

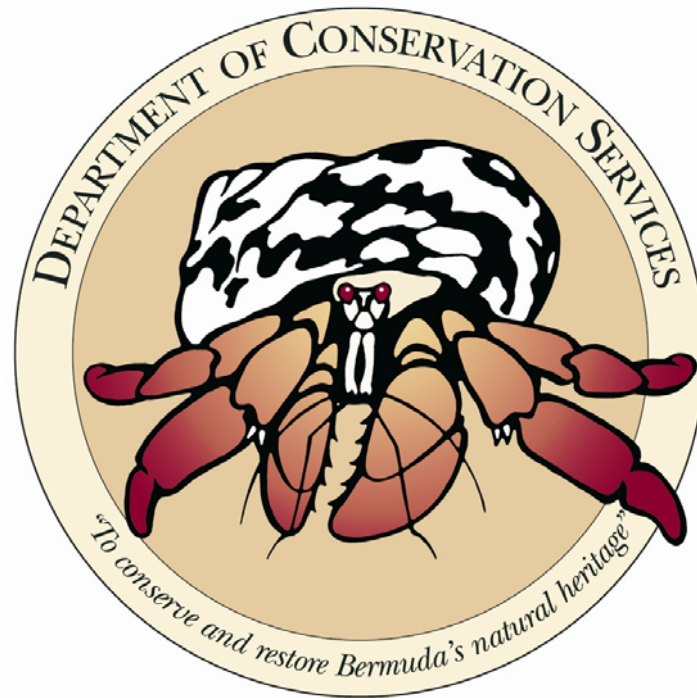
**BREEDING SUCCESS SURVEY OF WHITE-TAILED
TROPICBIRD *Phaethon lepturus catsbyii*
On the Islands of Bermuda – 2006 to 2008 Nesting Seasons
And
Comparison of Breeding Success between Natural and
Artificial ‘Igloo’ Nest Sites**



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Survey of Breeding Success
Of White-Tailed Tropicbird Chicks
Phaethon lepturus catsbyii
From Nonsuch Island Living Museum, Bermuda

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Breeding Success Survey of White-tailed Tropicbird
Phaethon lepturus catsbyii
On the Castle Harbour Islands, Bermuda
2006-2008 Nesting Seasons
Jeremy Madeiros

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EXECUTIVE SUMMARY:

Between April 2006 and October 2008 a Survey was carried out by the Terrestrial Conservation Officer (Dept. of Conservation Services, Bermuda Government, Ministry of the Environment) to determine the breeding success and status of Bermuda's only common nesting seabird, the White-tailed Tropicbird *Phaethon lepturus catsbyii*.

This species is widespread around the world's Tropical and Subtropical Oceans, with at least six sub-species found through the North Atlantic, South Atlantic, Indian and Pacific oceans. Bermuda hosts nearly half the breeding population of the North Atlantic subspecies with approximately 2000 pairs nesting on coastal cliffs and offshore islands, while another 2000 pairs are spread throughout the Caribbean basin.

Bermuda's Tropicbird population has been studied at various times in the past, with some of the most thorough observations of nesting behavior, measurement and photo-documentation of chick growth rates etc. being carried out by P. Gross in 1930. Further studies of breeding success were carried out by noted naturalist William Beebe on Nonsuch Island between 1929 and 1930, as described in his book 'Nonsuch, land of Water'. Bermuda's first conservation officer, David B. Wingate studied breeding success in a sample of between 118 and 200 nest sites on nine of the Castle Harbour Islands between 1970 and 1984, recording breeding success levels ranging between 49.6 % and 73.7 % annually. More recently, Mr. Patrick Talbot undertook to repeat Wingate's work, tagging and monitoring nests on the same nine islands over 3 years from 2002 to 2004.

The present survey was undertaken by the author in his role as Terrestrial Conservation Officer to continue and build on the breeding success studies restarted by Mr. Talbot. As the Castle Islands Nature Reserve is managed by the Terrestrial Conservation Division and the Conservation Officer also acts as warden for this Reserve, living on Nonsuch Island during much of the year, I was in a convenient situation to undertake regular monitoring of the important Tropicbird nesting concentrations in this area. The WT Tropicbird is also one of the keynote species for the Castle Harbour Islands, which contain possibly the largest concentration of nesting pairs of this species at any single site in the Atlantic Basin. As such, it is disproportionately important to the biodiversity of Bermuda, with a thorough understanding of the breeding success and biology of the Tropicbird being essential for the successful survival and management of the species.

A management program and recovery plan for the Tropicbird is essential in addressing threats and monitoring breeding success to enable the species to maintain and possibly increase its numbers on Bermuda, as has been the case with the Cahow or Bermuda petrel *Pterodroma Cahow*. The Cahow has experienced a recovery in breeding success, with a five-fold increase in breeding population over the last 45 years entirely due to an intensive management and research program for that species. Extension of many of the long-term management techniques used for the Cahow to the Tropicbird could have similar benefits for Bermuda's globally important nesting population of this beautiful and iconic species.

1. Introduction:

Bermuda supports the largest North Atlantic nesting colony of the White-tailed Tropicbird (*Phaethon lepturus catsbyii*), representing almost half the estimated breeding population for this subspecies (Schreiber and Lee, 2000). The WT Tropicbird is Bermuda's only common nesting seabird, with an estimated population of approximately 2000 nesting pairs. There are concerns that this population has decreased significantly over the last 45 years, from an estimated number of 3000 – 4000 pairs in 1960.

The population is known to be suffering from a number of human-induced problems contributing to a general decline in nesting pairs on the main inhabited islands of Bermuda. These include predation of eggs and chicks by introduced rats (*Rattus norvegicus* and *R. rattus*) and American Crows (*Corvus brachyrhynchos*), predation of adults and chicks by feral cats (*Felix domesticus*) and domestic dogs, and loss of nesting sites to coastal development (including the construction of docks, retaining walls and other coastal storm protection works). Cliff erosion from the effects of hurricane waves in recent years has also caused the destruction of a large number of natural nest sites.

The only area on Bermuda where the number of breeding Tropicbirds has remained largely stable over the last 40 years is the Castle Harbour Islands Nature Reserve. This area is managed to exclude rats and domestic animals and there is an ongoing program to install artificial nest sites to supplement existing sites and replace those destroyed by erosion during several major hurricane events between 1989 and 2006. These islands support a total of approximately 500 to 600 active nest sites, representing almost a third of Bermuda's remaining Tropicbird breeding population.

It has proven very difficult to gain an accurate idea of the exact size of Bermuda's breeding Tropicbird population, due to (1) the wide distribution of the population at scattered locations around the entire coastline of the islands, and (2) the inaccessibility of a high percentage of the nest sites in sheer and dangerous coastal cliffs. Indeed, the ability of the Tropicbird to use these cliffs, composed as they are of soft and crumbly limestone and too dangerous in most cases for human access, most likely is the main reason why the Tropicbird remains Bermuda's only common Seabird.

Due to the importance of Bermuda's breeding population of WT Tropicbird and concern that there has been a perceived decline in this population, a long-term study of approximately 250 Tropicbird nest sites was initiated in 2006 by the Terrestrial Conservation Officer on 7 of the Castle Harbour Islands. This follows on from a 3-year study of breeding success of some 300 nest sites on 9 of the Castle Harbour Islands carried out by Mr. Patrick Talbot as his Masters Thesis. Previous studies of nest sites in this area during the 1960s and 1970s by Dr. David Wingate also provide a baseline for breeding success of this species.

This present survey was undertaken with the aim of expanding upon survey methods used in the past so that direct comparison of results can be made and used to detect changes in breeding success and determine future management needs and recommendations for this beautiful and iconic species.

2. Survey Objectives:

This study has a number of short and long-term objectives aimed at providing increased understanding of the present status of Bermuda's Tropicbird population and providing guidelines for future management of the species. These are outlined as follows:

- Monitoring tropicbird breeding success in both natural and artificial nest sites on the managed Castle Harbour Islands Nature Reserves;
- Measuring growth rates of a sample of Tropicbird chicks on Nonsuch Island;
- Banding of both adult and fledgling birds to determine pair and nest fidelity, survival rates of fledglings and age of first return and breeding.
- Surveying Tropicbird nest sites at locations which are not managed to exclude rats or feral cats or control human disturbance. These sites act as controls and give insight into breeding success and causes of failure elsewhere on Bermuda.
- Locating and marking all safely accessible Tropicbird nest sites on selected islands within the Castle Harbour Islands Nature Reserve and control locations elsewhere on Bermuda.
- Comparison of breeding success between natural nests and artificial 'Igloo' nests.
- Identify present and potential threats and recommend management solutions.



Fig. 2: Adult White-tailed Tropicbird in nest cavity, Castle Harbour Islands.

3. Survey Methodology:

Methods used in this survey were similar to those used during previous surveys of Tropicbird nest sites carried out by D. Wingate and P. Talbot. Nest locations already marked and numbered during the previous surveys were re-used for the present survey on the Castle Harbour Islands, although many of the original nests had been destroyed or rendered unusable by hurricane activity, particularly Category 3 hurricane 'Fabian' in 2003. A number of new natural nest sites were discovered or had been occupied by new pairs of Tropicbirds since the last survey, and the program to install artificial 'Igloo' nest boxes has resulted in large numbers of new nests, which have all had to be numbered with plastic tags secured with stainless steel screws to the rock surface close to the nest entrances. New sites monitored in the survey (Bailey's Bay Island and Shelly Bay coastline) also had all of the safely accessible nests numbered and marked in this way.

Nests at each survey location were checked on average two to three times a month as weather and work schedules permitted. Because of the large number of nests scattered among many survey locations, it was usually not possible to check more than two to four locations on a given day. The exception to this was Nonsuch Island, which could be checked much more frequently as this author warden and lives on this island with his family during the summer months. Checks on Nonsuch could be generally made two to three times a week, which proved to be very valuable to monitor the growth and development of selected Tropicbird chicks (see Appendix 1, page 42).

During a check at a particular location, each marked nest was checked in turn for signs of visits (prints, excreta, feathers etc.) and whether a Tropicbird (or a pair) was present or not. If a bird was present, note was made whether it was incubating an egg or whether a chick was present, depending on what time of the breeding season the check was being made in. Note was also made of any rocks, pebbles, debris etc. that might be in the nest chamber, and an effort was made to remove if possible any such materials, which if left in the nest could cause egg breakage.

Once any chicks had hatched, note was made of its plumage development and what stage of growth it was in. Once chicks had reached the half-fledged to three-quarter fledged stage of development, it was briefly removed from the nest cavity if it was possible to reach it. Some deep nests required a small, long-handled net to reach and remove the chick. The chick was then put into a cloth weighing bag to gently restrain it and its body mass (weight) and wing chord length measured to determine its body condition and stage of development. Other morphometric measurements were also recorded if needed, including tarsus length, bill length, total head length etc. in particular with those chicks chosen for the growth study. Equipment used for this work included the following:

Incoloy Identification Bands (6.0mm internal diameter) – supplied by Porzana Ltd. (U.K. Wetlands Trust affiliation);

Banding Pliers – supplied by Porzana Ltd.

