

**Breeding Success and Status of Bermuda's Longtail  
Population (White-tailed Tropicbird)  
*Phaethon lepturus catsbyii*  
At Ten Locations on Bermuda 2009 – 2011**



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BERMUDA GOVERNMENT**

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**At Ten Locations on the Island of Bermuda**  
**2009 to 2011**

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## Table of Contents:

	Page No.
1. Executive Summary: .....	(4)
2. Introduction: .....	(5)
3. Objectives of Survey: .....	(7)
4. Methodology: .....	(8)
5. Threats to the Tropicbird on Bermuda: .....	(9)
6. Results of Study: .....	(12)
7. Artificial “Igloo” Nest Box Program-comparison of breeding success: .....	(15)
8. Discussion and Recommendations: .....	(17)
9. Acknowledgements: .....	(20)
10. References: .....	(21)

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## Figures:

Cover photo: Adult Tropicbird Incubating Egg in Nest Cavity: .....	(1)
Fig. 2: Survey locations for Tropicbird nest site checks: .....	(6)
Fig. 3: 60-day old Tropicbird chick removed from nest for measurement: .....	(9)
Fig. 4: High waves from passing hurricane Katia affecting nesting islands: .....	(11)
TABLE 1: Tropicbird Nesting Statistics (2009 – 2011 Nesting Seasons): .....	(12)
TABLE 2: Nest Nos. and Breeding Data from Individual Survey Locations: ....	(13)
TABLE 3: Breeding Success of Artificial Tropicbird Nests 2009-2011: .....	(16)
TABLE 4: Breeding Success of Natural Tropicbird Nests 2009-2011: .....	(16)
Fig. 5: Barry Smith (Foreman, Conservation Crew) installing artificial nests: ....	(17)
Fig. 6: Artificial Tropicbird Nest Installed at Nonsuch Island by Cons. Crew: ....	(17)

## **(1) Executive Summary:**

The Longtail, or White-eyed Tropicbird, *Phaethon lepturus catsbyii*, is one of Bermuda's most beautiful and iconic bird species and the island's only common nesting seabird. Between 2009 and 2011 a survey was carried out by the terrestrial conservation officer (Department of Conservation Services, Ministry of Public Works) to continue research on determining the breeding success, present status and threats affecting the species. The results of this survey are presented in this report, in which methods of assisting and protecting the species are also discussed.

The White-tailed Tropicbird is widespread through the Tropical and Subtropical Oceans of the world, including the North Atlantic, South Atlantic, Indian and Pacific Ocean basins. It is split into at least six recognized sub-species, with the North Atlantic *catsbyii* subspecies nesting on Bermuda and through the Caribbean area. Bermuda is the largest and most important single breeding location for this sub-species, with approximately 2500-3000 nesting pairs, compared to about 2000 nesting pairs for the entire Caribbean region. The nesting population of tropicbirds on Bermuda is therefore internationally significant and of great importance to the survival of this species.

The present survey continues on from previous surveys carried out at ten locations at the east end of Bermuda between 2006 and 2008. Eight of the ten survey locations are at the Castle Harbour Islands Nature Reserve, which contains the largest concentration of nesting pairs for a single site in the Atlantic Basin. This has resulted in the Castle Harbour Islands being designated as an International Important Bird Area (I.B.A.) by Birdlife International. The tropicbird is therefore very important to the biodiversity of Bermuda, and it is essential that a thorough understanding of the breeding success and threats affecting the species be obtained in order to ensure its continued survival.

The survey found that overall, breeding success for the tropicbird remains quite high for a seabird species, although varying considerably between different years, ranging between 64.3% and 72.1%. It was also found that a number of threats affect the tropicbird on Bermuda, including introduced invasive animals that can eat eggs, chicks and/or adult birds or compete for nest sites, and coastal development that can destroy nesting areas. The largest single threat to the tropicbird on Bermuda is the destruction of hundreds of nests by high waves and erosion during hurricanes. One of the management techniques addressing this problem is the installation of artificial nests in areas where large numbers of nests have been lost. An important part of this survey was to confirm whether the birds use these nests successfully. The survey confirmed that not only do tropicbirds readily use these nests, but that they enjoy higher levels of breeding success in them at 74.39% than they do with the natural nest sites, which have 66% breeding success.

The importance of the tropicbird to the island's natural heritage has been recognized in law and it and its nesting sites are fully protected under the Bermuda Protected Species Act 2003. Management recommendations outlined in this report, if implemented, should help to ensure the continued protection and survival of this beautiful symbol of Bermuda.

