

FOREWORD

The rediscovery of the Cahow *Pterodroma cahow* (also known as the Bermuda Petrel) on only 1 ha of islets after 300 years of presumed extinction, and its subsequent recovery to a status of exponential growth, must surely rank as one of the most extraordinary conservation success stories of all time (Gehrman 2012). It also revived hope that other seabird species, particularly in the *Pterodroma* genus, that were decimated and lost to science during the era of European colonization of Oceania might have survived, inspiring searches with increasingly sophisticated techniques that have resulted in a cascade of other successful rediscoveries right up to the present.

This begs the question, how were so many seabird species able to survive, and why has it taken us so long to confirm their continued existence? The explanation is that no other group of species has posed such a challenge in detection once greatly reduced in population. They range widely dispersed over vast stretches of ocean; breed only in the most hostile and inaccessible environments of remote offshore islets and mountaintops; come and go from their breeding grounds only at night; and nest only in burrows or cavities totally concealed from daytime searches without such aids as sniffer dogs and burrow scopes.

If the goal of rediscovery is ultimately to preserve and restore these “lost” species, then it can be seen that there are three stages to the process and only in the third stage does conservation management become possible. The first stage is rediscovery itself in the sense of proving that the species still survives; the second stage is locating the actual nest sites so that conservation management becomes possible; and the third stage is conservation management itself, which may or may not result in a partial or complete recovery of the population. In the case of the Cahow, it took 300 years for the first stage, another 10 years to find all the nest sites, and 30 more years to build the foundations for a significant level of recovery under conservation management. Relatively few of the other rediscovered species have moved very far into the second stage and only one or two, such as the Taiko of Chatham Island and Zino’s Petrel of Madeira, can boast of any progress into the third stage of actually reversing trends from decline to increase.

Looking now at the history of the *diablotin* (the traditional Caribbean name for the Black-capped Petrel), my successful expedition of rediscovery in 1963 was the first of that cascade of rediscoveries inspired by the Cahow. It was also the first to use the new technique of listening for nest colonies at night in likely areas — a technique learned from my own experience with the Cahows. Nevertheless, it had already taken 90 years to reach that first stage, and I did not succeed in finding nest sites myself. That was not for want of trying, as documented in this monograph. In 1966 a government position was created for me in Bermuda which enabled me to devote my efforts full-time to conservation issues on Bermuda. While thinking and acting globally had been exciting and productive, the time had come to act locally, for I had realized by then that it was a far cry from rediscovering a species to actually managing and restoring it. The challenge of saving the Cahow in my own homeland would be a lifetime commitment, let alone trying to save the *diablotin* in a country that I could visit only occasionally (Haiti) and where I didn’t even speak the languages. Meanwhile, David Lee, Chris

Haney and others discovered the core of the *diablotins*’ feeding range in the Gulf Stream during the 1970s and 1980s, confirming what I had already concluded from my discoveries in Haiti: the species still survived in substantial numbers despite what we had been led to expect. Indeed, there was strong evidence that the population had attained a new equilibrium within the constraints of human development pressures and introduced invasive species that prevailed at the time. Nevertheless, and incredibly, it took another 50 years before that second stage of actually locating active nest sites was finally achieved.

This monograph neatly brackets that era of rediscovery and introduces us to the next era of nest site discovery and conservation management. It took the application of sophisticated new techniques of mobile radar and thermal imaging cameras to take off the blinders and finally break the logjam. This has resulted in a flood of additional nest discoveries within the last two years through the combined efforts of *Grupo Jaragua* and the American Bird Conservancy. With nest site discovery, other modern technologies such as light-sensitive geolocators and mini-transmitters for satellite tracking can now be used to reveal the at-sea range of specific nest colonies in greater detail, as already achieved for the Cahow (Madeiros 2012). But new technology can work both ways. Who could have anticipated the advent of cellular telephones, which have resulted in a proliferation of telecommunications masts on many Caribbean island mountaintops — precisely in the areas where the largest remnant colonies of the petrels survive? I remember my dismay, and my urgent warning about the hazard, which I expressed when I revisited the Loma del Toro colony in the Sierra de Bahoruco in 1989 and saw the newly erected telecommunications mast there. I had already had to address the same problem of bright lights and stay wires in connection with the Cahow many years before.