PESOLA precision spring weight scales (0-100g, 0-300g, 0-600g, 0-1000g) supplied by
AFO Banding Supplies, Box 1770 Manomet, MA 02345 508/224-6521
Cloth weighing bags – supplied by American Birding Association
Scherr - Tumico precision calipers (AFO Banding Supplies)
Wing chord rulers (AFO Banding Supplies)



Fig. 3: measuring culmen (bill) length on nearly fully-fledged tropicbird chick

4. Present Status of White-tailed Tropicbird on Bermuda.

The status of breeding populations of White-tailed Tropicbirds on the main islands of Bermuda, which are heavily developed with a dense human population, is only poorly understood and breeding success may vary widely between one area and another. These populations are much more exposed to predation from introduced mammal predators and other limiting factors caused by human activity than is the case on the Castle Harbour Islands, and are mostly unmanaged and unmonitored. Numbers of breeding pairs were thought to have declined to a much greater extent in these areas than on the smaller offshore islands, and the largest remaining groupings of nesting Tropicbirds on the main islands tend to be found on coastal cliff areas away from heavily populated areas. One common characteristic of these sites are cliffs sheer enough to prevent access by larger mammal predators such as domestic cats and dogs, in addition to discouraging undue human disturbance. Although higher, more extensive cliff areas can support larger numbers of nesting Tropicbirds, even small cliff areas 8' to 15' in height can support small groups of the birds, provided that there are suitable protected nest holes or cavities. In the past, Tropicbirds were far more widely dispersed around the main islands, even nesting in cavities in stone quarries and dry stone boundary walls on inland hillsides.

The aforementioned Castle Harbour Islands contain the largest remaining concentration of Tropicbird nest sites on Bermuda, with recent estimates of at least 500 to 550 nesting pairs. These islands have been managed since the early 1960s to exclude mammal predators such as rats, cats and dogs, and avian predators or competitors such as American Crow and Rock Doves have been prevented from nesting and culled when necessary. As a result, the total number of nesting pairs of Tropicbirds here is thought to have changed little in the last 50 years.

4.1. Summary of Threats to Tropicbirds on Bermuda

The White-tailed Tropicbird is subject to a number of natural and human-induced threats on Bermuda, which are summarized as follows:

(1) Predation of birds by mammal and avian predators

Bermuda originally had no native mammals, making it an ideal location for nesting seabirds. A number of mammal species have since been introduced by humans, both deliberately and accidentally. Some have been recorded as preying on adult or nestling Tropicbirds, including Black and Norway Rats (*Rattus rattus* and *R. norvegicus*), Domestic Cat (*Felis domesticus*) and Dogs. Rats are generally widespread and common across Bermuda, except on the Castle Harbour Islands Nature Reserve. The islands in this reserve are kept rat-free by annual baiting with anticoagulant rodenticides, which have provided good protection for seabirds such as the Tropicbird and the Bermuda Petrel, or Cahow. Rats tend to predate on eggs and young to half-fledged chicks in the nest cavities. Attacks on adult Tropicbirds and late-fledged chicks appear to be quite rare.

Predation by domestic and feral cats and dogs appears to be uncommon but some extreme examples have been documented. A number of adult and fledgling Tropicbirds have been killed by feral Cats in the Spittal Pond Nature Reserve sporadically over the last 15 years. Despite the protected status of this area, it is a common dumping-off location for unwanted Cats and feral Chickens by members of the public, who have been bothered by these animals on their own properties. They will sometimes trap these animals but, not wanting to see them euthanized, will take them to the nearest park, nature reserve or other open space area and release them. An extreme example of cat predation was documented in the 1980s when Government Conservation Officer D. Wingate was called to an area on the edge of the St. George's Golf Course on the north shore, where the carcasses of more than 25 adult White-tailed Tropicbirds were found under a thicket. A single large feral Tomcat was evidently responsible and was later observed dragging yet another freshly killed adult tropicbird into the thicket. This Cat had eliminated virtually all nesting pairs over a nearly half-mile stretch of the north coastline of St. George's Island and was later caught and destroyed by the Conservation Officer.

Feral Cats, often sustained by illegal feeding stations, continue to present in large numbers in many Park and Nature Reserve areas, where they decimate local and migratory bird and reptile populations.

In contrast to the situation with Cats, Dogs are well controlled on Bermuda and there have been only rare cases recorded of predation on Tropicbirds.

Avian predators include American Crows, which predate on Tropicbird eggs and young chicks, and Peregrine Falcons, which on rare occasions have preyed on both adult and fledgling Tropicbirds. Feral Domestic Pigeons are a serious competitor with Tropicbirds, having taken over almost 50% of cliff nesting cavities in the Harrington Sound area by 2005. They are the subject of an ongoing control program which had reduced their numbers by two-thirds in some areas by 2008.

(2) Hurricane & storm erosion and flooding

Severe storms such as hurricanes can pose significant threats to Tropicbirds, both by the direct destruction of nest cavities through cliff erosion and collapse, and through flooding of low-lying nest cavities by storm waves, which can result in the loss of eggs, chicks or adult birds. During hurricane 'Fabian' in 2003, over 300 known Tropicbird nest sites were destroyed on the Castle Harbour Islands alone, mainly on the seaward-facing sides of the islands, by waves recorded at over 35' (12 m) in height. This has created a shortage of available nest sites and has possibly caused an increase in fights between adult birds over the remaining suitable nest cavities. This threat is compounded by the overlap between the nesting season of the Tropicbird and the hurricane season, and early hurricanes in particular can result in significant loss of chicks, which are swept out of low-lying nests. The high number of nests that were destroyed in recent years by hurricanes has been addressed by a ongoing program of artificial nest installation (see section 7).

(3) Human disturbance and Coastal Development

Nesting failure of Tropicbirds has been documented in some areas of Bermuda by disturbance by people and stuffing of trash into nest cavities, especially by people fishing or eating lunch in rocky coastal areas. There have also been cases where well-meaning but misinformed members of the public have removed chicks from nests, believing them to have been abandoned by their parent birds and not understanding that the chicks are left alone in the nests while the adults forage for food out at sea.

The amount of development in coastal areas of Bermuda has increased considerably in recent years, and the construction of docks, stairways, retaining walls and terraces on rocky coastal areas have occasionally caused the destruction of or obstructed active Tropicbird nesting cavities. After consultations with the Bermuda Department of Planning, there are now provisions to protect Tropicbird nest sites affected by new coastal development applications. In some areas where it is impossible to avoid affecting Tropicbird nesting sites (see section 4.2.), it has been required for the developers to install artificial nests to provide alternate sites for the birds under guidance from the Department of Conservation Services, and to carry out construction outside of the nesting season when disturbance is more critical.

4.2. Protection, Research and Management of Tropicbirds on Bermuda

In recent years, there has been increasing concern about the declining population of Tropicbirds nesting on Bermuda. The Tropicbird, or 'Longtail' as it is commonly called on the island, is much loved by Bermudians who consider it to be the harbinger of Spring and a symbol of the islands. It has indeed achieved such iconic status that it supports a cottage industry which includes jewelry, photography, clothing etc. Recognition that this highly visible and beautiful species is declining in numbers has led to a number of conservation initiatives which affect protection, research and management of the population. These include the following:

- (1) The Tropicbird has been protected for many years by the Protection of Birds Act 1975, which states that it is an offence to take, sell, or have in one's possession a protected bird or the skin, plumage or egg of a protected bird. The Tropicbird has recently been given further protection as a threatened species under the Protection of Species Act 2003.
- (2) Research is now being carried out which is aimed at determining current population numbers, aspects of breeding biology, nesting success and habitat requirements of the species. This includes growth studies of Tropicbird chicks and a banding program for both fledglings and adult Tropicbirds, using metal identification bands and colored coil ring bands. In addition, a large number of nest sites in the Castle Harbour Islands Nature Reserve are being monitored annually for a study of breeding success in this area, which is intensively

managed to exclude mammal predators. This is coupled with studies of smaller groups of Tropicbird nests at other locations on the main islands of Bermuda, such as the coastline west of Shelly Bay in Hamilton Parish and the Spittal Pond Nature reserve in Smith's Parish, in addition to other offshore islands, such as Bay Island in Bailey's Bay and Palm Tree Island in Ely's Harbour.

- (3) There is now a program of artificial Tropicbird nest box installation (Fig. 3) to supplement natural nest sites and replace sites destroyed by hurricane and storm activity. These nest boxes are made of mold-formed compressed polystyrene foam shells strengthened with a 'fibrebond' fiberglass reinforced concrete-epoxy coating. These are called 'Igloo' nests because of their dome shape and are specially ordered and imported by the Bermuda Audubon Society. These are offered for sale to the public for installation on private coastal properties and are also used by the Terrestrial Conservation Division of the Dept. of Conservation Services, as part of an ongoing program of providing additional nesting sites in coastal nature reserve areas and islands. As of September, 2008, over 70 of these Igloo nests had been installed on 4 of the Castle Harbour Islands, including 48 on the Nonsuch Island Nature Reserve. One of the great advantages of these artificial nest sites is that they are built in such a way that it is easy to monitor them for signs of breeding activity, development of the chick etc. It is also easier to remove the birds from these artificial nests for morphometric measurements, banding (or ringing), growth studies of chicks etc. than it is from most natural nest sites (See Section 8, and Appendix 1).



Fig. 3: Artificial "Igloo" nest installed on cliff edge and camouflaged with natural rocks.

5. Breeding Biology of White-tailed Tropicbird on Bermuda



Figure 4: White-tailed Tropicbird egg removed from nest after being abandoned

The White-tailed Tropicbird is a widespread but never abundant seabird which falls within the family *Phaethontidae*. This family belongs within the order *Pelecaniformes*, which includes pelicans, boobies, cormorants, frigatebirds and anhingas. There are a total of three species of Tropicbirds, including the Red-tailed Tropicbird, which nests only in the Pacific and Indian Oceans; and the Red-billed Tropicbird, the largest of the family, which is found in the eastern Pacific Ocean, northwest Indian Ocean, South Atlantic Ocean and Caribbean Sea area of the North Atlantic Ocean. The White-tailed Tropicbird is the smallest, most delicate and graceful of the tropicbirds and also the most widely distributed, being found in all tropical oceans around the world (Seabirds, P. Harrison, 1985). It is also divided into several subspecies inhabiting different regions; *Phaethon lepturus fulvus*, which nests in the Indian Ocean on Christmas Island, has a rich, golden-apricot orange wash on its white plumage. *P. l. lepturus* nests on other island groups throughout the same ocean. *P. l. dorothea* nests throughout the Pacific Ocean from Hawaii to New Caledonia. The Western Atlantic subspecies, *P. l. catsbyii*, nests from Bermuda to the Bahamas and on various Islands throughout the Caribbean area. Bermuda has the largest breeding population of this subspecies with at least 2000 breeding pairs; this number equals the total remaining population estimated to nest throughout all islands

in the entire Caribbean area (Status and Conservation of West Indian Seabirds, E. A. Schreiber and David S. Lee, 2000).

