colonies of the Bermuda petrel on larger, more elevated islands containing suitable habitat, that are less at risk from hurricane erosion than the original tiny nesting islets. It involves moving (translocating) Cahow chicks approximately 18 days before fledging, from nests on the original nesting islets, to artificial burrows constructed on the much larger and higher elevated Nonsuch Island.

Gadfly petrels such as the Cahow generally return when mature to the same area that they originally departed from as fledglings, a trait known as *site faithfulness*. To take advantage of this tendency, a total of 105 Cahow chicks selected from all four of the original nesting islets were moved to a new group of artificial nest burrows on Nonsuch Island over a five-year period between 2004 and 2008. On Nonsuch, they were hand-fed daily on imported squid and locally sourced fresh Anchovies, and their weight, wing growth and plumage development recorded daily until they were fully developed. The chicks were fitted with identification bands, or rings, and then monitored through their exercise period, when they emerge for several nights to exercise flight muscles and imprint on their surroundings. At the end of this period, they fledge to the open ocean on their own, hopefully to return when mature to the translocation site. A total of 102 translocated Cahow chicks eventually fledged successfully from Nonsuch by 2008 (**Carlile et al. 2012**).

By 2008, the first four translocated Cahows were recaptured back at the translocation site on Nonsuch, 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. This resulted in the first chick hatched on Nonsuch since the 1620s. In addition, a total of 15 returned translocated Cahows were re-captured at the translocation site by the end of this season.

Between 2010 and 2015, the number of established breeding pairs carrying out nesting activity at the new Nonsuch Island nesting colony rose from 4 to 14, with the number of successfully fledged chicks produced annually by this colony increasing from 1 chick in 2010 to 9 chicks in 2015. 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 confirmed returning translocated Cahow chicks was therefore 49, out of 102 that originally fledged from Nonsuch (representing a 48 % return rate).

For the most recent 2015/2016 breeding season, the total number of breeding pairs on Nonsuch rose to 15, of which 10 produced successfully fledging chicks. The total number of Cahow chicks that have hatched and successfully fledged from the new Nonsuch nesting colony since 2009 has now risen to 46 (**See Tables 1 and 2**).

TABLE 1: Breeding results at new translocation colony on Nonsuch Island 2008/2009 to 2015/2016 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

Overall, for the 2015-2016 Breeding Season, the first Cahow chick to fledge to sea at the (A) translocation colony site did so during the night of May 16, 2016, while the last one fledged out to sea on the night of June 15th, 2016.

Table 2: This table shows the breeding success of all active Cahow nest burrows at the Nonsuch "A" nesting colony between 2009, when the first pair of translocated birds returned to breed, and 2016, when the number of breeding pairs have increased to 15.

NONSUCH ISLAND	2009	2010	2011	2012	2013	2014	2015	2016
Nest No.	Breeding Success (Chick fledged = 1, failed = 0)							
R816			0	1	1	1	1	1
R817			1	1	0	1	0	0
R818	1	1	1	1	0	1	1	0
R819						1	1	1
R820					0	0	1	1
R821							1	1
R830				1	0	0	0	1
R831		0	0	0	0	1	1	1
R832		0	1	1	1	0	1	1
R833				0	0	1	0	1
R834		0	0	0	0	1	0	0
R835					1	1	1	1
R836				1	1	1	1	1
R837			1	1	1	0	0	0
R838								0
Total no. of chicks/year	1	1	4	7	5	9	9	10

Annual Breeding Success of Cahow Pairs on Nonsuch Island since Pair Establishment

3 (b): 4th Year Results of 2nd Translocation Project on Nonsuch

2016 marked the fourth year of a second translocation project aiming to establish a second Cahow nesting colony on Nonsuch Island. Following the success of the first translocation project, this project is aimed at establishing a second 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 artificial nest burrows were constructed about 200 meters to the east of the original colony site. A total of about 80 fledgling Cahows are to be moved over a 5-6-year period from nest burrows on all four of the original nesting islets to the new burrows, where they could be fed and monitored daily until they fledged out to sea. In this way, they hopefully 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, and is situated at 35' to 45' above sea level, well beyond the reach of hurricane waves and surge.

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 mixing and pouring concrete to make new Cahow nest burrows at the new translocation site. Additional nest burrows have since been constructed at this site by the terrestrial conservation crew and conservation officer.

In the event, both the traditional concrete artificial burrows and the new design plastic burrows seemed to work well, being readily accepted by the translocated chicks. For 2016, eight Cahow chicks were translocated to the "B" nest colony site from three of the four original nesting islets, all of which successfully fledged out to sea. Out of the successfully fledging chicks, 2 originated from nest burrows on Horn Rock (C13, F3), 3 from nests on Green Island (# 4, # 5, # 6), and 3 from nests on Long Rock (Long D2, D3, D7).