We are now on the threshold of that third stage of conservation management for the *diablotin*, and I have no illusions about how challenging a task it is going to be. At sea, the petrel may soon face an additional threat from oil exploration within its core range. On land, it will not be as easy to manage those mountaintop sanctuaries as it is to manage uninhabited satellite islands (Wingate 2001). Exlosures using sophisticated new predator-proof fences developed in New Zealand will likely have to play a part. But both types of location can benefit from the installation of seabird nest boxes combined with audio attraction and nestling translocation to accelerate nest establishment at higher concentrations in protected locations. In Haiti and other Caribbean islands, the challenge of reforestation and biodiversity conservation is going to have to begin from the mountaintops working downward, so the *diablotin* should be one of the earliest beneficiaries. The groundwork for National Parks in Haiti and the Dominican Republic have already been laid by the pioneering efforts of Woods, Servile and Ottenwalder back in the 1980s, and progress is now being accelerated by the *Declaración de Santo Domingo: Corredor Biológica en el Caribe* 2010, inspiring increased cooperation and assistance from First World development agencies, charities and research institutions. The most recent Conservation Action Plan of the International Black-capped Petrel Conservation Group (Goetz *et al.* 2012), working in close cooperation with Haitian and Dominican colleagues and tied into local community

development, is an admirable example of the way forward, but ultimately it will depend on homegrown conservationists from those same local communities to achieve long-term success. The *diablotin*, with its extraordinary history of survival in the face of adversity, will become an iconic symbol of success in meeting that challenge.

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DIABLOTIN *PTERODROMA HASITATA*: A BIOGRAPHY OF THE ENDANGERED BLACK-CAPPED PETREL

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SUMMARY

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The Black-capped Petrel *Pterodroma hasitata* was believed extinct throughout much of the 20th century. It is the only gadfly petrel currently known to breed in the Caribbean Basin. Now seriously endangered, the species is presumed extirpated from Martinique, Dominica, and Guadeloupe, and breeding populations currently occur only on Hispaniola and perhaps Cuba. A related form (now considered a full species) once bred, but is now apparently extinct, on Jamaica. The Black-capped Petrel breeding population may number as few as 500 breeding pairs. Remaining populations suffer from multiple threats to terrestrial and pelagic habitats, including harvest by humans and predation by introduced mammals. The exact sizes, locations, and detailed chronologies of all Black-capped Petrel breeding sites remain poorly studied, although major colonies are today apparently restricted to steep sea and inland cliffs along the La Selle Ridge in Hispaniola. The largest known breeding population occurs in Haiti, although there is continued discussion about a possible breeding site in Cuba in the Sierra Maestra mountain range. Accounts from Cuba are based on the unverified assumption that birds observed at sea just offshore of that island are breeding locally.

All evidence at present indicates that waters in or adjacent to the Florida Current and the Gulf Stream between north Florida and southern Virginia provide the primary foraging range of Black-capped Petrels. A small foraging area just off of southeast Cuba has also been reported, but the extent and seasonal use of this area are unknown. Concentrations of birds can be found along the Gulf Stream in southeastern US waters throughout the year, but are particularly common in May, August, and late December through early January. Concentrations of adult birds during winter, when peak breeding activity is underway, suggest that breeding birds forage along the Gulf Stream while commuting to and from breeding colonies. Such long-distance foraging is certainly possible for *Pterodroma* species.