The sexes are similar in appearance in the white-tailed Tropicbird, although the tail streamers of males average longer (Seabirds, Peter Harrison, 1985). There is no seasonal variation in plumage among adult birds. It is unclear how old W. T. tropicbirds are when they first return to breed. Banding studies of the species on Bermuda have been carried out since 2004 and seem to indicate that adult pairs generally return together to the same nest site, for at least several years consecutively. In several cases, one bird has returned to the same nest site for two to three years, but with different partners. Based on observations of other seabirds in the same family, it is most likely the male which chooses and defends particular nest sites, to which he attracts the same or different females during each nesting season. These aspects of breeding biology are still unclear and will be best answered by continuing banding/recapture studies over a longer period, backed with sexing of individuals, most likely by means of blood sampling.

The Bermudian population of White-tailed Tropicbird differs from the majority of the breeding populations of the species by being migratory, spending the cool winter months far to the south, most likely east of the Lesser Antilles and north of northern South America. This is most likely due to the fact that Bermuda is the most northerly breeding site for this species in the Atlantic basin, and is subject to much cooler temperatures in the winter months than any of the other, more tropical breeding locations.

On Bermuda, Tropicbirds make their first appearances as early as late February and early March, although nest site visitation and serious courtship activity does not generally commence until April. The highly visible aerial courtship flights, during which pairs of birds fly in unison one slightly above the other, sometimes with synchronized beating wings, sometimes slowly descending in a gentle glide, and attempt to bring the long tail streamers into contact, continues through most of the breeding season. A third bird very often accompanies the courting pair, but it is unknown whether this indicates competition between more than one male, if these are young or immature birds which are learning by observation or curiosity, or if there is another, so far undetermined role. Mating is carried out in the nest cavity, and not in the air as is commonly believed.

The first eggs are generally laid in late April and early May, after which both adults take turns incubating the egg for 40 to 48 days. Already-established, more experienced pairs often are the first birds to lay, with new, relatively inexperienced pairs generally nesting later in the nesting season. There is some evidence through personal observation that the first incubation shift, most likely by the male, is considerably longer at 8 to 14 days, after which the two adults take turns at 3 to 4 days each on incubation duties. More research could be carried out in this regard by color-marking the two adults.

A small percentage of otherwise intact eggs are abandoned each year, almost always by new pairs nesting for the first time. This appears to be because only one bird attempts to brood the egg after it is laid, and has to eventually leave to feed when it is not relieved by

its partner. It is unknown whether these are predominantly male or female birds, but this abandonment is probably due to the new pairs not yet having completely synchronized their nesting timing. This is supported by the fact that many of these failed pairs go on to successfully breed the following year on their second attempt.

The first hatched chicks are seen as early as late May and the beginning of June, with the majority of chicks hatching through June and July. Pairs of Tropicbirds nesting for the first time, and those that may have lost their egg early in the nesting season have produced chicks hatching as late as late August / early September. The chicks are fed whole squid (*Loligo sp.*) and small Flying Fish (*Cypselurus furcatus* and *Hirundichthys affinis*) and Ocean Robin-like fish, and grow rapidly (see Section 4). Tropicbird chicks often regurgitate their stomach contents when they are removed from nests for banding or growth measurement, and analysis has shown that the amount of food given by the adults to the chick can range from 25 grams to over 90 grams. A more usual feed consists of 40 – 70 grams and typically consists of 2 or 3 squid and 1 or 2 small fish.

Tropicbird chicks normally put on weight rapidly and can reach maximum weights ranging from 450 grams to as high as 620 grams. Chicks that are not being adequately fed, either through lack of adequate care from younger, inexperienced adults, premature abandonment or through death of one of the adults, do not gain adequate weight or develop fat reserves and have a high failure rate. The chicks normally reach their peak weights at about 45 to 50 days of age, after which the frequency of feeding visits by the adults usually diminishes and the chick uses its accumulated fat reserves to complete its development, losing weight over the last 14 – 21 days before final departure.

Tropicbird chicks on Bermuda normally fledge from the nest and fly to sea at about 65 days after hatching. They gradually lose some weight during the last two weeks in the nest, and fledge normally at 320 to 369 grams in weight. There are no practice flights and the chick departs and heads to sea on its own and apparently without parental involvement or assistance.

On their departure from the nest site, chicks often initially can not get airborne, especially from low-lying nests, and fall or land in the sea. These birds will then generally bathe to rid their plumage from soil or excreta accumulated from their stay in the nest and will then swim and/or flap further out to sea if close inshore. They will then attempt to take off from the water and fly offshore, but face a real danger of having their plumage become waterlogged, be unable to become airborne, and eventually drown. A number of recently fledged, waterlogged chicks are picked up by Department boats or members of the public every year and either kept overnight to dry out, being released from the cliffs of Nonsuch Island the next day, or if underweight or underdeveloped taken to the Wildlife Rehabilitation centre at the Bermuda Aquarium, Museum and Zoo (BAMZ). Here they are force-fed and monitored until ready to fledge and are fitted with identification bands before being released. Nevertheless, a number of Tropicbird chicks perish when they attempt to fledge from nests, fall into the water and become waterlogged, and this is now seen as a significant source of fledging mortality.

6. Studies of White-tailed Tropicbird Breeding Success on Bermuda: 2006 - 2008 Breeding Season Surveys

Because of the importance of Bermuda's Tropicbird population as the largest North Atlantic breeding colony (and the largest single breeding colony of the *Phaethon lepturus catsbyii* subspecies), it is of critical importance to gain an understanding of the breeding success of this species on the island, as well as determining threats to the species, causes of breeding failure, nest disturbance and nest site availability.

This study was undertaken as a continuation of work initially carried out over a three-year period by Patrick Talbot (Head Aquarist at the Bermuda Aquarium, Museum and Zoo) as part of his master's thesis. Between 2001 and 2004, a total of 346 Tropicbird nest sites on nine of the Castle Harbour Islands were monitored monthly by Mr. Talbot and assistants. Note was taken of nesting activity (if any), eggs laid, chicks hatched, chicks fledged, nests destroyed and new nests occupied. Banding (ringing) of tropicbird chicks and adults was also undertaken from 2003 to 2009 by the Terrestrial Conservation Officer to study whether the same adults return to the same nest sites on consecutive years, whether pairs stay together over long periods, age of chicks when they first return to nest, and whether chicks return to the island of their birth as adults.

This report covers surveys of Tropicbird breeding success carried out by the Terrestrial Conservation Officer during the 2006, 2007 and 2008 nesting seasons for the species. The following details were recorded and tabulated for each nesting season:

- Total number of nest sites monitored at each survey location
- Total number of nest sites where nesting activity was confirmed
- Active nest sites with successful breeding/chick successfully fledged
- Active nest sites with failed breeding
- Inactive/vacant nest sites with no nesting activity confirmed
- Number of nest sites with new prospecting activity, where nests are visited by new pairs of Tropicbirds but no egg-laying takes place.

6.1. Description of Survey Locations:

In order to obtain a thorough idea of breeding success for the White-tailed Tropicbird on Bermuda, a number of coastal locations with differing physical characteristics were chosen which were representative of breeding habitat used by the species throughout the rest of the Bermuda Islands (see Fig. 5). The Castle Islands Nature Reserve was chosen for the majority of the sites, as at least 14 of the islands making up this area are known to support Tropicbird nest sites (see Fig.6). Eight of these were chosen for this survey, representing a wide range of physical size, topographical/geological characteristics, exposure to storm/hurricane erosion & flooding and total number of nest sites/colony size. Three of these islands (**Long Rock**, **Green Island** and **North Cock Rock**) are extremely low in elevation at only 12' to 18' (4m to 6m) above high water mark and

Tropic Bird Breeding Survey Sites 2006-2008

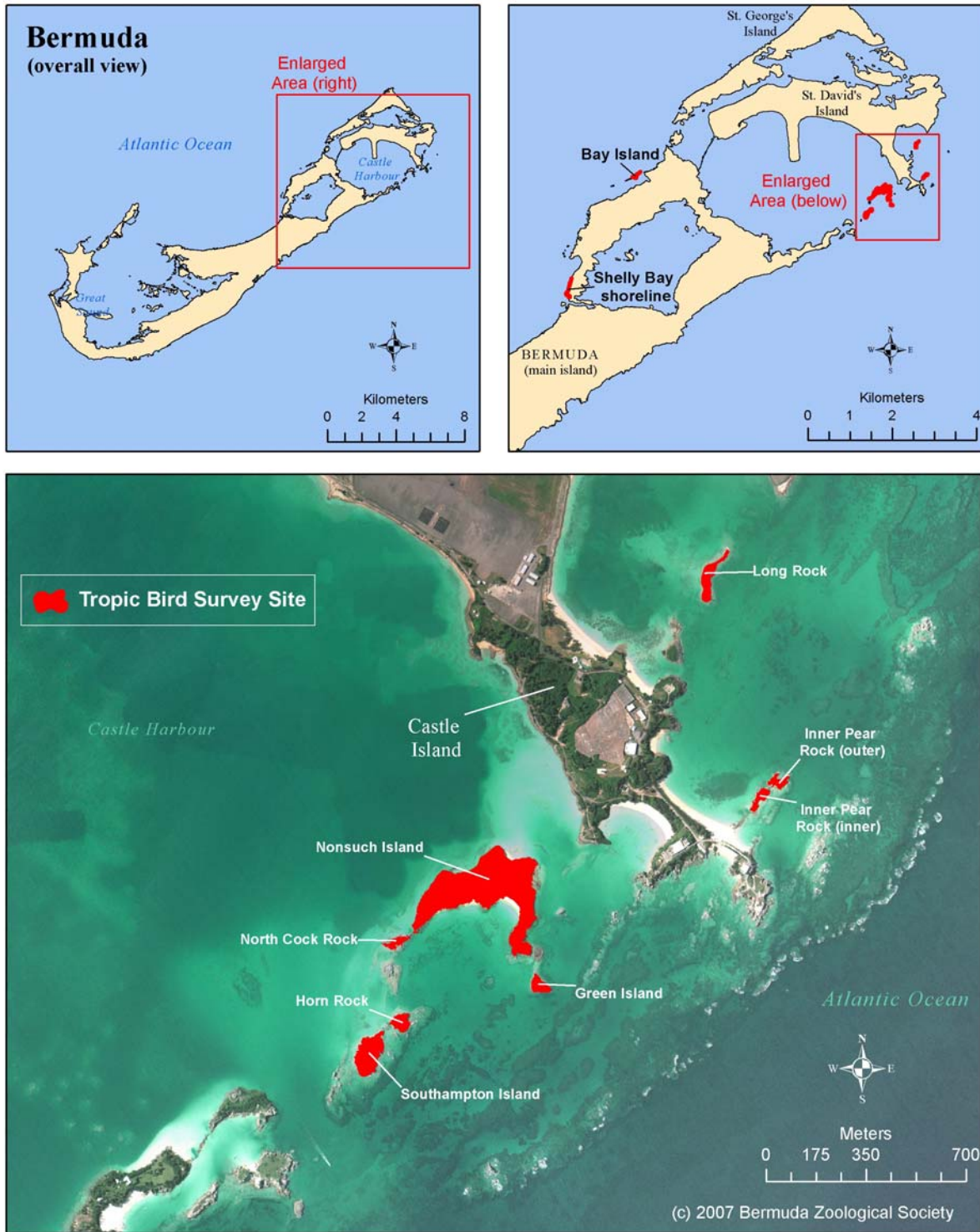


Fig. 5: Tropicbird Breeding Survey Site Locations 2006 – 2008

*Breeding Success Survey of White-tailed Tropicbird
Phaethon lepturus catsbyii
On the Castle Harbour Islands, Bermuda
2006-2008 Nesting Seasons
Jeremy Madeiros*