## (2) Introduction:

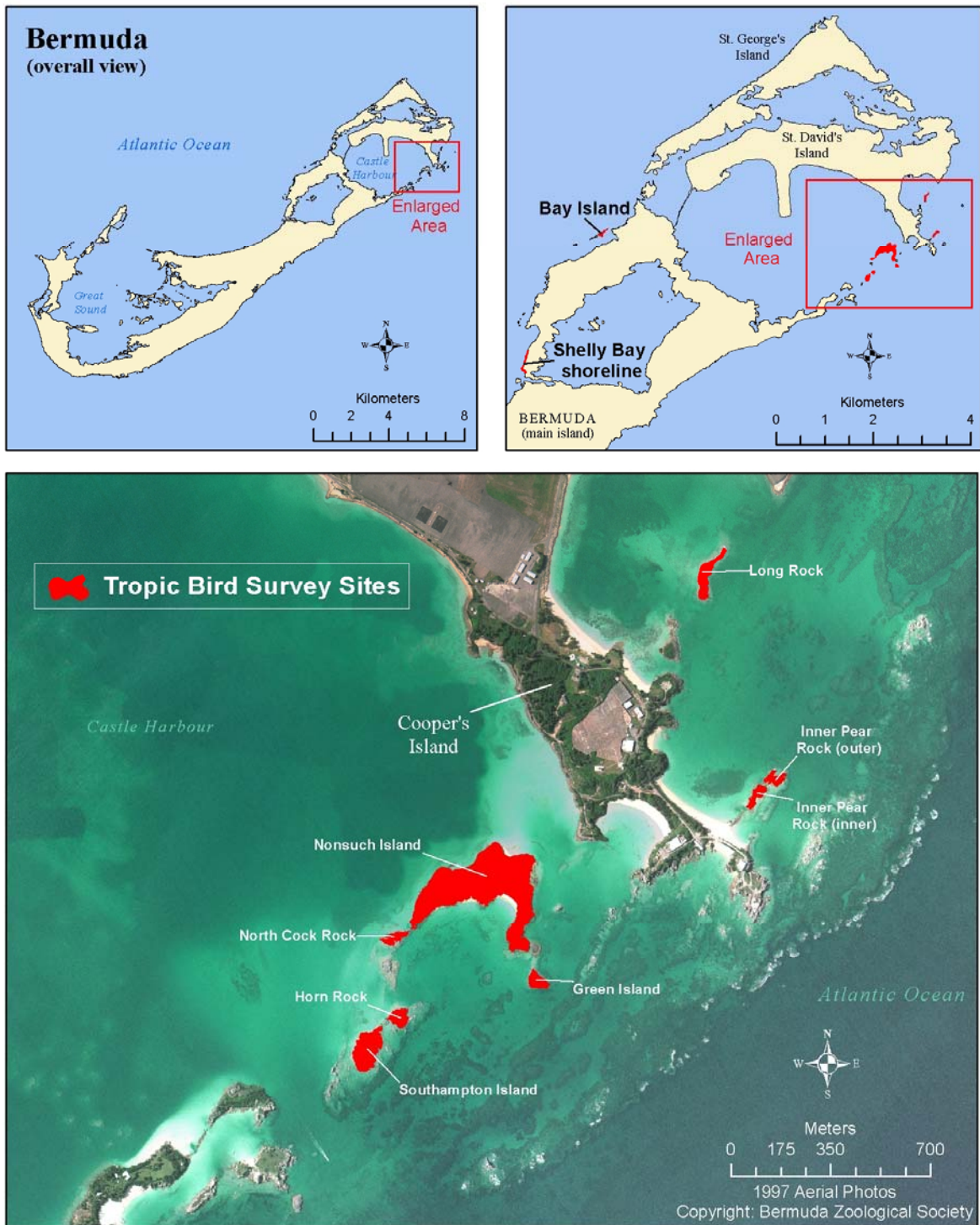
The Bermuda Longtail, or White-tailed Tropicbird as it is correctly known, is one of Bermuda's best-known and most loved bird species. Long considered to be the first harbinger of spring and foretelling of warmer weather to come, the first sighting of a Longtail is an event that is always recorded in the local newspapers. It was also long considered to be Bermuda's unofficial National Bird, although that honor was officially given to the endemic and critically endangered Cahow, or Bermuda petrel *Pterodroma cahow* in 2003.

The Tropicbird is a beautiful, black and white seabird with a wingspan of just over 3 feet (about 1 meter), which can be found in subtropical seas in the Atlantic, Indian and Pacific Oceans (Harrison, 1983). It's most distinguishing features are the two incredibly long central tail feathers, which at up to 18" can be longer than the rest of the bird's body. It nests in holes and cavities in rocky shorelines and coastal cliffs, although it can nest on the ground under vegetation on the few islands that have no introduced rats, cats, dogs or other predators. Quite thinly spread out and never common, many populations around the world, including through the Caribbean region, have declined in recent decades due to the impacts of introduced mammal predators and coastal development.

The North Atlantic contains a distinct sub-species, *Phaethon lepturus catsbyi*, which only nests in Bermuda, the Caribbean and islands off the northern coast of South America. The Bermuda population of about 2500-3000 nesting pairs is very important as it represents about half of the entire population of this subspecies (Schreiber and Lee, 2000). This means that Bermuda's Tropicbirds are not only important to the local environment, but are of international significance. Little has been known until recently as to whether Bermuda's breeding population of the species had declined from increasing levels of predation by introduced mammalian and avian species, and also from the effects of recent hurricane activity and the increasingly developed nature of the island.