The first Cahow chick (from the Long Rock D7 nest) was translocated to Nonsuch Island on the 3rd May, 2016. This also became the first chick to successfully fledge out to sea, on the 16th May, after 13 days in its translocation burrow on Nonsuch. The final chick was not translocated until the 2nd June, with the last chick fledging out to sea on 15th June. The median date for translocation of chicks was the 18th May, while the median date for fledging of chicks was the 31st May. The age of chicks at their translocation ranged from 68 to 83 days after hatching (mean age = 75 days), while their age at fledging ranged from 81 to 98 days after hatching (mean = 91 days). (**See Table 3 for full translocation results and figures**).

TABLE 3: 2016 Cahow Translocation Project Results

Date of Translocation of Bermuda Petrel Chicks to Nonsuch Island, Age at Translocation, Number of Feeds and Total Feed Weight, Period of Emergence to Fledging, Date of Fledging, and Age, Weight and Wing Chord (Length) at Fledging.

Individual	**Translocation**		**Number of Feeds**		**Emergence to fledging (days)**	**Fledging**			
(Origin – Island & nest No.)	**Date moved (2016)**	**Age when moved (days)**	**No. of feeds after moving**	**Total Feed weight (grams)**	**(Exercise period)**	**Date fledged (2014)**	**Age from hatching (Days)**	**Weight (grams)**	**Wing Chord (mm)**
LONG D7	3 May	68	7	362 g	4	16 May	81	256g	256mm
LONG D3	9 May	71	5	242 g	4	24 May	86	304g	265mm
GREEN 4	10 May	75	8	388 g	3	28 May	93	266g	259mm
GREEN 5	16 May	72	9	487 g	5	10 June	97	267g	265mm
LONG D2	24 May	73	7	289 g	2	15 June	95	215g	249mm
GREEN 6	26 May	79	5	235 g	4	8 June	92	259g	264mm
HORN C13	29 May	82	6	293 g	4	14 June	98	306g	272mm
HORN F3	2 June	83	2	82 g	1	7 June	88	232g	247mm
Median	18 May					31 May			
Mean		75.37	6.12	297g	3.37		91.25	263.12g	259.6mm

While 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 consisted of human-quality fresh unfrozen squid (*Loligo sp.*) obtained from Miles Supermarket, Pitts Bay Rd. Pembroke. In addition, fresh fish were netted locally and provided by Mr. Chris Flook, who had also provided fish for the original translocation project from 2004 to 2008. Due to the lack of Anchovies, fish provided were mainly Atlantic Threadfin Herring (*Opisthonema oglinum*). A typical meal for one Cahow chick consisted of 1 or 2 Squid bodies (with or without heads) and 5 to 6 Herrings or equivalent.

The number of meals given to each translocated Cahow chick before fledging ranged from 2 – 9 meals (mean = 6. 12 meals), and individual meal weights usually ranged from 40 grams to 60 grams (extreme ranges 10 grams – 72 grams). The total combined amount of food from all meals given to each chick also varied widely from a low of 82 grams to a high of 487 grams (mean = 297grams).

The number of nights that the chicks emerged to exercise before fledging ranged from 1 to 5 nights (mean = 3.37 nights), with chicks fledging to sea between the 16th may and the 15th June (median fledging date = 31st May).

The weight of the chicks at fledging ranged from a high of 306 grams to a low of 215 grams, with the latter considered to be well below the target weight of 250-280 grams. However, the mean fledging weight was 263.12 grams, which compares favorably with naturally fledging chicks. The wing chord (outer wing length from the wrist joint) of fledging chicks ranged from 247mm to 272mm (mean = 259.6 mm).

Fig. 6: Senior Conservation Officer giving weight check to Cahow chick, assisted by Lizzy Madeiros and Sophie Rouja.

As was the case during both 2014 and 2015, the main difficulty encountered during the 2016 translocation of Cahow chicks to the (B) colony site on Nonsuch was a scarcity of fresh Anchovy baitfish (*Sardinella anchovia*), which are one of the primary food items fed to translocated chicks. These are very nutritious, oil-rich fish which allow the fledglings to build up fat reserves which are vital in allowing the chicks to survive during the critical period just after fledging, when they are still learning how to sustain themselves. Anchovies were in very short supply throughout 2016, leading to a decision to reduce the number of Cahow chicks being translocated. In the event, the lack of Anchovies led to the necessity of using the less desirable Threadfin Herring (*Opisthonema oglinum*), which is not as oil-rich as the Anchovies or as good as building fat reserves on the fledglings.

