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Cover image - Patch reef near the wall off Grotto Beach (photo by Lee Florea).

Reduction in nesting success of brown booby birds and magnificent frigatebirds on White Cay, San Salvador, Bahamas

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1. Abstract

Magnificent frigatebirds (*Fregata magnificens*) and brown booby birds (*Sula leucogaster*) are two species found on White Cay, one of several small cays to the north of San Salvador Island, The Bahamas. Nesting success of these seabirds may be influenced by threats to nesting habitat, such as hurricanes. The goal of this study was to quantify nesting reduction and vegetation abundance to establish new baseline values for these species going forward. Nesting birds were counted in spring 2013 and percent plant cover was compared side-by-side with photographs from spring 1995-1997. The photographs revealed decreases in bird abundance as well as decreases in vegetation distribution and abundance, especially the reduction of bay lavender. Decreases in bay lavender, possibly due to hurricanes, may be causing the loss of nesting frigatebirds. Other potential causes of seabird decline could be predation on eggs or adults, disease, lack of food, or human influence.

2. Introduction

The Bahamas are home to many species of seabirds. San Salvador offers an environment that is sparsely inhabited by humans, and supports a variety of animal populations. This island is home to 14 (82%) of the 17 seabird species that breed in the Bahamas, and two of the largest species include the brown booby (*Sula leucogaster*) and magnificent frigatebird (*Fregata magnificens*) (Hayes 2003).

The brown booby in adult plumage has a sharp demarcation across the breast separating dark head and back from the white underparts. The juvenile stages are drab, unless the bright white down feathers are still present. Clutch size is usually 1 or 2 eggs, and the altricial young have a long developmental period with feedings observed 40 weeks post-fledging (Nelson 2005). Brown boobies nesting in colonies in the Bahamas have experienced detrimental declines in the Caribbean, often due to human influence and development (Carey et al. 2001).

The magnificent frigatebird is sexually dimorphic with dark plumage in the male and a white breast in the female. Juveniles have white heads. Frigatebirds have the longest nesting period of any seabird (Trivelpiece and Ferraris 1987), as fledglings have been observed being fed by the mother up to 18 months post-fledging (Bried and Jouventin 2002). The males tend to reproduce every year, while females reproduce every other year (Diamond 1973). Their slow growth and maturation can make them particularly vulnerable to threats to nests (Hayes 2003), reducing their population.

Both the brown booby and the magnificent frigatebird typically nest in colonies. Brown boobies place their nests on the ground and not in trees (Nelson 2005) although they are equally likely to nest on inclined ground, or cliffs (Chaves-Campos and Torres 2002). The uniform distribution of nests is common in colonial birds in the booby family (Minias 2014); the reported inter-nest distance in the Bahamas is between 2 and 3 meters apart (Nelson 2005). Frigatebirds nest in trees (Trivelpiece and Ferraris 1987) or other vegetation that keeps the birds off the ground (Diamond 1973). On San Salvador, the brown booby and magnificent frigatebird have been observed to nest on White Cay, a 4 ha cay farthest from the mainland, and Cato Cay, a 2 ha cay off the north coast. From 1993-2003

there were only 33 pairs of frigatebirds and 200 pairs of brown booby nesting on these islands (Hayes 2003).

Storms threaten nesting birds on small, exposed cays. Hurricanes in the Caribbean often destroy trees used by nesting frigatebirds (Schreiber 2002). Since they show high site fidelity, fewer birds may nest in subsequent years because of habitat destruction. Hurricanes can have direct effects on seabirds through chick mortality and indirect effects through flooding and destruction of vegetation (White et al. 1976; Hass et al. 2012). There is a predicted increase in hurricane strength and incidence over time in the Caribbean (Mousavi et al. 2010; Hass et al. 2012) that would have repercussions on nesting seabirds, particularly those that provision nestlings and fledglings over an extended period (Diamond 1973). Hurricanes are documented regularly in the Bahamas. The island of San Salvador was hit with 13 hurricanes during the period of 1899 to 1987, and another 20 hurricanes passed within 160 km (Wunderle et al. 2007). Storms affecting San Salvador during the time frame of this study include Lili (1996) and Floyd (1999), and more recently, Frances (2004), Irene (2011), and Sandy (2012). Flooding and storm surge during Floyd were extensive as the eye passed only 24 km north of San Salvador, and winds were recorded up to 250 km/hr (Ball 2008).