Some of the first published studies of the Tropicbird on Bermuda were carried out by researcher A. Gross in 1910 at various locations across Bermuda, including Morgan's Island in Ely's Harbour, Somerset and at Tucker's Town, St. George's ((Gross, 1912). Dr. William Beebe also surveyed a number of Tropicbird nests on Nonsuch Island; St. George's in 1929 and 1930 to determine dates of nesting and breeding success (Beebe, 1932). Conservation officer David Wingate monitored a large number of Tropicbird nest sites on the Castle Harbour Islands from the 1960s to the late 1980s to determine the annual breeding success and numbers of active nests of the species. Head aquarist at B.A.M.Z. Patrick Talbot restarted this survey monitoring nests in the same area from 2000-2003 as part of his masters thesis. Because of the importance of Bermuda's nesting population and the need to know more about the present status of the species on the island, I took over study of the population in 2005 in my role as Terrestrial Conservation Officer (Bermuda Govt.) to compile information on current levels of breeding success and possible threats to the species. These findings can then be used to determine methods of protecting and assisting the Globally Important population of White-tailed Tropicbird on Bermuda.

## Tropic Bird Breeding Survey Sites 2009-2011



**Fig. 2: Survey locations for Tropicbird nest site checks**

### **(3) Objectives of Survey:**

Bermuda has been identified as supporting the largest single breeding population of the Western Atlantic subspecies of White-tailed Tropicbird (*Phaethon lepturus catsbyii*), with up to 50% of all known breeding pairs. Population studies of other breeding locations throughout the greater Caribbean area have shown that many of these breeding populations are in decline (Bradley and Norton, 2009). As a result, the Bermuda breeding population has been identified as being of global importance to the survival of this species. This was highlighted by the designation in 2009 of the Castle Harbour Islands area as an International I.B.A. (Important Bird Area) by Birdlife International, as being the breeding habitat of a significant percentage of the North Atlantic population of White-tailed Tropicbird (up to a third of Bermuda's entire breeding population), as well as the entire global population of the endangered Bermuda petrel, or Cahow.

The objectives of this survey are listed as follows:

- 1) To determine the size of Bermuda's breeding Tropicbird population;
- 2) To determine the breeding success rate of this breeding population at ten survey sites around the eastern half of Bermuda, and to see how breeding success varies from year to year;
- 3) To determine the effect that hurricanes and severe storms have on breeding success and availability of natural nest sites;
- 4) To see what effect introduced predators such as rats, cats and dogs have on Tropicbird breeding success, and work out methods of addressing these and other potential threats to the species;
- 5) To determine Tropicbird chick growth rates, and whether this varies from year to year according to availability of food items such as squid and fish from the ocean around Bermuda;
- 6) To compare breeding success for the Tropicbird between birds nesting in artificial nest sites and birds nesting in natural cliff rock cavities, and determine whether the program of providing artificial nests has been successful in offsetting decline of the nesting population from the loss of natural nest sites due to hurricane erosion.

#### **(4) Methodology:**

Every year, over 200 marked Tropicbird nests are monitored at ten different survey locations through the eastern half of Bermuda (See Fig. 2). Eight of these locations are on the Castle Harbour Islands, which are Nature Reserves managed to eradicate rats and other predators, and where human disturbance is strictly controlled (Nonsuch Island, Long Rock, Inner Pear Outer Rock, Inner Pear Inner Rock, Green Island, Horn Rock, North Cock Rock and Southampton Island). The other two locations are near Shelly Bay, Hamilton parish, and on Bay Island, Bailey's Bay. These locations are not managed, and contain rats, crows (which predate on Tropicbird eggs and chicks) on Bay Island, and at Shelly Bay, human disturbance, rats, feral cats and dogs, which are walked by people on the adjacent Railway Trail, and sometimes are let off their leashes to roam freely among the coastal area.

Due to other work commitments, it was not possible to check Shelly Bay and Bay Island during the 2009 nesting season, and Bay Island and Green Island during the 2010 season.

For this study, all accessible Tropicbird nests are marked with plastic number tags and are checked weekly through the nesting season between May and October. These include nest sites that may not be active and visited by Tropicbirds in any particular year, but have been used for nesting in the past. Any visits of adult Tropicbirds, courtship activity, and nesting activity such as eggs being laid, or chicks hatching are recorded, and confirmed chicks are then monitored through their development to ensure that the number that successfully fledge to sea is accurately known. Causes of breeding failure were also determined where possible. All Tropicbird chicks in nests where they could be reached and removed were fitted with identification bands or rings. This is being carried out so that a large number of known-age birds would be easily identifiable for confirmation of many aspects of breeding biology. Between 2003 and 2011, almost 700 Tropicbird chicks have been fitted with bands.