3 (c): Cahow Recovery Program – Public Outreach/Education:

One of the objectives of the Cahow recovery Program is to increase public outreach and education about Bermuda's National Bird and the broader conservation issues involved in its management. To this end, for the fourth year, an infrared "night vision" video camera was used in a Cahow nest burrow to provide video footage of the breeding activities of adult Cahow and the development of a chick from 1 week of age to fledging. Video clips of the development of the chick, which was named "Tempest" by Elizabeth Madeiros, was provided free to the public over the following website: http://lookbermuda.com/CahowCam .This project, which was funded entirely by the Ascendant Group of Companies, involved the modification of several of the concrete nest lids with 4" PVC electrical conduit pipes so that a customized "Go Pro 2" camera modified by Mr. JP Rouja to be sensitive to infrared light (See Fig. 12) could be installed to take video footage of the Cahow adults and chicks inside their burrows, which are completely dark.

Fig. 7: Adult Cahow with chick in nest burrow as viewed by infrared "CahowCam"

This video camera, fitted with military-grade infrared lights that are completely undetectable by humans or animals, enables high-definition video footage to be taken at the colony site**.** The CahowCam has the great advantage of making observations of these critically endangered birds accessible to the public, without causing disturbance to the birds or threatening their breeding success in any way.

Another advantage that this system brings is that it allows the managing researcher to check on the progress of egg incubation, growth of the chicks etc. in the nest without causing any disturbance to the birds. Breeding behavior of the adult birds, as well as chick behavior, can also be observed in a totally non-obtrusive manner. This not only has great benefits for behavioral research, but also can be provided to the public, who can participate in the "citizen science" aspect.

Following are some of the highlights that the CahowCam revealed during 2015/2016:

(1) For the second time, the hatching of a Cahow chick was captured over the internet. The hatching took an unusually long time, lasting almost 2 days. The CahowCam revealed that the chick was not able to enlarge the initial hole it pecked through the eggshell, and was becoming weak. The decision was made to help the chick by carefully enlarging the hole, and shortly after, the chick finally emerged on the 5th March, helped from the eggshell by the incubating male bird in the latter stages of this process.

(2) Once the wet, exhausted chick was free from the eggshell, the male bird then intensively preened the chick before settling down to brood it for several hours. By the time the chick was seen again, its down had completely dried out and it had assumed the familiar "puffball" appearance. The chick was then given its first feed by the male bird within hours of hatching.

(3) A large number of feeding visits by the adult Cahows to the chick were recorded, with the chick steadily growing and gaining weight, until it reached its peak weight of 435 grams on the 18th May, 2016. The chick then went through the normal process of losing weight or "slimming down" during the pre-departure exercise period, fledging to sea on the night of 6th June.

(4) Within hours of the departure of the Cahow chick, the "CahowCam recorded a much smaller, unknown tubenose seabird entering the nest chamber to investigate and re-arrange nest material. Examination of recorded video footage enabled this seabird to be identified as a **Leach's Storm-petrel** (*Oceanodroma leucorhoa*), which, although common well offshore during the winter and spring months, has never been recorded on land on Bermuda, and certainly not prospecting a nest burrow! This bird, evidently a male, then visited the burrow almost nightly, arranging nest material and calling loudly for hours at a time at the burrow entrance to attract a mate. This Storm-petrel visited the nest almost nightly between th 6th June and 9th July, 2016. Although unsuccessful in attracting a mate, it will be very interesting to see if the same bird returns to this nest burrow in 2017.

The infrared CahowCam has proven to be an asset for the Recovery Program, revealing previously unknown behavior and enabled 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. A partnership with the Cornell Bird Laboratory is being investigated to bring the CahowCam to a much wider audience.

Other public outreach efforts relating to the Cahow Recovery Project has 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 included the Cahow in their curriculum, with the latter again giving a generous donation to the Recovery Project. A total of 18 tour groups, mostly from local middle and secondary schools and the Bermuda College, and totaling 314 people, were allowed to see Cahows at close range on Nonsuch Island being assessed and measured as part of the research program.

Fig. 8: Explaining how Baffles work on nest entrances to Warwick Academy IBA group

3 (e): Update on Cahow Banding Program:

The Cahow banding program has been a key component of the Cahow Recovery Program since 2002, with 5.5 mm metal bands made of a strong, corrosion-resistant alloy called incoloy being fitted to the right legs of adult Cahows and the left legs of fledgling birds. These bands can last for the life of the birds and are imprinted with unique individual codes and a return address. The bands are vital for allowing easy, positive identification of individual Cahows in the field, enabling researchers to follow these birds for essentially their entire breeding lifespan, through recaptures over successive years.