are completely overwashed by high waves and storm surge during hurricane events, causing severe erosion and damage to or destruction of nest sites. Almost all soil has been washed off of these low islands, resulting in extremely restricted vegetation cover, generally prostrate specimens of Buttonwood *Conocarpus erecta*, Sea Ox-eye *Borrchia arborescens* and Sea Purslane *Sesuvium portulacastrum*. Four Islands (**Inner Pear Inner Rock, Inner Pear Outer Rock, Horn Rock** and **Southampton Island**) are higher in elevation at 25' to 32' (8m – 10.5m) above high water and are composed of softer rock formations (generally 'Southampton' formation aeolianite limestones no more than 50,000 to 70,000 years of age). These islands are characterized by high, eroded cliffs rising to central elevated areas with a layer of thin sandy soil supporting a thick low growth of salt-tolerant native coastal plants. The most common vegetation on these islands includes Sea Ox-eye, Prickly Pear cactus *Opuntia stricta* var. *dilenii*, Sea Lavender *Mallotonia graphalodes*, Sea Purslane, Scurvy Grass *Cakile lanceolata* and the endemic Darrell's Fleabane *Erigeron darrellianus* and Bermudiana *sisyrinchium bermudiana*. The rare native coastal shrub Coast Sophora *Sophora tomentosa* is also found on Horn Rock and native Bay Grape *coccoloba uvifera* and introduced Tamarisk *Tamarix gallica* form low, windswept clumps on Southampton Island.

The final Island used as a survey location in the Castle Harbour area is **Nonsuch Island**, which is considerably larger at 15.5 acres and of higher elevation at up to 65' above high water than any of the other islands used as survey locations in this area. With extensive high sea cliffs on both its northern and southern coastlines, Nonsuch also supports the largest number of Tropicbird nest sites of all the Castle Harbour Islands, with an estimated total of over 140 active sites, about half of which are safely accessible and included in the survey. Nonsuch is formed from the same relatively recent soft Southampton formation limestone previously mentioned, and differs greatly from the other islands in being covered with a dense forest cover composed of Native and endemic tree species. This forest cover has been replanted starting in 1962 as one of the earliest and most successful examples of ecological restoration, a project which continues to the present day. The main canopy tree species include the endemic Bermuda Palmetto *Sabal bermudana*, Bermuda Olivewood *Cassine lanceanum* and Bermuda Cedar *Juniperus bermudiana*, grading to Bay Grape and Buttonwood nearer to the coastline. Understory species include Bermuda Snowberry *Chiococca bermudiana*, White Stopper *Eugenia auxillaris*, Forestiera *F. segregata* and Bermuda Sedge *Carex bermudiana*.

All of the Castle Harbour Islands used in this survey are designated Nature Reserves and as such are managed to exclude non-native plant and animal species. Particular emphasis is placed on eradication of introduced mammal species and all islands are monitored and maintained Rat and Mouse-free and are off-limits to domestic animals. Other introduced species such as American Crow *Corvus brachyrhynchos* and the Kiskadee Flycatcher *Pitangus sulphuratus* are monitored and their numbers kept to a minimum by selective shooting when necessary. These measures are undoubtedly beneficial for the Tropicbirds and other bird and plant species surviving on these islands. Rats and American Crows in particular are known predators of Tropicbird eggs and chicks. One group of four Crows living on the Frick's Point property at the east end of the Tucker's Town peninsula was

responsible for predating on more than 45 Tropicbird eggs and an unknown number of young chicks over a four-week period during June and July, 2007 before three were shot by a pest control officer. No further egg predation was noted after this control measure.

The two control sites are quite different in appearance and the amount of management they receive than the aforementioned locations. **Bay Island** is located in Bailey's Bay on the north shore of Bermuda's main island in Hamilton Parish. It is a high, heavily eroded island of about two acres (0.8 Ha) composed of a younger, soft aeolianite limestone similar to that of Inner Pear Rock or Horn Rock. The only vegetation is a forest of invasive introduced Casuarina trees *Casuarina equisetifolia*, with coastal species such as Sea Ox-eye and various grasses in the more open areas. Mr. Mark Outerbridge first located and monitored a number of Tropicbird nest sites here and informed me of this location in 2006. This island is privately owned and is known to have a population of rats in addition to being a roost site for a varying number of American Crows.

The last site is located along a quarter-mile long stretch of the north shoreline of the main island of Bermuda just west of **Shelly Bay** in Hamilton Parish (see Fig. 5). This site consists of steeply sloping eroded shoreline with coastal cliffs from 18' to 30' in height. This area is easily accessible from the adjacent Railway Trail and is heavily used by the general public for fishing, jogging and dog-walking. Many of the Tropicbird nests in this area are very exposed and vulnerable and there has been a problem with some nest holes being stuffed with trash left by people fishing from the cliffs. This area is also visited by Rats eating discarded bait and food scraps and is vulnerable to both human disturbance and domestic animals. This site has been regularly monitored and visited by Ms. Michelle Pasquin for the last few years, and she first alerted me to the site and has photographed the nests and regularly removed trash from nest sites and the surrounding area. The success of this site despite its less than ideal situation, which will be covered in the following sections, is largely due to her commitment to and concern for the Tropicbirds nesting along this area.

6.2. Summary of 2006 Tropicbird Breeding Success Survey

During the 2006 Tropicbird breeding season, a total of 170 nest sites were monitored regularly at eight different locations between mid-April and late October. These locations consisted of six of the Castle Harbour Islands (Long Rock, Inner Pear Rock Inner, Inner Pear Rock Outer, Green Island, Nonsuch Island, North Cock Rock and Horn Rock) and Bay Island, Bailey's Bay. Following is a breakdown of survey results for each location:

Nonsuch Island:

The survey location with the largest number of nest sites was Nonsuch Island, with 58 monitored Tropicbird nests. Of these, 13 were recorded as inactive, with no adult birds seen or nesting activity observed. Of 40 active nest sites on Nonsuch, there were 32 nests with chicks successfully fledged and 8 nests with failed nesting. This represents 80% breeding success among active nest sites. In addition, new prospecting activity was observed in 5 nests.

Long Rock

This is the easternmost of the islands surveyed and also is one of the lowest in elevation, making it vulnerable to hurricane and storm wave overwash. Four of the nests were located in cement burrows originally built for Bermuda petrel *Pterodroma cahow*. There were a total of 16 nest sites monitored, of which 6 were inactive in 2006. Tropicbird chicks successfully fledged from 7 of the remaining nests, while nesting failed in the remaining 3. This represents 70% breeding success among active nest sites.

Inner Pear Rock (Outer)

This island was among those severely eroded during hurricane Fabian in 2003, with a number of nest sites destroyed or damaged. Among the nests being monitored are six artificial Tropicbird 'Igloo' nests installed after the hurricane to replace destroyed natural nest sites. Out of 20 nest sites, five were recorded as inactive, while active sites produced 9 successfully fledged chicks, 5 failed nest sites (64 % breeding success). Prospecting activity was recorded in 1 nest.

Inner Pear Rock (Inner)

This heavily eroded island had only nine monitored Tropicbird nests, with three inactive sites. Of the remainder, four were successful and produced fledged chicks, while nesting failed in two (66% breeding success in active nest sites).

Horn Rock

This island supported the second-highest number of Tropicbird nests in the 2006 survey, with 41 monitored nests. Horn Rock was also heavily impacted by hurricane Fabian, losing over 50% of all nest sites in 2003, so the present number includes 16 artificial nests installed or built after the hurricane. These comprise 13 'Igloo' nests, in addition to two which were built by cementing slabs of rock together to create sheltered cavities, and one in a disused concrete cahow nest burrow. Seven nests were inactive in 2006, while of the thirty active nests, Tropicbird chicks successfully fledged from sixteen, with nesting failure in fourteen (53% breeding success). In addition, prospecting activity was noted in four nests.

Green Island

This low, exposed island only supports eight Tropicbird nest sites, two of which are in concrete burrows originally built for Cahows (Bermuda Petrels) *Pterodroma cahow*. Four sites were inactive in 2006, while three nests produced successfully fledged Tropicbird chicks and one nest failed (75% breeding success)

North Cock Rock

This is the smallest and most low-lying of the locations surveyed and only contains three monitored Tropicbird nests. One nest was inactive, while a successfully fledged chick was produced at one and prospecting activity was recorded in the last nest (50% breeding success).

Bay Island (Bailey's Bay)

This was the only site that was surveyed in 2006 that was not in the Castle Harbour Islands Nature Reserve. It is an unmanaged site that is known to contain both Rats and a roosting site for American Crows, both of which are known to predate on Tropicbird eggs and young chicks (see section 6; page 16). Out of a total of 15 Tropicbird nests at this location, three were inactive while chicks successfully fledged in ten nests, one nest failed, and prospecting activity was recorded in one nest (91% breeding success).

Summary for Surveyed Castle Harbour Islands only (2006):

For the Castle Harbour locations surveyed, there were a total of one hundred and fifty-five Tropicbird nest sites which were regularly monitored. Thirty-nine of these were inactive, while breeding activity was recorded in one hundred and five. Of these nests, chicks successfully fledged from seventy-two, with breeding failure in thirty-four (68.5% breeding success). New prospecting activity was noted in eleven nests. (See Table 1, page 21 for a full summary of survey results for the 2006 breeding season).