As part of a long-term study of growth rates, a sample of Tropicbird chicks are regularly weighed and measured through their development for weight, outer wing length, Tarsus (lower leg) length, and bill length (See Fig. 3). The variations in growth rates and maximum chick weights from year to year are indicators of the productivity of the ocean in Bermuda's vicinity. Years where chicks grow rapidly and reach higher weights indicate plenty of prey items such as squid, ocean robins and flying fish, which also attract larger numbers of commercially important oceanic food fish such as Tuna, Wahoo and Dolphin Fish (or Mahi-mahi).

An additional component of this survey was to determine whether artificial Tropicbird nests have a higher breeding success rate than natural cliff cavities. This was carried out by surveying all artificial nest sites that have been installed at survey locations separately from all natural nest sites and cavities, and comparing what the breeding success of each group was relative to the total number of active nests, where nesting activity was taking place, for each nesting season.





**Fig. 3: 60-day old Tropicbird chick removed from nest for weighing & measurement**

## **(5) Threats to the Tropicbird on Bermuda**

There are a number of known threats facing the nesting population on Bermuda, and one of the objectives of this project is to identify these threats and work out methods to control or counteract them. Following are the threats that have been identified as presently affecting the Tropicbird on the island:

- 1) Over the last 20 years, a large number of natural Tropicbird nest sites have been lost to erosion and cliff collapse during strong hurricanes passing near to or over the island. During hurricane “Fabian” in 2003, it is estimated that almost 300 nests were lost on the Castle Harbour Islands alone, with some islands losing more than half of all nest sites. During the present survey, hurricane “Igor” approached Bermuda as a Category 3 storm during September, 2010, creating huge ocean swell, reaching 20’ to 25’, for several days. The hurricane itself weakened to a Category 1 storm by the time it passed just to the west of Bermuda on September 19<sup>th</sup> and 20<sup>th</sup>, with winds gusting between 90mph to 110mph. There was, however heavy damage and erosion to the southern coastline from several days of pounding by the waves of the hurricane, especially on the exposed Castle Harbour Islands. Over 30 of the tagged nests being monitored for this study were destroyed, with more than 12 Tropicbird chicks washed out of surveyed nests and killed during the storm.

Further minor losses of nest sites and chicks were experienced in 2006, 2009 and 2011 due to high waves from passing hurricanes (see Fig. 4). These losses cause shortages of suitable nest sites for the Tropicbird because the birds cannot dig their own nests in the rock, but have to wait for erosion to carve out new cavities in newly collapsed cliff areas, a process that can take many decades. Because of the potential detrimental effect this would have on Bermuda's Tropicbird population, a joint project between the Department of Conservation Services (DCS) and the Bermuda Audubon Society (BAS) has seen the installation of literally hundreds of artificial "Igloo" nests in locations where natural nests have been lost to hurricane erosion. These nests have also been available for sale to the public from the BAS for installation in appropriate private coastal properties. This present study shows an overall increase in the number of active nest sites at the study locations (See Table 1), which is largely due to the large number of artificial nests that have been installed at seven of these locations (See Section 7).

- 2) Additional threats to the Tropicbird on Bermuda include the loss of nest sites due to building of docks, stairways and retaining walls in rocky coastal areas, which can destroy or block nesting cavities. The Department of Conservation Services has worked with the Planning Department to identify areas where coastal development projects may threaten Tropicbird nesting areas. The developer may be required to either modify or move the development area or where this is not possible, to purchase and install artificial "Igloo" nests to compensate for any nests destroyed by the development.
- 3) Human disturbance, which can be caused either by nest cavities being stuffed with trash (most often by people fishing off the rocks and bringing food and drinks with them), or by people either poking at the birds in the nests with sticks, or by removing the chicks, believing them to be abandoned and not understanding that they are left alone for much of the day while the adults are at sea catching food for the chicks.
- 4) Predation by introduced mammal predators. This has included domestic animals such as dogs and cats, which have been recorded as killing both adult Tropicbirds and chicks in nests that they can reach. This problem is compounded by the large number of feral (escaped) cats on Bermuda, which are estimated to number up to 10,000 and are fed in some areas by feline assistance groups and individuals. Spaying and neutering programs for this feral population have helped but have not stopped the growth of this population. Predation on Tropicbirds by rats, which can eat both eggs and young chicks, has also been recorded.
- 5) Avian (bird) predators can also pose a considerable threat to nesting Tropicbirds on Bermuda, with introduced American Crows being of particular concern. In 2009, a single small group of 4 crows was found to have destroyed over 50 eggs from Tropicbird nests in the Tucker's Town area, and to have killed and eaten well over a dozen chicks, before being eradicated by a pest control officer. As each pair of Tropicbirds generally lays only one egg each season, this can have a

serious impact on the breeding success over large areas of Bermuda's coastline (although established pairs can sometimes produce a second egg after a recovery period). Also during 2009, a Peregrine Falcon stayed for much of the summer on Bermuda and in September regularly visited the Castle Harbour Islands, where it killed and ate a number of birds. These included Mourning and Ground Doves, Shorebirds and at least two adult and four fledging Tropicbirds, whose remains were found on Nonsuch Island, Horn Rock and Southampton Island (no action was taken against this falcon as it is a naturally occurring migrant species).