The Cahow Banding Program has now been underway for thirteen years, As of June, 2016, a total of 626 Cahows have been fitted with identification bands, the majority of which have been fledgling birds* This includes 149 birds banded as breeding adults, and 477 birds banded as chicks before fledging to sea. In other terms, these numbers represent almost 75 % of the current adult breeding population, and about 85% of all chicks to have fledged since 2002. (*This does not represent the total population of Cahows, as only about a third of fledglings survive their first years at sea; the total world population of the species is conservatively estimated at approximately 330 individuals, including immature and non-breeding birds).

Banding of Cahow chicks is of particular value due to the fact that it enables the easy identification and study of individual birds whose age is accurately known, as well as the nest, island and parent birds that they originated from. These known-age birds have already provided a wealth of previously unknown information on many aspects of behavior and breeding biology, including the following:

1) The survival rates of chicks during the period between fledging to sea and their first return to the nesting grounds as sexually mature young adults;
2) The differences in survival rates of naturally-fledged birds (raised entirely by the adults), as compared to those that have been translocated (raised partly by adult birds, partly by humans).
3) The age of chicks upon their first return to the nesting grounds, which was found to differ between male and female birds;
4) The period of time between the first return of the young birds, to the choosing of nest sites and mates, and the first breeding attempts;
5) Whether young Cahows always return to their exact point of departure, or if they return to other islands/nesting colonies; the program has confirmed that this differs considerably between male and female birds.

In addition, the banding of adult Cahows is providing concrete data on breeding success rates, site faithfulness and pair faithfulness, and eventually on the longevity of individual birds (**Madeiros et al. 2012**). The information provided by the Cahow banding project will continue to increase knowledge of the species, as long as the banding project and annual recapture and band checks of the birds continue into the future.

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 proposed for the next two nesting seasons:

2016 – 2017 Breeding Seasons:

- Continue translocations of near-fledged Cahow chicks from nesting islands to "B" colony site on Nonsuch Island, moving 15 – 20 chicks annually until a target figure of 75 to 90 chicks have been moved to and fledged from Nonsuch;
- Install 2nd sound attraction system at new "B" colony site on Nonsuch Island and play disc of recorded Cahow courtship calls.
- Continue banding program for adult and fledgling Cahows;
- Continue monitoring of nesting islands for the presence of rats; set out rodenticides when necessary;
- Continue installation of additional artificial nest burrows at nesting colonies, including at the new colony on Southampton Island.
- Investigate the potential deployment of extremely accurate GPS loggers on Cahows to more accurately determine oceanic range and important foraging areas for the species.
- Enter into partnership with Cornell Laboratory of Ornithology to install improved CahowCam video camera in nest burrow on Nonsuch, and distribute through the internet to viewers.

2017 – 2018 Breeding Seasons:

- Continue translocating near-fledged Cahow chicks from the original nesting islands to the "B" colony site on Nonsuch Island if needed. If target number of translocated chicks has been reached during previous year, switch from active translocation of chicks to monitoring of burrows at translocation site;
- Continue use of Sound Attraction System at "B" colony site on Nonsuch;
- 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;
- Carry out the deployment of extremely accurate GPS loggers on selected adult and fledgling Cahows.

Section 4 (b): Acknowledgements:

I would like to acknowledge with thanks the following Departmental staff, volunteers, organizations, schools and members of the public for their assistance in the Cahow Recovery Project during the 2015 – 2016 breeding season:

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I am deeply indebted to the Terrestrial Conservation Crew for their hard work in building artificial concrete nest burrows and assistance in managing nesting habitat for the Cahows on both Nonsuch Island and the original nesting islets. The Terrestrial Conservation Crew consists of Barry Smith (Foreman), Llewellyn Rewan, Kiwon Furbert and Marvin Jones.

The research work carried out by the Cahow Recovery Program has been possible only because of donations by schools, businesses, organizations and members of the public. For example, the geolocational loggers which have 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 is producing 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 Ascendant Group of Companies, who have supported and provided volunteers to construct new Cahow nest burrows and a new solar power system for the Cahow Recovery Project. We are deeply grateful for the interest and generosity shown by these and other donors.

In conclusion, I would like to acknowledge and thank Leila Madeiros and my children Seth and Elizabeth, whose support and patience have made this demanding project possible over the last 16 years.

Jeremy Madeiros,
Senior Terrestrial Conservation Officer

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Fig. 9: New breeding pair of Cahows on Nonsuch, with male on left and female on right