A decline in bird nesting on White Cay was recognized between 1997 and 2013, which seemed to correlate with changes in vegetation abundance, possibly related to storm damage. The goal of this study was to start to quantify nesting reduction and vegetation abundance to establish new baseline values and add a monitoring schedule for nesting pairs of brown boobies and magnificent frigatebirds on White Cay. It was expected that frigatebirds would be more influenced by vegetation destruction than boobies because frigatebirds depend on trees or bushes to elevate their nests above ground level.

3. Methods

Juvenile brown boobies and magnificent frigatebirds were counted April 22, 2013. There were so few birds that direct counts rather than samples were obtained. White Cay was divided into three general areas to examine for juvenile birds and vegetation: a high plateau to the north, a low rocky beach in the middle, and a high ridge sloping south. Vegetation was assessed by estimating percent cover found in each area using photographs showing similar surface areas. Birds in juvenile plumage were counted in each area.

Frigatebird and booby juveniles were identified based on several characters. Frigatebird juveniles are larger than boobies, have larger beaks with a hook on the end, darker feathers, and sit in taller vegetation. Frigatebird juveniles have white heads and dark bodies, while the youngest birds still in down have fluffy white plumage. Brown booby juveniles are drab brown all over, while younger birds have fluffy down patches.

Panoramic photographs of White Cay were taken April 22, 2013 to compare to photos from 1995-1997. All photos were taken in April or May each year. The photographer captured an assortment of angles and island regions to ensure sufficient visual and surface area coverage. Panoramas were organized based on their directional location along the island, for example, “west coast looking north.”

Enlarged photos from 1995-1997 were chosen that had sufficient amounts of landscape and clear landmarks, so their location and direction could be identified. Examples of such landmarks include unique rock formations, distinctive shorelines, and the island of San Salvador in the background. These landmarks were used to label the setting of the older photographs.

The photographs with landmarks from previous years were matched with photos from 2013 that showed the same landmarks. However, some matched photos show landmarks viewed from varying positions.

Landmarks were boxed in red, and the location and direction for viewing were explained with each set of pictures, usually with red arrows indicating the angle at which one would be looking.

After photographic matches were confirmed, they were used to estimate the percent cover of plants, and numbers of brown boobies and frigatebirds. The surface area covered was matched as much as possible between photographs for accurate estimates. Birds that were in more than one photograph were not counted more than once. If a photograph from the past could not be matched up with a current location, it was not used in the analysis to ensure a conservative estimate of birds and vegetation.

4. Results

There were drastic changes in both vegetation and bird populations between 1995 and 2013. Common purslane (*Portulaca oleracea*), red-stemmed purslane (*P. rubricaulis*), seashore rush grass (*Sporobolis virginicus*), and coast spurge (*Euphorbia mesembrianthemifolia*) were the only four plants observed on White Cay in 2013, mixed to provide a low-growing ground cover in sparse patches on the rock, although the majority of the island is lacking vegetation (Table 1). Bay lavender (*Tournefortia gnaphalodes*) was not present in our photographs in 2013, but was present in the photographs from 1995-1997. However, there are other records of a small patch of bay lavender present on the island in 2013 (Landry, pers. comm.). Vegetation was thicker and more widespread in 1995-1997 (Table 1).

There were reductions in bird populations as well. There were as many as 15 juvenile frigatebirds observed in the photographs in each of 3 years from the 1990's, while there were no frigatebirds in 2013 (Table 1). The southern slope was abundantly populated with brown boobies in the mid-1990's (Figure 1), while in 2013, there were only 16 brown boobies in that particular area. In addition to the reduced numbers of birds and plants, there were a large number of dead sea fans (*Gorgonia* spp.) observed washed up and dried on the southern end of the cay in 2013.

5. Discussion

Direct effects of hurricanes that may contribute to nestling mortality are drowning or death due to hypothermia after storm surge, heavy rain and wind, but indirect effects may be more important and longer lasting for bird populations (Wiley and Wunderle 1993). The most important indirect effect of a hurricane on birds is the loss of vegetation used for nesting sites that can decrease bird abundance (Wiley and Wunderle 1993). For example, after hurricane Hugo, shrubs used by nesting great egrets in South Carolina were damaged more heavily than grassy and low growing vegetation. The nesting great egret population declined as those that attempted to nest in grassy vegetation had nests washed away (Shepherd et al. 1991).