- 6) Another threat involves another introduced feral pest species, the Rock Dove or Domestic Pigeon, which occupies Tropicbird nest cavities during the winter months and so befouls these cavities with droppings and parasitic mites that the Tropicbirds will no longer use them. Almost half of all Tropicbird nest sites had been taken over by Pigeons in this way by 2005 in areas such as Harrington Sound, Spittal Pond and the North Shore. Pigeons are known carriers of bacteria such as salmonella, which causes food poisoning, when they forage for rotten food in trash cans in parks and cities, and pose a real human health risk due to their habit of roosting and excreting on roofs, contaminating the water supply. As a result, they have been the subject of an ongoing culling program which has successfully reduced their numbers to a third of that recorded 10 years ago.



**Fig. 4: High waves from passing hurricane “Katia” affecting Tropicbird nesting islands in September, 2011**

## (6) Results of Study:

The number of active (with confirmed nesting activity), accessible Tropicbird nests at the study locations increased from 160 in 2009, to 171 in 2010, and to 215 in the 2011 nesting season (See Table 1). Although some of this increase is attributed to two of the survey locations not being accessible in 2009 and 2010, the rest was due to the continued installation of artificial nests. The number of confirmed successfully fledged chicks rose from 103 in 2009, to 121 in 2010, and to a record number of 155 chicks in surveyed nests during the most recent, 2011 nesting season. This represents overall breeding success rates of 64.3 % for 2009, 70.7 % for 2010, and 72.1 % for the 2011 nesting seasons (See Table 1). These rates are relatively high for any seabird species and strongly indicate that low breeding success is not the main limiting factor for the species on Bermuda.

A comparison with the previous 3-year period of this long-term study (2006 – 2008) shows similar levels of breeding success at the same study locations, varying between 65% and 70.6%. This period was also marked by a major hurricane impact during 2006, with “Florence” passing only 60 miles southwest of Bermuda. This storm also resulted in a number of nest sites being destroyed (although less than during hurricanes “Fabian” and “Igor”). Few Tropicbird chicks were killed during Florence, however, partly due to the fact that it was possible to move many chicks from low-lying nests before the hurricane hit. These chicks were either moved back to their nests after the hurricane passed, or were fed and raised until mature and taken back to Nonsuch Island where they fledged to sea.

For the present, 2009 - 2011 survey, Tropicbird breeding success varied widely between survey locations during different nesting seasons (See Tables 1 & 2). Breeding success was impacted in 2009 by hurricane “Bill”, which passed 200 miles southwest of Bermuda and killed several chicks in their nests, and by a Peregrine Falcon which took a number of adult and fledgling Tropicbirds. Hurricane “Igor” had a major impact during the 2010 season, destroying about 30 of the surveyed nests and killing more than 12 chicks in these nests. It should also be noted that some locations could not be surveyed on specific years.

**TABLE 1:**

**TROPICBIRD NESTING STATISTICS – 2009 to 2011 NESTING SEASONS**

<b>YEAR</b>	Total No. of surveyed nest sites	Total No. of nests with nesting activity	Total No. of fledged chicks	Breeding Success percentage	No. of newly prospected nest sites
<b>2009</b>	206	160	103	64.3 %	27
<b>2010</b>	253	171	121	70.7 %	24
<b>2011</b>	257	215	155	72.1 %	23
<b>Totals:</b>	<b>716</b>	<b>546</b>	<b>379</b>	<b>69.4%</b>	<b>74</b>

**TABLE 2: Total Nest Numbers and Breeding Data at Individual Survey Sites (2009 – 2011 Breeding Seasons)**

**LONG ROCK**

<b>Year:</b>	<b>Total No. of Nests</b>	<b>Active Nest Sites</b>	<b>Chick Fledged Successfully</b>	<b>Nesting Failed</b>	<b>Prospected Nest Sites</b>
<b>2009</b>	<b>16</b>	<b>12</b>	<b>8</b>	<b>4</b>	<b>0</b>
<b>2010</b>	<b>19</b>	<b>12</b>	<b>7</b>	<b>5</b>	<b>1</b>
<b>2011</b>	<b>19</b>	<b>18</b>	<b>12</b>	<b>6</b>	<b>1</b>

**INNER PEAR ROCK (OUTER)**

<b>Year:</b>	<b>Total No. of Nests</b>	<b>Active Nest Sites</b>	<b>Chick Fledged Successfully</b>	<b>Nesting Failed</b>	<b>Prospected Nest sites</b>
<b>2009</b>	<b>20</b>	<b>17</b>	<b>11</b>	<b>6</b>	<b>1</b>
<b>2010</b>	<b>24</b>	<b>19</b>	<b>12</b>	<b>6</b>	<b>3</b>
<b>2011</b>	<b>20</b>	<b>16</b>	<b>12</b>	<b>4</b>	<b>3</b>