Fig. 6: Tropicbird Breeding Survey Location on Castle Harbour Islands

This season was impacted by Category 1 hurricane 'Florence' which passed only 54 miles to the west of Bermuda on the 11th September, affecting the island with large surf up to 20' to 25' and winds gusting up to 111 mph. This storm was late enough in the Tropicbird breeding season so that most chicks had already fledged, but at least 4 of the chicks being monitored were swept out of low-lying nests and killed, while another 5 chicks were temporarily removed from low nests and kept in boxes at my house on the

main island where I rode out the hurricane with my family. Two of these were returned successfully to their nest sites the day after the storm, but the nest sites of the other three were destroyed by the high waves and erosion associated with the hurricane. These birds were fed on a diet of packaged Squid (*Loligo sp.*) and fresh Anchovies (*Sardinella anchovia*) obtained from the Bermuda Aquarium, Museum and Zoo. These and several other Tropicbird chicks that were taken into care by myself or the Wildlife Rehabilitation Centre at BAMZ all completed their development and were taken out to Nonsuch Island from where all eventually fledged successfully out to sea.

TABLE 1:
TROPICBIRD BREEDING SUCCESS SURVEY RESULTS (2006)

Location	Total number of nests	Inactive nests	Active nest sites (chick successfully fledged)	Active nests (Failed)	Nests with prospecting activity
Nonsuch Island	58	13	32	8	5
Long Rock	16	6	7	3	
Inner Pear (Outer)	20	5	9	5	1
Inner Pear (Inner)	9	3	4	2	
Horn Rock	41	7	16	14	4
Green Island	8	4	3	1	
North Cock Rock	3	1	1		1
Bay Island Bailey's Bay	15	3	10	1	1
Total Number of Nest Sites	170	42	82	34	12
Castle Harbour Islands only	155	39	72	33	11

Breeding Success (Total) = 70.6%

Breeding Success (Castle Harbour Islands Only) = 68.5%

2006 – TOTAL FIGURES FOR ALL SITES:

Number of Tropicbird nest sites monitored at all survey locations 170
 Number of sites with nesting activity confirmed 116
 Number of sites with chicks successfully fledged 82
 Number of sites with new prospecting activity 12
 Number of sites with no nesting activity recorded 42

6.3. Summary of 2007 Tropicbird Breeding Success Survey

For the 2007 Tropicbird breeding season, a total of 257 nest sites were monitored at ten different locations around the eastern section of Bermuda. Eight of these were on Islands in Castle Harbour, including Long Rock, Inner Pear (Outer) Rock, Inner Pear (Inner) Rock, Green Island, Nonsuch Island, North Cock Rock, Horn Rock and Southampton Island. These are all sites which are designated Nature Reserves and are managed to exclude mammal predators, including rats, cats, dogs etc. and where human impact and disturbance is minimized. The remaining two locations were Bay Island in Bailey's Bay and the Shelly Bay coastline on the north shore of Hamilton Parish.

Following are full accounts of the number of nest sites at each survey location during the 2007 season, with their respective status and breeding success of the active sites:

Nonsuch Island

The site with the greatest number of observed nest sites was Nonsuch Island, with 67 nests being monitored. This is an increase from the 58 nest sites monitored in 2006. The increase was due to the installation of new artificial nest sites as part of the management program for the species (5) and by the discovery of new sites on the island which were added to the survey list (4). Of the nest sites surveyed, 56 were listed as active, while prospecting activity was recorded at 10 additional nest sites. Another 11 nest sites were recorded as being inactive. Of the active nest sites, chicks successfully fledged from 31 sites, while another 15 sites had failed breeding (representing 67.3 % breeding success).

Long Rock

Out of a total of 16 Tropicbird nest sites on Long Rock, 13 were recorded as active and 3 as inactive. Of the active sites, 8 produced chicks that successfully fledged while nesting failed in five nests (61.5 % breeding success).

Inner Pear (Outer)

Out of 19 Tropicbird nest sites located on this island, 14 were active, 2 had prospecting activity, and 3 were inactive. Of the active nest sites, chicks successfully fledged from 10 sites, while nesting failed at 4 sites (71 % breeding success).

Inner Pear (Inner)

Out of a total of 14 Tropicbird nest sites on this island, 10 were recorded as being active, with 4 being inactive. Of the active nest sites, chicks fledged successfully from 7, while 3 failed (representing 70% breeding success).

Green Island

Out of a total of 9 Tropicbird nest sites on this island; 2 were inactive, 7 active, and 1 had prospecting activity. Out of active nests, 3 were successful and 3 failed (50 % breeding success).

Horn Rock

This relatively high island contains a large number of Tropicbird nests, including 13 artificial 'Igloo' nests. There were 5 additional nest sites established since 2006, for a total of 46 monitored nest sites.

33 of these nest sites were active, with 21 having successfully fledging chicks, and 12 being unsuccessful (64 % breeding success). A total of 6 nests were inactive his season. Prospecting activity was observed in 7 nests.

Southampton Island

This island contains a considerable number of nest sites, including 8 artificial 'Igloo' nest boxes. There were a total of 45 Tropicbird nest sites monitored on Southampton Island during 2007, 7 of which were inactive, with 32 active nest sites. Of the active nest sites, chicks fledged successfully from 16 of them, with failed breeding at 16 nests (50% breeding success). There were 6 nests with new prospecting activity.

Bay Island (Bailey's Bay)

This unmanaged island has a total of 20 Tropicbird nests in 2007, of which 4 were inactive; there were a total of 13 nests with breeding activity, with 10 producing successfully fledged chicks and 3 with failed breeding. Prospecting activity was observed in 3 additional nests.

Shelly Bay Coastline

This new site was added to the survey this year and is located on the north coastline of the main island of Bermuda, as a unmanaged site with a known rat population and which is subject to considerable human disturbance. There are a total of 18 Tropicbird nests at this site, of which 2 are inactive. Out of 15 active nests at this site, 12 produced successfully fledged chicks and 3 had failed breeding (80 % breeding success). Prospecting activity was observed at 1 additional nest.

Nesting Summary for 2007

The total number of nest sites being monitored increased substantially from 170 in the 2006 breeding season to 257 in 2007 (see Table 2). This increase is mainly due to the inclusion of Southampton Island (45 monitored nests) and the Shelly Bay coastline (18 monitored nests) in the survey, and new nests on 3 of the original surveyed islands. Out of a total of 257 Tropicbird nest sites which were monitored in the 2007 breeding survey, 43 were inactive with no adults or nesting activity seen. A total of 193 nests showed signs of breeding activity, with 119 producing successfully fledged chicks and 74 with failed nesting (eggs laid but failed or disappeared, chicks died or disappeared before fledging). This represents a total breeding success of 61.25 %. There were a total of 31 nests with prospecting activity. The increase in nests with prospecting activity over last year is noteworthy as it indicates significant numbers of newly establishing pairs of Tropicbirds that will often produce their first eggs the following year.

For the Castle Harbour Islands only, a total of 213 nest sites were monitored, with 33 being inactive, 95 successfully producing fledged chicks, 68 with failed nesting, and 27 with prospecting activity. On the other two, unmanaged sites, Bay Island in Bailey's Bay had 20 monitored nest sites, with 4 being inactive, 10 with chicks successfully fledged, 3 with failed nesting, and 3 with prospecting activity. The Shelly Bay coastline area produced some of the most surprising results, with 18 observed nest sites producing a total of 12 successfully fledged chicks. Two of the nests in this location were inactive,

Three had failed nesting, and one had prospecting activity. There was therefore 70% breeding success for the active nest sites at this location, the highest figure out of all locations monitored during 2007. This result was surprising given the presence of both Rats and American Crows, which are known predators of Tropicbird eggs and chicks.

TABLE 2
**Breakdown of Breeding Success and Nest Numbers at each Survey Site:
 (2007 Nesting Season)**

Location	Total number of nest sites	Inactive nest sites	Active nest sites (chick successfully Fledged)	Active nests (failed)	Nests with prospecting activity
Nonsuch Island	67	11	31	15	10
Long Rock	16	3	8	5	
Inner Pear Outer	19	3	10	4	2
Inner Pear Inner	14	4	7	3	
Green Island	9	2	3	3	1
Horn Rock	46	6	21	12	7
Southampton Island	45	7	16	16	6
North Cock Rock	3	1	1		1
Bay Island, Bailey's Bay	20	4	10	3	3
Shelly Bay Coastline	18	2	12	3	1
Total Number of Nest Sites	257	43	119	64	31
Castle Harbour Islands only	219	37	97	58	27

Breeding Success (All Active Nest Sites) = 65 %

Breeding Success (Castle Harbour Islands Only) = 62.5 %

2007 - TOTAL FIGURES FOR ALL SITES:

Number of Tropicbird nest sites at all survey locations 257
 Number of sites with nesting activity 183
 Number of sites with chicks successfully fledged 119
 Number of sites with new prospecting activity 31
 Number of sites with no activity 43

6.4. Summary of 2008 Tropicbird Breeding Season Survey

During the 2008 Tropicbird breeding season, a total of 259 nest sites were monitored again at ten separate locations, Long Rock, Inner Pear Rock (Outer), Inner Pear Rock (Inner), Green Island, Nonsuch Island, Horn Rock, Southampton Island, Bay Island (Bailey's Bay) and the Shelly Bay coastline (Main Island). These were the same locations surveyed during 2007. A number of new nest sites were discovered at these locations during this survey, accounting for the slight increase in monitored nest sites from the 2007 season.

Although no major hurricane affected Bermuda in 2008, Tropical Storm 'Bertha' made an almost direct hit on the island in late July with heavy rain and strong winds gusting up to hurricane force (75 mph). Several days before impacting the island, 'Bertha' had briefly become a Category 3 Hurricane when well southeast of the island, with the southern coastline of Bermuda was subjected to medium – sized groundswell for several days. This necessitated rescuing 5 Tropicbird chicks from low-lying nest sites and putting them into cardboard boxes where they were fed daily with Squid and fresh Anchovies until they were ready for fledging. The rehabilitation facility at the Bermuda Aquarium, Museum and Zoo also had 6 chicks arrive at their facility following the storm. All but 1 of these rescued chicks eventually fledged successfully to sea. Very few chicks appeared to have been killed by the storm, with only 2 failures directly caused by monitored nests being overwashed by 'Bertha's' waves.

Following is a breakdown of results for nesting activity at all monitored sites during the 2008 nesting season:

Nonsuch Island again contained the largest number of monitored nest sites, with a total of 71 nests, of which 49 were active, 39 which produced successfully fledging chicks, and 10 of which failed. 14 nest sites also had prospecting visits, while 8 nest sites were inactive. Since Nonsuch supports 140 – 150 Tropicbird nest sites, the monitored nests represent about half of all nests on the island. The remaining nests are located on the inaccessible northern and southern cliff faces.

Long Rock (Total of 17 nest sites, 13 of which were active, 10 of which had chicks successfully fledged, 3 of which failed, and 4 which were inactive).

Inner Pear Rock (Outer)

Total of 20 Tropicbird nest sites, of which 10 were active; of the active nests, 7 successfully produced fledged chicks, while nesting failed in 3 nests (70% breeding success). There was also new prospecting activity at 1 nest.

Inner Pear Rock (Inner)

This island had a total of 11 Tropicbird nest sites, of which 9 were active; of the active nests, chicks successfully fledged from 6, while nesting failed at 3 nests (66.6% breeding success).