On White Cay, frigatebirds rely only on bay lavender to keep their nests elevated, as the other four plant species are low growing ground cover (Table 1) and frigatebirds nest in trees or shrubs up off the ground (Diamond 1973). There were anecdotal reports and observations by the authors of the reduction in bay lavender shrubs, frigatebird nests, and frigatebird hatchlings in the years between 1997 and 2013, corroborated by the photographic analysis. It is possible that frigatebird reproduction has shifted to the protected seabird breeding colony on Cato Cay (Carey et al. 2001), as that is the only other cay of San Salvador to have evidence of nesting frigatebirds (Hayes 2003). The authors also observed a decline in booby numbers between 1997 and 2013 that was corroborated by the photographic analysis as well. However the reduction was not as great as that of the frigatebirds, potentially because the brown boobies nest on the ground and do not rely on specific vegetation types (Nelson 2005).

Table 1. Changes in vegetation cover and total bird abundance on White Cay.

	1990s	2013
% bare rock	65	75
% "ground cover" [1]	30	25
% Common purslane (*Portulaca oleracea*) and red-stemmed purslane (*P. rubricaulis*)	n/a	13
% Seashore rush grass (*Sporobolis virginicus*)	n/a	10
% Coast spurge (*Euphorbia mesembrianthemifolia*)	n/a	2
% Bay lavender (*Tournefortia gnaphalodes*)	5	0
Magnificent frigatebird juveniles *(Fregata magnificens*)	38	0
Brown booby juveniles (*Sula leucogaster*)	26	16
Brown booby nesting adults	96	0

[1] "Ground cover" refers to both purslanes, seashore rush grass, and coast spurge combined for analysis in the 1990s.

In our study, a population of bay lavender in the dry wash was evident in May 1996 before Hurricane Lili hit in October. The bay lavender in the pictures from May 1997 are just dead branches, and these are only found in the more protected rock crevices. In April 2013, no live bay lavender or dead branches are seen in the dry wash. Bay lavender is a plant adapted to rocky coasts and sandy shorelines (Kass et al. 2011). Despite the hardy nature of this rocky coast shrub, exposed areas of bay lavender may be wiped out during hurricanes. However, dune plants often have compensatory growth of buried shoots that increase growth of stems (Gilbert and Ripley 2008). If sandy areas of White Cay are deep and abundant enough, burial of bay lavender during stormy conditions may facilitate later regrowth. Other aspects of bay lavender biology that may interact with frequent storm disturbance could include the role of competitors and abiotic effects such as limited fresh water. These remain to be studied, although there has been some work on pollinators and possible water-borne seed dispersal in bay lavender (Everson et al. 2016). If the bay lavender population increases on White Cay, we may see an increase in the number of nesting frigatebirds.

Hurricanes may not be the only weather-related influences on bird populations. Interacting factors relating to weather events such as El Nino can cause changes in food webs involving plankton and fish (Mellink et al. 2000). Storms may destroy reefs which provide important food sources for birds (Schreiber 1997) and inundation of freshwater feeding sites may occur (Shepherd et al. 1991).

Other potential causes of seabird decline could be predation on eggs or adults, disease, lack of food, or human influence. Predation by mammals is unlikely as introduced rats, cats, and dogs on the mainland have not been documented on White Cay (Carey et al. 2001). Disease, such as avian herpesvirus infection (de Thoisy et al. 2009) has been known to infect frigatebirds, but has not been documented on San Salvador. Human influence on White Cay may be minimal, because it is small, isolated, and not subject to development, although there have been historical reports of egg gathering by Bahamian residents (Captain Storr, pers. comm). If human activity on the mainland increases, this could cause increases in rat populations that make it more likely that they find their way to the cays (Hayes 2003). These possible factors interacting with severe

weather may also contribute to the decline of frigatebirds, but remain to be tested thoroughly.

The new baseline data established by our study in 2013 confirms the decline in nesting bird populations over the 18 year time span examined. In the future, changes in the bird nesting patterns on White Cay will be monitored and hopefully inform efforts to protect important habitat for threatened seabirds in the Bahamas.

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7. References

Ball, M. 2008. Evaluation of hurricane processes and potential hazards on San Salvador, Bahamas. In Abstracts and Program: the 14th Symposium on the Geology of the Bahamas and other Carbonate Regions. Gerace Research Centre, San Salvador Island, Bahamas.

Bried, J., and P. Jouventin. 2002. Site and mate choice in seabirds: an evolutionary approach. In E. A. Schreiber and J. Burger [eds.], Biology of Marine Birds, 263-305. CRC Press, Boca Raton, Florida, USA.

Carey, E., S. D. Buckner, A. C. Alberts, R. D. Hudson, and D. Lee. 2001. Protected areas management strategy for Bahamian terrestrial vertebrates: iguanas and seabirds. IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, Minnesota, USA.