**INNER PEAR ROCK (INNER)**

<b>Year:</b>	<b>Total No. of Nests</b>	<b>Active Nest Sites</b>	<b>Chick Fledged Successfully</b>	<b>Nesting Failed</b>	<b>Prospected Nest Sites</b>
<b>2009</b>	<b>11</b>	<b>8</b>	<b>5</b>	<b>3</b>	<b>1</b>
<b>2010</b>	<b>10</b>	<b>5</b>	<b>3</b>	<b>2</b>	<b>5</b>
<b>2011</b>	<b>13</b>	<b>12</b>	<b>9</b>	<b>3</b>	<b>0</b>

**GREEN ISLAND**

<b>Year:</b>	<b>Total No. of Nests</b>	<b>Active Nest Sites</b>	<b>Chick Fledged Successfully</b>	<b>Nesting Failed</b>	<b>Prospected Nest Sites</b>
<b>2009</b>	<b>8</b>	<b>5</b>	<b>3</b>	<b>2</b>	<b>0</b>
<b>2010</b>	<b>*</b>	<b>*</b>	<b>*</b>	<b>*</b>	<b>*</b>
<b>2011</b>	<b>8</b>	<b>8</b>	<b>5</b>	<b>3</b>	<b>0</b>

**NONSUCH ISLAND**

<b>Year</b>	<b>Total No. of all Nests</b>	<b>Active Nest Sites</b>	<b>Successful Nests (Chick Fledged)</b>	<b>Nesting Failed</b>	<b>Prospected Nest Sites</b>
<b>2009</b>	<b>74</b>	<b>56</b>	<b>39</b>	<b>17</b>	<b>11</b>
<b>2010</b>	<b>76</b>	<b>59</b>	<b>41</b>	<b>18</b>	<b>0</b>
<b>2011</b>	<b>70</b>	<b>60</b>	<b>47</b>	<b>13</b>	<b>2</b>

**\* Nest Sites not checked on this Island during this Year**

TABLE 2 (continued)

**HORN ROCK**

<b>Year</b>	<b>Total No. of all Nests</b>	<b>Active Nest Sites</b>	<b>Successful Nests (Chick Fledged)</b>	<b>Nesting Failed</b>	<b>Prospected Nest Sites</b>
<b>2009</b>	<b>45</b>	<b>35</b>	<b>18</b>	<b>17</b>	<b>5</b>
<b>2010</b>	<b>52</b>	<b>35</b>	<b>24</b>	<b>11</b>	<b>6</b>
<b>2011</b>	<b>44</b>	<b>39</b>	<b>25</b>	<b>14</b>	<b>4</b>

**NORTH COCK ROCK**

<b>Year</b>	<b>Total No. of all Nests</b>	<b>Active Nest Sites</b>	<b>Successful Nests (Chick Fledged)</b>	<b>Nesting Failed</b>	<b>Prospected Nest Sites</b>
<b>2009</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>0</b>	<b>0</b>
<b>2010</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>1</b>
<b>2011</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>0</b>

**SOUTHAMPTON ISLAND**

<b>Year</b>	<b>Total No. of all Nests</b>	<b>Active Nest Sites</b>	<b>Successful Nests (Chick Fledged)</b>	<b>Nesting Failed</b>	<b>Prospected Nest Sites</b>
<b>2009</b>	<b>29</b>	<b>25</b>	<b>17</b>	<b>8</b>	<b>9</b>
<b>2010</b>	<b>55</b>	<b>27</b>	<b>22</b>	<b>5</b>	<b>7</b>
<b>2011</b>	<b>35</b>	<b>27</b>	<b>18</b>	<b>9</b>	<b>6</b>

**BAY ISLAND (BAILEY'S BAY)**

<b>Year</b>	<b>Total No. of all Nests</b>	<b>Active Nest Sites</b>	<b>Successful Nests (Chick Fledged)</b>	<b>Nesting Failed</b>	<b>Prospected Nest Sites</b>
<b>2009</b>	<b>*</b>	<b>*</b>	<b>*</b>	<b>*</b>	<b>*</b>
<b>2010</b>	<b>*</b>	<b>*</b>	<b>*</b>	<b>*</b>	<b>*</b>
<b>2011</b>	<b>23</b>	<b>16</b>	<b>11</b>	<b>5</b>	<b>3</b>

**SHELLY BAY COASTLINE**

<b>Year</b>	<b>Total No. of all Nests</b>	<b>Active Nest Sites</b>	<b>Successful Nests (Chick Fledged)</b>	<b>Failed Nesting</b>	<b>Prospected Nest Sites</b>
<b>2009</b>	<b>*</b>	<b>*</b>	<b>*</b>	<b>*</b>	<b>*</b>
<b>2010</b>	<b>14</b>	<b>12</b>	<b>11</b>	<b>1</b>	<b>1</b>
<b>2011</b>	<b>22</b>	<b>17</b>	<b>15</b>	<b>2</b>	<b>4</b>