Green Island

There were a total of 9 Tropicbird nests on this island during the 2008 nesting season; of these, nesting activity was recorded at 5 nests, with chicks successfully fledging from 3 nests, while there was nesting failure at 2 nests (60% breeding success). There were also prospecting visits at 1 nest.

North Cock Rock

This low islet has the smallest number of nests of any location on the survey, with 2 active nests producing 1 successfully fledging chick and 1 failure (50% breeding success).

Horn Rock

This island has the second-highest number of Tropicbird nests of any location on the survey, with 50 nests in 2008, of which 37 showed nesting activity. Of the active nests, 22 produced successfully fledged chicks, while breeding failed in 15 nests (59.4% breeding success). In addition, there was prospecting activity at 6 nests.

Southampton Island

This relatively large island had a total of 44 Tropicbird nests in 2008, of which 36 had nesting activity; of the active nests, a total of 20 produced successfully fledged chicks, while there was breeding failure in 16 nests (55% breeding success). There were prospecting visits at 2 nests.

Bay Island (Bailey's Bay)

This unmanaged island had a total of 18 Tropicbird nests in 2008, of which 13 had nesting activity; of the active nests, 10 produced successfully fledged chicks, with breeding failure in 3 nests (76.9% breeding success). 2 nests had prospecting activity.

Shelly Bay Coastline (Main Island of Bermuda)

The coastline west of Shelly Bay, in Hamilton Parish on the main island of Bermuda, had a total of 16 Tropicbird nests in 2008. Out of these, a total of 11 had nesting activity, with 8 producing successfully fledged chicks, and 3 experiencing nesting failure (72.7% breeding success). In addition, there was prospecting activity at 2 nests.

TABLE 3:

**Breakdown of Nest Numbers and Breeding Success at all Survey Sites
(2008 Nesting Season)**

Location	Total No. of Nests	Inactive Nest Sites	Active Nests with Fledged Chicks	Active Nests with Failed Breeding	Nests with Prospecting Activity
Nonsuch Island	71	22	39	10	14
Long Rock	17	4	10	3	4
Inner Pear Rock (Outer)	20	10	7	3	1
Inner Pear Rock (Inner)	11	2	6	3	0
Green Island	9	4	3	2	1
Horn Rock	50	13	22	15	6
North Cock Rock	3	1	1	1	0
Southampton Island	44	8	20	16	2
Bay Island (Bailey's Bay)	18	5	10	3	2
Shelly Bay Coastline	16	5	8	3	2
Total Number of Nest sites	259	74	126	59	32
Castle Harbour Islands Only	224	64	108	53	28

Total Breeding Success (All Active Nest Sites) = 68.1 %

Breeding Success (Castle Harbour Islands Only) = 67 %

2008 – Total Figures for all Sites:

Number of Tropicbird nest sites at all survey locations258

Number of nest sites with nesting activity 185

Number of nest sites with chicks successfully fledged 126

Number of nest sites with new prospecting activity 32

Number of inactive nest sites with no activity 73

7. Use and Installation of Artificial Tropicbird ‘Igloo’ Nests:

7.1. Description of Artificial Nest Program:

As previously mentioned, there is an ongoing program of artificial Tropicbird nest installation. This is the result of a successful collaboration between the Bermuda Government’s Department of Conservation Services and the Bermuda Audubon Society (BAS), an environmental NGO (Non-Governmental Organization) specializing in the protection and restoration of wetlands and other natural habitats important to resident and migratory birdlife. In this collaboration, the Audubon Society has developed the ‘igloo’ artificial nest design, which is formed of light but heavily insulating compacted polystyrene cast over a mold into a half-dome shape (hence the ‘Igloo’ designation) with 2” thick walls about 2’ (24”) in diameter (see Figs. 3 and 7). These basic domes are manufactured in the United States and are shipped to Bermuda in packing boxes. Once the domes have been received, they are prepared by carefully cutting a approximately 4” by 6” (10 cm by 15 cm) entrance hole into the bottom of one side of the dome, then a 2” by 1.5” (5 cm by 4 cm) ventilation hole on the opposite side and two-thirds of the way to the top of the dome. The domes are then coated by Conservation Services workers or BAS volunteers with at least two layers of ‘Fibrebond’ (fiberglass-reinforced concrete) mix to both the inside and outside of the dome, which provides strength and durability.

Almost 300 ‘igloo’ nests have been installed on Government and BAS nature reserves and parklands and at private properties by early 2009. These include 47 installed on Nonsuch Island, 14 on Horn Rock, 8 on Southampton Island and 6 on Inner Pear Rock (total = 68). Other locations where Igloo nests have been installed by Terrestrial Conservation and BAS personnel include Cockroach Island, Harrington Sound; the Alfred Blackburn Smith Nature Reserve, Paget Parish, Lambda Island, Great Sound and the Bermuda Aquarium, Museum and Zoo (BAMZ) Hamilton Parish (see Fig. 6). These artificial nests are available to the public for \$75.00 each and have already been installed at a number of coastal private properties and tourism developments.

These artificial nests, although requiring a fair amount of labour to properly prepare and install, have some distinct advantages over most natural nest cavities; they are relatively easy to install in locations on the edge of a cliff or terrace where they are safest from disturbance. It is also relatively easy to reach in and extract the chick or the adult tropicbird for banding (ringing) or morphometric measurements. Rocks and pebbles which have fallen into or been dug up can also be easily removed from the nest chamber, reducing the possibility of the egg being broken or pipped. And finally, a large number of nests can be installed in favorable locations, to create nesting densities greater than could be achieved by the birds if they had to depend solely on natural nest sites. Nesting Tropicbirds are absent or present in only low numbers on many otherwise ideal coastal locations on Bermuda solely because of the absence of suitable nesting cavities in the coastal cliffs in those areas. The use of artificial ‘Igloo’ nests has already established nesting Tropicbirds in several areas on Bermuda where they had not previously been present. There is therefore great potential to establish new nesting colonies at safe locations where they are not exposed to storm erosion or flooding. They have already

been used to provide replacement nesting cavities at locations on the exposed south coastline where numbers of natural nest sites have been destroyed by cliff collapse and erosion from hurricane activity (e.g. Castle Harbour Islands and Spittal pond).

The ‘igloo’ nests are easily installed on terraces or cliff edges in three steps:

- 1) A shallow depression or bowl 2’ across and 4” to 6” deep is dug into the rock on the cliff/terrace edge with a mattock or pickaxe (Fig. 7);
- 2) About 60 lbs. (one 5-gallon bucketful) of cement mix is prepared and applied in a almost complete ring all around the outer edge of the excavated depression, with a 6-inch gap left where the nest entrance will be. The lower edge of the igloo is then placed onto this ring of wet concrete with the entrance hole facing out so that it will be visible to birds flying by just off the cliff (Fig. 8).
- 3) The rest of the concrete is then used to permanently fix the edge of the nest to the underlying rock, and to cement natural rocks to the outer surface of the nest to camouflage it as a natural-appearing rock outcrop (Fig. 9).



Fig. 7: Preparation of cliff edge by Marvin Jones of the Terrestrial Conservation Crew for artificial ‘igloo’ nest installation on Nonsuch Island.



Fig. 8: 'Igloo' nests being cemented to cliff edges by Terrestrial Conservation Crew



Fig. 9: Installed 'igloo' nests with covering of cemented natural rocks.

7.2. Comparison of Breeding Success between artificial & Natural Nests:

Results were recorded over the period 2006 – 2008 of breeding success in all artificial nest sites at locations monitored for this study. Although the great majority (75) of these are the ‘Igloo’ nest design mentioned previously in this report, there are also a smaller number of Tropicbird nests built either by cementing slabs of rock or boulders together (4), by digging out new or deepening shallow existing cavities (5) or in disused cement burrows originally built for Bermuda petrels, or Cahows (7). To avoid confusion, only ‘Igloo’ artificial nests were considered in this comparison.

These artificial nests can be installed in more safely accessible areas than most natural cliff nest sites, and are generally easier to remove Tropicbird adults or chicks from for banding and morphometric measurement. This is important to avoid causing undue disturbance to the birds, which can lead to the abandonment of nest sites by the adults. Another advantage is the greater ease of reaching in and removing rocks or pebbles brought in or dug up by the birds, or debris swept in by storms or hurricanes that could prevent the birds from entering or cause breakage of the egg.

As part of the breeding survey (see Section 6), a comparison was made of breeding success between natural and artificial nest sites with confirmed breeding activity (See Figs. 10 and 11). The results of this comparative survey are shown as follows and summarized in Table 1:

2006

For the 2006 nesting season, a total of 41 active artificial ‘Igloo’ nest sites were recorded, with 34 producing successfully fledged chicks (mean breeding success 82.9 %). This compares with a total of 74 active natural nest sites that were monitored during this season, with 56 producing successfully produced chicks. This represents 75.6 % breeding success recorded for all active natural nest sites for that year.

2007

For the 2007 nesting season, a total of 68 artificial ‘Igloo’ Tropicbird nest sites were monitored as part of the breeding success survey. Out of these, a total of 39 had nesting activity, with 31 of these producing successfully fledged chicks (79.4 % breeding success). In comparison, there were a total of 136 active natural nest sites monitored during 2007, of which 79 produced successfully fledging chicks. The breeding success for all active natural Tropicbird nest sites in 2007 was recorded at 58 %. (See Fig. 10)

2008

For the 2008 nesting season, out of a total of 75 artificial ‘Igloo’ Tropicbird nest sites, nesting activity was recorded at a total of 57, with 41 of these producing successfully fledged chicks (71.9 % breeding success). Out of 183 natural nest sites monitored during the 2008 season, nesting activity was recorded at a total of 132 nests, with 84 of these producing successfully fledged chicks (63.6 % breeding success). (See Fig. 11).

Over the entire 3-year survey period, nesting activity was recorded in a total of 137 artificial ‘igloo’ nests; out of these, a total of 106 chicks were confirmed as successfully fledging during the same period, for a total breeding success rate of 77.3 %. During the same period, a total of 342 natural nest sites had breeding activity; with 219 of these producing confirmed successfully fledged chicks (64 % breeding success).

Simply stated, the artificial ‘igloo’ nests had a 13.3 % higher overall breeding success rate than the surveyed natural nest sites over the 3-year survey period. This is a very significant figure and indicates the potential of these easy-to-install nests for both supplementing available natural sites and providing a larger choice of available unoccupied sites for young, newly prospecting birds. In addition, they can provide sorely needed alternative sites for previously established pairs that have lost their original nests due to erosion, hurricane damage or coastal development. This has been particularly important in the aftermath of strong hurricanes such as ‘Felix’ in 1995, ‘Gert’ in 1999 and ‘Fabian’ in 2003. It is estimated that up to 300 natural nest sites on the Castle Harbour Islands alone, representing nearly 50 % of the pre-hurricane natural nest sites, were destroyed during hurricane ‘Fabian’ alone. Some of the nesting islands lost over 70 % of their original nest sites.