Chaves-Campos, J., and J. Torres. 2002. Distribution of nests of the brown booby (*Sula leucogaster*) in relation to the inclination of terrain. *Ornitologia Neotropical* 13: 205-208.

de Thoisy, B., A. Lavergne, J. Semelin, J. F. Pouliquen, F. Blanchard, E. Hansen, and V. Lacoste. 2009. Outbreaks of disease possibly due to a natural avian herpesvirus infection in a colony of young magnificent frigatebirds (*Fregata magnificens*) in French Guiana. *Journal of Wildlife Diseases* 45: 802-807.

Diamond, A. W. 1973. Notes on the breeding biology and behavior of the Magnificent Frigatebird. *The Condor* 75: 200-209.

Everson, K. M., C. L. Landry, and E. Richardson. 2016. Reproductive biology of bay lavender (*Heliotropium gnaphalodes* L.; *Boraginaceae*). In R. Erdman and R. Morrison [eds.], Proceedings of the 15th Symposium on the Natural History of the Bahamas, 73-81. Gerace Research Centre, San Salvador Island, Bahamas.

Gilbert, M. E., and B. S. Ripley. 2008. Biomass reallocation and the mobilization of leaf resources support dune plant growth after sand burial. *Physiologia Plantarum* 134: 464-472.

Hass, T., J. Hyman, and B. X. Semmens. 2012. Climate change, heightened hurricane activity, and extinction risk for an endangered tropical seabird, the black-capped petrel *Pterodroma hasitata*. *Marine Ecology Progress Series* 454: 251-261.

Hayes, W. K. 2003. Can San Salvador's iguanas and seabirds be saved? *Bahamas Journal of Science* 11: 2-8.

Kass, L., N. Elliott, and C. Landry. 2011. Natural history of Bahamian dune plants: importance in coastal conservation. In J. E. Baxter and E. S. Cole, [eds.], Proceedings of the 13th Symposium on the Natural History of the Bahamas, 35-45. Gerace Research Centre, San Salvador Island, Bahamas.

Mellink, E. 2000. Breeding of brown boobies in the Gulf of California: seasonality and apparent effects of El Nino. *Waterbirds: The International Journal of Waterbird Biology* 23: 494-499.

Minias, P. 2014. Evolution of within-colony distribution patterns of birds in response to habitat structure. *Behavioral Ecology and Sociobiology* 68: 851-859.

Mousavi, M. E., J. L. Irish, A. E. Frey, F. Olivera, and B. L. Edge. 2010. Global warming and hurricanes: the potential impact of hurricane intensification and sea level rise on coastal flooding. *Climatic Change* 104: 575-597.

Nelson, J. B. 2005. Pelicans, cormorants and their relatives: Pelicanidae, Sulidae, Phalacrocoracidae, Anhingidae, Fregatidae, Phaethontidae. In C. M. Perrins, W. J. Bock, and J. Kikkawa [eds.], Bird Families of the World, vol. 17. Oxford University Press, New York, New York, USA.

Schreiber, E. A. 1997. The Barbuda magnificent frigatebird colony: status report and management recommendations. ENCORE and World Wildlife Fund, Washington D.C., USA.

Schreiber, E. A. 2002. Climate and weather effects on seabirds. In E. A. Schreiber and J. Burger [eds.], Biology of Marine Birds, 179-215. CRC Press, Boca Raton, Florida, USA.

Shepherd, P., T. Crockett, T. L. De Santo, and K. L. Bildstein. 1991. The impact of hurricane Hugo in the breeding ecology of wading birds at Pumpkinseed Island, Hobcaw Barony, South Carolina. *Colonial Waterbirds* 14: 150-157.

Trivelpiece, W. Z., and J. D. Ferraris. 1987. Notes on the behavioural ecology of the Magnificent Frigatebird *Fregata magnificens*. *Ibis* 129: 168-174.

White, S. C., W. B. Robertson Jr., and R. E. Ricklefs. 1976. The effect of hurricane Agnes on growth and survival of tern chicks in Florida. *Bird-Banding* 47: 54-71.

Wiley, J. W., and J. M. Wunderle Jr. 1993. The effects of hurricanes on birds, with special reference to Caribbean islands. *Bird Conservation International* 3: 319-349.

Wunderle, J. M. Jr., D. Currie, and D. N. Ewert. 2007. The potential role of hurricanes in the creation and maintenance of Kirtland's warbler winter habitat in the Bahamian archipelago. In B. J. Rathcke and W. K. Hayes [eds.], Proceedings of the 11th Symposium on the Natural History of the Bahamas, 121-129. Gerace Research Center Ltd., San Salvador Island, Bahamas.