\* Nest Sites not checked at this location during this Year

## **(7) Artificial “Igloo” Nest Box Program – Comparison of Breeding Success between Artificial and Natural Nest Sites:**

One of the objectives of this study has been to compare the breeding success of Tropicbirds nesting in artificial nests installed at the study locations, compared to that of birds nesting in natural rock cavities. This is important to confirm whether this is an effective method of counteracting impacts on the nesting population, caused by the loss of hundreds of natural nests from hurricane erosion over the last 20 years. This includes over 30 nests destroyed by hurricane “Igor” in 2010 during this present survey.

As of September, 2011, a total of 96 artificial nests have been installed (See Figs.5 & 6) at seven of the survey locations (Long Rock, Inner Pear Rock, Green Island, Nonsuch Island, Horn Rock, Southampton Island, and Shelly Bay). Breeding success rates at these artificial nests have been comparable in two of the three seasons during which this survey was carried out (Tables 3 and 4). In 2009, breeding success at artificial nests was 73.3 %, while at natural nest sites it was 59.0 %. In 2010, artificial nests had 61.3% breeding success, with natural nests having 76.1 % success, while in 2011 breeding success at artificial nests was at 81.1 %, compared to 67.8 % for natural nest sites. The lower breeding success for artificial nests (as compared to natural nest sites) during the 2010 season may have been due to the impact of hurricane “Igor” late in the nesting season. Many of the artificial nests have only been occupied recently, with recently established nesting pairs generally nesting later in the season than older pairs, which dominate in the natural nest sites. When the hurricane hit Bermuda in mid-September, most of the chicks in the natural nest sites had already fledged, while many of the chicks were still in more recently established artificial nests. Many of these were inundated, with chicks swept out and killed, by exceptionally high seas during this two-day hurricane.

When breeding success results from the previous 3-year period of this survey (2006 – 2008) are also factored in (Madeiros, 2008), it is evident that overall, breeding success is generally higher for the artificial nests than for the natural nests (See Tables 3 and 4). During the entirety of the 6-year period while the breeding success rates of artificial and natural Tropicbird nest sites have been compared, nesting activity was carried out a total of 328 times in artificial nests, of which 244 produced successfully fledging chicks. During the same period, nesting activity was carried out a total of 697 times in natural nests, of which 460 produced successfully fledged chicks.

The overall breeding success for all active artificial and natural Tropicbird nests over the last six years at the survey locations is therefore shown as follows:

Breeding Success of all active artificial Tropicbird nests 2006-2011: ..... 74.39%

Breeding Success of all Active Natural Tropicbird Nests 2006-2011: ..... 65.99%

The breeding success of the artificial nests appears to be markedly higher than that of natural nest sites, most likely because they can often be installed in ideal locations high enough on cliff edges to be out of reach of inundation by hurricane waves. The entrances of the artificial nests are also small enough that predators such as Crows find it hard to reach in to remove eggs or young chicks.

These results illustrate that the program of artificial nest installation has already been a success in maintaining and increasing the numbers of breeding pairs and fledged chicks and should be continued and, where appropriate, expanded. This technique also has potential application in many other locations where White-tailed Tropicbirds nest, especially in the Caribbean where this species has been confirmed as declining in numbers at many known nesting locations (Bradley and Norton, 2009).

**TABLE 3: BREEDING SUCCESS OF SURVEYED ARTIFICIAL TROPICBIRD NESTS**

2006 - 2011

YEAR	Total No. of Surveyed Nests	Total No. of Active nests	Nests with Successfully Fledged Chicks	Nests with Failed Breeding	Annual Breeding Success
2006	-	41	34	7	82.9%
2007	68	39	31	8	79.4%
2008	75	57	41	16	71.9%
2009	85	60	44	18	73.3%
2010	82	62	38	24	61.3%
2011	96	69	56	16	81.1 %

**TABLE 4: BREEDING SUCCESS OF SURVEYED NATURAL TROPICBIRD NESTS**

2006 - 2011

YEAR	Total No. of Surveyed Nests	Total No. of Active nests	Nests with Successfully Fledged Chicks	Nests with Failed Breeding	Annual Breeding Success
2006	-	74	56	18	75.6 %
2007	-	136	79	57	58.0 %
2008	183	132	84	48	63.6 %
2009	121	100	59	41	59.0 %
2010	171	109	83	26	76.1 %
2011	161	146	99	47	67.8 %





**Fig. 5: Barry Smith (foreman, Conservation Crew) installing artificial Tropicbird nest**



**Fig. 6: Artificial “Igloo” nest installed at Nonsuch Island by Conservation Crew (Left-Barry Smith; right-Kiwon Furbert)**

## **(8) Discussion and Recommendations:**

Based on these results, this survey shows the White-tailed Tropicbird maintaining a surprisingly high breeding success on Bermuda, both at managed and unmanaged locations. It also indicates that the nesting population is stable at most survey locations, and is even increasing slightly at five locations. However, numbers of active nest sites fell at three survey locations during the time of the survey (Nonsuch Island, Horn Rock and Southampton Island), due almost entirely to nest sites being destroyed during hurricanes.