TABLE 1:

	2006	2007	2008
Total number of active artificial nests:	41	39	57
Number of artificial nests with chicks fledged:	34	31	41
Mean breeding success for all active artificial nests:	82.9%	76.0 %	71.9 %
Total number of active natural nests:	74	136	132
Number of natural nests with chicks fledged:	56	79	84
Mean breeding success for all active natural nests:	75.6%	58.0 %	63.6 %

Comparison of Breeding Success of White-tailed Tropicbird in Artificial ‘Igloo’ Nest Sites and Natural Nest Sites (See also Figs. 11 & 12)

2007 Tropicbird Breeding Data

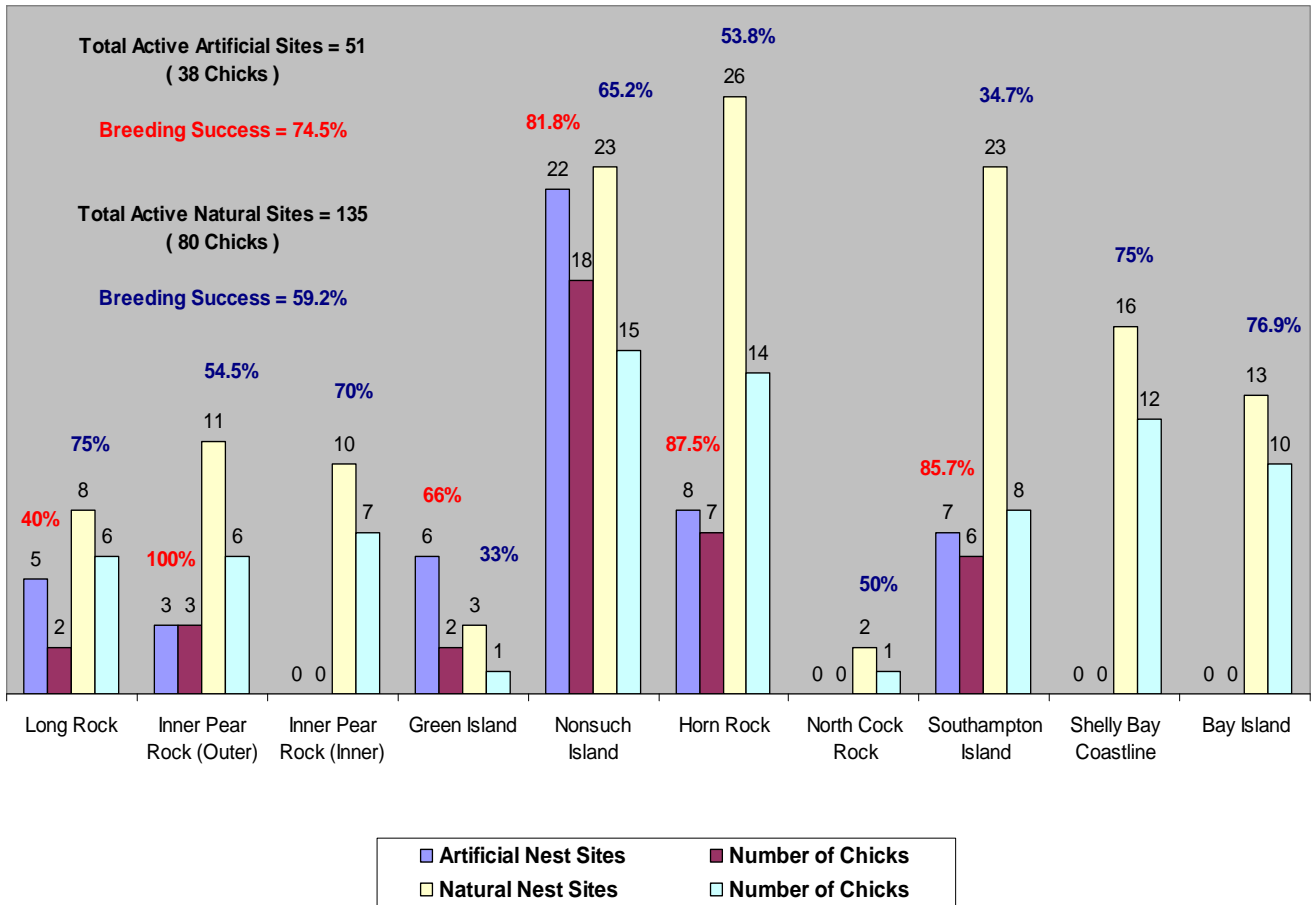


Fig. 10: Comparison of Breeding Success between Artificial and Natural Nest Sites at all survey locations during the 2007 Nesting Season

2008 Tropicbird Breeding Data

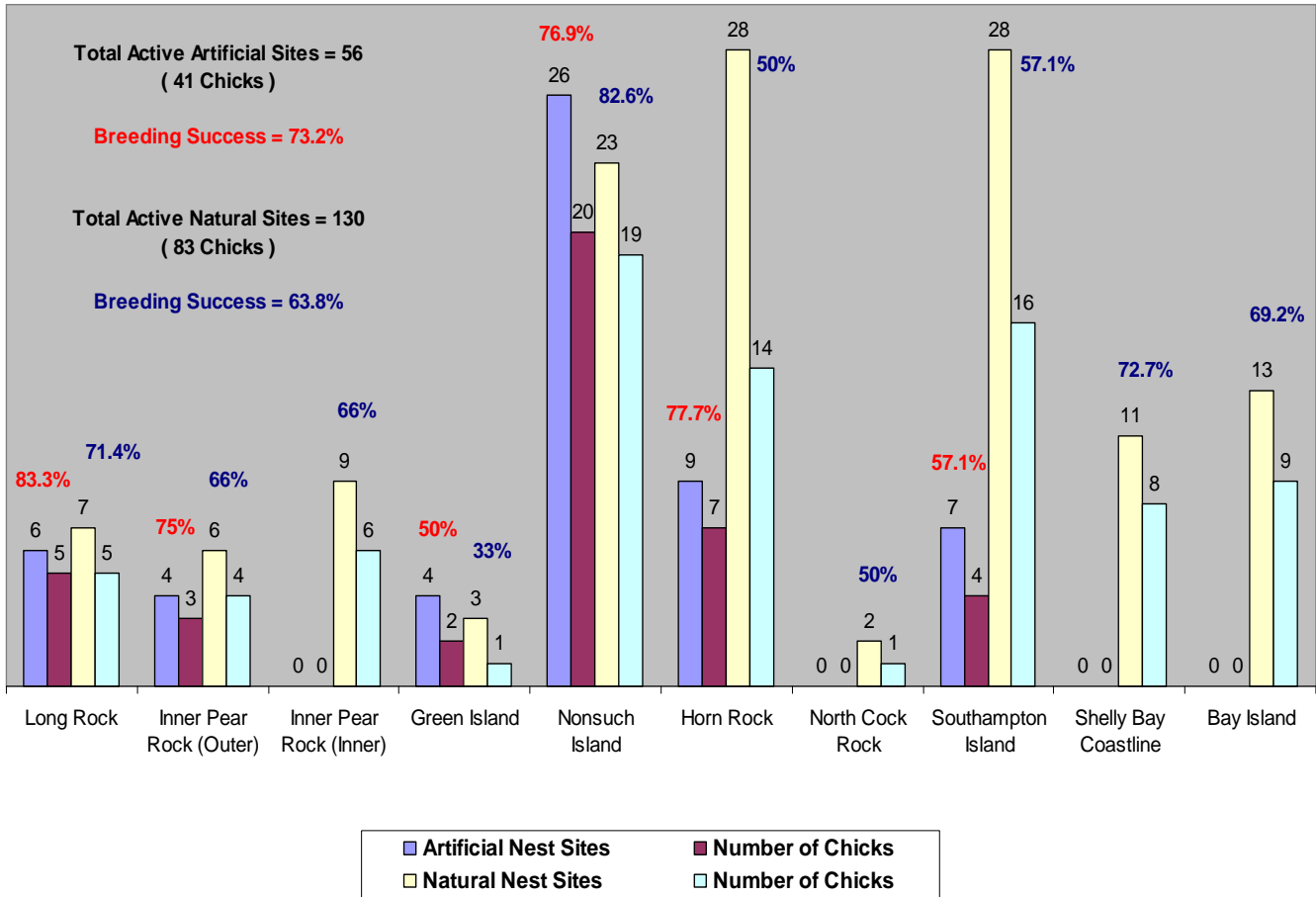


Fig. 11: Comparison of Breeding Success between Artificial and Natural Nest Sites at all survey locations during the 2008 Nesting Season

8.0. Tropicbird Banding Program:

A program to fit Tropicbird fledglings with identification bands was initiated in 2002. The bands used with White-tailed Tropicbirds measure 6.0 mm inside circumference (compared with 5.5 mm inside circumference for the Bermuda Petrel) and are manufactured in England by Porzana Ltd. (U.K. Wetlands Trust affiliation). These bands are made of incoloy, a strong, light corrosion-resistant alloy widely used in bird research programs and proven to be highly durable, lasting 30 or more years even when used with seabirds in marine environments. Each band used in this program has a unique letter/number code and a Bermuda post box address and message to send information to that address for anyone finding the bird or the band.

8.1. Banding Protocols:

Although the great majority of Tropicbirds banded thus far have been fledglings, adult Tropicbirds have also been banded when possible. However, adult Tropicbirds have proven liable to abandon their nest sites during some periods of their breeding season if subjected to banding or morphological measurement. As a result, new protocols were put into place to minimize the possibility of abandonment, which are as follows:

- Adult Tropicbirds should only be banded from nests where the bird can be easily extracted and where the nest entrance can be temporarily blocked when the bird is returned. This keeps the bird from immediately departing and gives it time to calm down; after a few minutes, the nest entrance can be quietly unblocked;
- Adult Tropicbirds should only be removed for banding and measurement during the period when they are most unlikely to abandon the nest; this appears to be during the egg brooding period.
- Adult Tropicbirds are highly likely to abandon their nests if they are handled during the initial nest prospecting/courtship period of their nesting season, and so should not be disturbed during this period (usually March to June).
- The time period when Tropicbirds are removed from the nest for banding or measurement should never exceed 5 minutes, to reduce stress to the birds and minimize the threat of nest abandonment.
- During hot, windless days, it is of extreme importance to keep birds shaded and cool when removed from the nest; if possible, the handler should retire with the bird to a nearby shaded spot, but if this is not possible, the bird should be shaded with the handler's own body. Failure to do so can result in collapse or death of the bird, as they are already somewhat stressed by the handling process and can quickly become overheated.
- A cloth weighing bag should be used to put the bird in for weighing and measurement once it is removed from the nest cavity; this will keep it calmer and easier to control as they cannot see the handler. Experience has shown that adult Tropicbirds are so aggressive that they are difficult to control, liable to injure themselves and nearly impossible to band, measure or fit with a band without the use of a bag.