Surveys over the last 6 years indicate an estimated local population range of 2500 – 3000 nesting pairs over the entirety of the Bermuda islands, compared to an estimated population of 4000 – 6000 pairs in the early 1900s (Gross, 1912). The basic conclusion of this report is that the White-tailed Tropicbird at present has a relatively stable breeding population on Bermuda, with some areas of the island experiencing moderate declines while others are showing moderate increases in the number of breeding pairs. The species is however subject to a number of threats on the island, of which the most serious is a shortage of suitable nest sites due to storm erosion and coastal development. Hundreds of Tropicbird nests have been destroyed or rendered unusable over the last 10 years alone due to erosion and coastal cliff collapse caused by hurricane waves. In addition, widespread coastal development has resulted in nesting areas at many coastal locations around the island being destroyed or covered by buildings, retaining walls, docks and terraces. It is submitted that these are the most important and detrimental limiting factors for the Tropicbird on Bermuda at the present time.

Predation by introduced mammal and bird predators such as Crows, rats, dogs and cats is also a threat. Large development projects in the coastal nesting habitat of Tropicbirds have also introduced domestic cats and dogs into areas they may not have previously had easy access to, and where they can predate on or impact nesting birds. Nest-site competition by escaped (feral) Domestic Pigeons or Rock Doves has previously had a major impact on the Tropicbird through their habit of taking over nesting cavities in large numbers. This threat has been effectively controlled in most areas of Bermuda by an ongoing culling program, carried out by licensed pest control officers, that has succeeded in reducing numbers of feral Pigeons by almost two-thirds. This has also been helpful in addressing a public health risk that Pigeons pose through contamination of drinking water by their droppings.

Another introduced pest species, the American Crow, can also become a major predator of Tropicbird eggs and chicks, although only a small number of Crows seem to develop the technique for doing so. However, even a relatively small number of Crows can do a large amount of damage in a small period of time. As they also can cause an enormous amount of damage to farmer's crops, Crows are periodically culled in specific areas, although there is no coordinated program to reduce their overall population, as is the case with the Domestic Pigeon.

**Recommendations** to reduce threats to Bermuda's breeding Tropicbird population and encourage more nesting and better breeding success include the following:

- 1) Artificial nests when correctly installed have been proven to be effective in counteracting losses of nests from hurricanes and hold great promise if more widely used. The artificial "Igloo" nest, which can be purchased from the Bermuda Audubon Society, is the most frequently used artificial nest, but nests can also be made from concrete blocks or paving stones and placed on cliff edges, walls or terraces overlooking the coastline. The present program for installing artificial nests should be continued and expanded, particularly in areas where natural nests have been destroyed by hurricanes or coastal development.
- 2) Control measures should be implemented or continued to control or eradicate introduced invasive mammal and bird predators which have been proven to kill Tropicbird adults or chicks at their nesting sites on Bermuda. These include rats, feral cats and crows. Domestic dogs and cats have also been proven to kill nesting Tropicbirds on relatively rare occasions, but can easily be controlled by their owners simply restricting them from nesting areas during the nesting season April to September.
- 3) Feral (escaped) Domestic Pigeons are serious competitors for the same coastal cliff cavities that Tropicbirds normally use for nesting. A control program for the Pigeon coordinated by the Department of Conservation Services has been very successful and has resulted in a resurgence of successful Tropicbird nesting activity in areas where almost all nest sites had been taken over by pigeons just ten years ago. It is essential that this control program, through trapping and shooting by licensed pest control officers, be continued to prevent rapid resurgence of the feral pigeon population.
- 4) A control program for the introduced American Crow, similar to that used for feral pigeons, should be seriously considered and would have benefits both for Tropicbirds and other native fauna, and for the agricultural industry on Bermuda.
- 5) The monitoring and banding program for the Tropicbird should be continued to provide more information on the breeding biology of the species.
- 6) At present, almost nothing is known of the oceanic range of Bermuda's breeding Tropicbird population, including the foraging range where adult birds gather food for their chicks and during the fall and winter months when they are not breeding on the island. It is recommended that a sample of adult breeding Tropicbirds are fitted with miniaturized archival geolocational data loggers, similar to those already fitted to Bermuda petrels or Cahows, and which have revolutionized knowledge of the oceanic range of that species. If sufficient funding is available, at least 10 to 12 loggers should be purchased and fitted to breeding adult Tropicbirds during 2012-2014.

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Finally, I would like to again thank my wife Leila, and children Seth and Elizabeth for allowing me the considerable time needed to carry out this survey over much of the last six years, and for assistance given in carrying out nest and chick checks.

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