8.2. Results of Banding Program:

Since 2002, a total of 229 Tropicbirds have now been fitted with identification bands, consisting of a total of 220 fledglings and 9 adult birds. The breakdown for banded birds by year reads as follows:

2002 Breeding Season

Total number of Tropicbirds banded	31
Adult Tropicbirds banded	3
Fledgling Tropicbirds banded	28

2003 Breeding Season

Total number of Tropicbirds banded 22
(All Tropicbirds banded were fledglings)

2004 Breeding Season

Total number of Tropicbirds banded 42
(All Tropicbirds banded were fledglings)

2005 Breeding Season

Total number of Tropicbirds banded 26
Adult Tropicbirds banded 2
Fledgling Tropicbirds banded 24

2006 Breeding Season

Total number of Tropicbirds banded 58
Adult Tropicbirds banded 4
Fledgling Tropicbirds banded 54

2007 Breeding Season

Total number of Tropicbirds banded 50
(All Tropicbirds banded were fledglings)

2008 Breeding Season

Total number of Tropicbirds banded 81
(All Tropicbirds banded were fledglings)

Summary of Numbers of White-tailed Tropicbirds Banded Since 2002:

Total number of all Tropicbirds banded 2002 – 2008 310
Total number of adult Tropicbirds banded 2002 – 2008 9
Total number of fledgling Tropicbirds banded 2002 – 2008 301

9.0. DISCUSSION OF SURVEY RESULTS:

9.1. Identification and Control of Introduced Competitors and Predators:

The primary aim of this survey has been to determine the present status of the regionally important nesting population of White-tailed Tropicbird on Bermuda. Although there are a number of threatening factors that can affect breeding success, notably predation of eggs and young chicks by introduced Rats and American Crows (see Section 4.1. p 9: summary of threats to the tropicbird on Bermuda), these seem to be mostly local in effect and have certainly been sustainable at all locations surveyed during the duration of the survey. Many of these threats have already been under active management to reduce or prevent their impact, for example in control efforts which have greatly reduced the population of feral Rock Doves, which are serious competitors with tropicbirds of cliff nest sites. Similarly, a group of American Crows that preyed on Tropicbird eggs and young chicks on the Tucker's Town Peninsula in 2008 were quickly eliminated by a pest control officer. Annual monitoring and vigilance will be essential in future management to detect and control such problems on an ongoing basis, as populations of such introduced pest species can rebound very quickly even when greatly reduced by culling. In the case of mammalian pests, such as rats, it is possible and preferable to remove them completely from isolated islands by baiting with an anticoagulant rodenticide, which is already carried out on an annual basis on the Castle Harbour Islands by the Terrestrial Conservation Officer. This is not possible at mainland sites or islands in close proximity to the mainland, as rats can quickly re-colonize the area, but baiting can be used effectively to greatly reduce the population density of rats in chosen areas during critical times of the nesting season when they are more likely to cause damage. These times include the egg incubation period and the early chick fledging period.

9.2. Breeding Success Results:

- Over the three-year survey period, the survey has shown that breeding success is relatively high, although varying widely between extremes of 33 % to 83 % at individual survey locations during any given nesting season.
- Overall breeding success for all active nest sites (both natural and artificial) monitored during the survey reached 78.2 % in the 2006 nesting season, 62.9 % for all active nest sites in the 2007 nesting season, and 66.1 % during the 2008 nesting season. The mean average of breeding success for all active Tropicbird nest sites over the 3-year period 2006 – 2008 was 67.7 %, in excess of two-thirds of all observed nesting attempts, which would seem to be sufficient to maintain present population levels and even to support a possible increase in breeding numbers.
- An unexpected result was that breeding success generally remained high during the survey period at unmanaged sites subject both to mammal predators (rats, dogs) and to human disturbance. At both Bay Island and the Shelly Bay coastline,

breeding success ranged from 72 % up to 76.9 % during 2007 and 2008 (these locations were not surveyed during the initial year of the survey in 2006). The mean average of breeding success for active nest sites at these two locations was 75.7 % over the 2007-2008 nesting seasons.

- Based on these findings, it appears that loss of nest sites due to a combination of severe hurricanes and coastal development works, are a much greater limiting factor to Bermuda's Tropicbird population at present than predation by introduced mammalian and avian predators. That having been said, there have also been well-documented cases of predation by rats, cats, dogs and American Crows, but these are generally isolated incidents which are not widespread, but restricted to specific localities.

9.3. Results of Breeding Success Comparison between Artificial and Natural Nest Sites:

In the comparison of breeding success between natural Tropicbird nest sites and the artificial 'Igloo' nests which have been installed at several of the survey locations in this study, results clearly show that active artificial nests had considerably higher breeding success than natural nest sites at the same locations (see section 7.2). Over the three years of the survey, overall results show 13.3 % higher breeding success, with all active artificial nests showing a mean breeding success of 77.3 % during the period 2006 – 2008, compared to 64.0 % mean breeding success for all active natural nest sites.

This result is most likely due to the following factors:

- Excessive sunlight from large or open nest entrances, such as are found in many natural nests, can cause heat stress in both incubating adult Tropicbirds and chicks. Under such conditions, adults often abandon eggs in open nests during prolonged hot sunny periods, and chicks can become severely stressed or die from dehydration or heat stress.
- The smaller entrances (generally about 5" by 6" in size) also make the Igloo nests less attractive to feral Pigeons, and make it much more difficult for Crows to be able to reach in and pull out eggs or young Tropicbird chicks.
- The accessibility of the artificial nests makes it easier to check for and extract rocks, stones or other debris which could otherwise cause egg breakage or prevent successful nesting.
- In addition, the artificial nests are almost always installed in locations such as cliff edges or ledges where they can be safe from access by mammal predators such as domestic cats and dogs, and are easier for adult Tropicbirds to fly directly in or out from.

In summary, it appears that the program to install artificial nests at known nesting locations has not only been successful in increasing the number of potential nest sites at particular nesting locations, but has been effective at replacing nests destroyed by storm and hurricane activity. In addition, it has been conclusively proved that these artificial nests, if correctly placed and installed, can have considerably higher breeding success than the natural cliff cavities and ledges.

10. Prioritized Recommendations:

Based on the findings of this survey, the following recommendations are put forward for the conservation and management of the White-tailed Tropicbird on Bermuda:

- 1) Offshore islands and sites identified as particularly important Tropicbird nesting areas should be protected from mammal predators by baiting for rats and restricting access by domestic animals;**
- 2) The program to install additional artificial ‘Igloo’ Tropicbird nests in appropriate National Parklands and Nature Reserves should continue, with additional support from the Bermuda Government (Dept. of Conservation Services); a target number of 20 to 50 nests should be installed annually;**
- 3) In addition, private landowners with coastal properties should be given further encouragement to install artificial Tropicbird nest sites, including ‘Igloo’ nests, at their properties on cliff edges and in retaining walls or terraces overlooking the water. In addition, any coastal development or coastal defense works that results in existing Tropicbird nests being destroyed or covered, should be required by the Planning Department as a condition of planning application approval to buy and install ‘Igloo’ nests in appropriate areas to compensate for the destroyed nests and provide the Tropicbirds with alternative nesting sites.**
- 4) A public information/education program should be continued using public outreach (newspaper articles, public lectures/PowerPoint presentations etc.) to educate the public about the importance of Bermuda’s nesting Tropicbirds, prevent disturbance or destruction to nesting birds and nest sites, prevent the public from stuffing trash and fishing line into nest holes;**
- 5) All Tropicbird nesting sites and areas should be given strict and total protection under the 2003 Protected Species Act and under appropriate planning zoning by the Planning Department in the Bermuda Development Plan 2009.**

11: Acknowledgements:

I would like to thank a number of people for assistance and logistical support during this survey; Patrick Talbot originally found and surveyed most of the Tropicbird nests on the Castle Harbour Islands, and installed many of the number tags which formed the backbone of this survey and which I was able to update and add to; Mark Outerbridge first found the thriving Tropicbird colony on Bay Island, Bailey's Bay, and drew my attention to it and its potential as a site for monitoring. Michelle Pasquin has been a real champion for the Tropicbird population along the coastline west of Shelly Bay, Hamilton Parish; without her constant efforts to remove trash left by thoughtless fishermen and improve the many marginal nests at this location, I have no doubt that it would certainly not have the distinction of having one of the highest breeding success rates of any of the sites being monitored. Instead, she has helped to turn this into a active colony that any member of the public walking along the Railway Trail can enjoy.

Mandy Schailer (GIS coordinator, Dept. of Conservation Services) and Lynn Thorne (BZS tours and education coordinator) both assisted with compiling maps and graphs for the report.

A number of Department staff, interns and volunteers have assisted in monitoring and banding Tropicbird nests and chicks during the course of this survey. These include Peter Drew, Ronald Burchall, Andrew Dobson, Aja Peters-Mason, Joseph Furbert, Annie Glasspool, Jennifer Gray, Elizabeth and Seth Madeiros, Lynn Thorne and Katherine Massey, among others.

Much praise is due to the Terrestrial Conservation Crew, who have done exemplary work in installing scores of artificial Tropicbird nests in many locations, some very difficult to reach, on a number of the Castle Harbour Islands. These nests are proving to be very successful and are making a real difference in providing alternate nest sites for the many birds that have lost their original nests due to hurricane activity. The Crew consists of Barry Smith (Foreman), Kiwon Furbert, Hillgrove Iris and Marvin Jones.

Finally, as always I would like to acknowledge my wife and family for their support and for enabling me to spend so much of my time chasing birds.

**Appendix 1:
Photo-record for growth of Tropicbird chick: Nonsuch nest # 391**



Figure 12: Tropicbird chick at 8 days of age



Figure 13: Tropicbird chick at 15 days of age

*Breeding Success Survey of White-tailed Tropicbird
Phaethon lepturus catsbyii
On the Castle Harbour Islands, Bermuda
2006-2008 Nesting Seasons
Jeremy Madeiros*



Figure 14: Tropicbird chick at 21 days of age



Figure 15: Tropicbird chick at 34 days of age

*Breeding Success Survey of White-tailed Tropicbird
Phaethon lepturus catsbyii
On the Castle Harbour Islands, Bermuda
2006-2008 Nesting Seasons
Jeremy Madeiros*



Figure 16: Tropicbird chick at 39 – 45 days of age ('Lion's mane' stage)



Figure 17: Tropicbird chick at 45 – 50 days of age

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Phaethon lepturus catsbyii
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2006-2008 Nesting Seasons
Jeremy Madeiros*



Figure 18: Tropicbird chick at 55 days of age



Figure 19: Tropicbird chick at 55 days of age



Figure 20: Fully developed Tropicbird chick ready to fledge at 64 days of age



Figure 21: 64-day old Tropicbird chick showing fully developed wings

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