Potential threats to Black-capped Petrels include introduced predators, human encroachment on breeding and foraging habitats, and offshore oil, gas, and wind energy development. Increased mercury levels associated with petroleum production also pose a potential threat, as the Black-capped Petrel seems to be highly susceptible to mercury bioaccumulation compared with other pelagic species. In addition, fires and other bright light sources are known to attract Black-capped Petrels, making collisions with wires and other structures on lighted ships and platforms a potential concern. Haitian social-economic instability and increasing habitat loss suggest the likelihood of further population declines and increasing vulnerability of the species to extinction.

Our findings are in accord with the recent decision by the US Fish and Wildlife Service (USFWS) to evaluate the need for additional protection of the species and the primary foraging habitat off the southeastern United States under the Endangered Species Act (USFWS 2012). Additional conservation measures and research strategies that warrant further consideration include (1) protection, monitoring, and management of known breeding populations and nesting habitat in the Dominican Republic and Haiti through controlling predators, installing artificial nest burrows in appropriate sites and hiring local wardens at breeding sites during the nesting season; (2) local and regional training, education and public awareness (e.g. Blanchard & Nettleship 1992); (3) restoration of the original common name *Diablotin* to common usage to promote the historical and cultural importance of this species; (4) studies to determine the distribution and genetic variability in the remaining populations; and (5) studies of satellite-tagged birds to assess their seasonal and geographic use of pelagic habitats.

INTRODUCTION

The Black-capped Petrel *Pterodroma hasitata* is the only gadfly petrel (Procellariidae) currently known to breed in the West Indies (Fig. 1). Once thought extinct, the species is currently known to nest on only one of the four islands upon which breeding was historically documented (Fig. 2). Pre-Columbian sub-fossil and bone remains of *Pterodroma* established as, or believed

to be, *P. hasitata* are known from Haiti (FSM uncatalogued), Martinique (USNM 428289, Wetmore 1952), and St. Croix in the Virgin Islands (USNM 225842, Wetmore 1918). The latter were originally described as Cahow *P. cahow* (also known as Bermuda Petrel) but, based on size and geographic probability, are now believed to represent *P. hasitata* (S. Olson pers. comm.). Cahow remains are also known from pre-Columbian middens on Crooked Island (Wetmore 1938).

Petrels were long thought extinct until Wingate (1964) discovered substantial breeding populations in the Massif de la Selle of southeastern Haiti in 1963. The species apparently survived along cliff faces of the inland mountains that were inaccessible to both humans and introduced predators. Wingate estimated a population of 2000–20000 breeding pairs in 1961. Subsequent surveys by Woods (1987) indicated that the population had declined by 40% because of the combined effects of habitat destruction, predation by introduced mammals and harvesting by humans. Recent estimates suggest that fewer than 2000 pairs remain in Haiti (Gochfield *et al.* 1994) and the West Indies (Lee 2000a), and the species is currently listed as endangered by the IUCN (IUCN 2011). A small colony also persists adjacent to the Haiti colonies in the Sierra de Bahoruco in the Dominican Republic (Ottenwalder & Vargas 1979, Lee & Viña 1993, Lee 2000a). Birds were heard calling at an inland site near Diablotin Mountain on Dominica in 1977 (van Halewyn & Norton 1984), and individual birds have been found on the island in recent decades, but direct evidence of nesting is lacking. Like many other seabirds in the region, populations of Black-capped Petrels today represent isolated relicts of larger and more widely distributed colonies. Colonies have been reduced to a few sites on cliffs and isolated cays that were inaccessible to humans and introduced predators. By the time the earliest natural history writers reported on the West Indies, all known colonies had been subject to heavy exploitation.

Current evidence indicates that waters in or adjacent to the Florida Current and Gulf Stream between northern Florida and southern Virginia as well as areas off the southeast coast of Cuba constitute the primary foraging areas for breeding Black-capped Petrels (Lee 1977, Haney 1987a, Lee & Viña 1993, Lee 1995). It was not until the late 1970s that the primary foraging range of the Black-capped Petrel was recognized to be the offshore zones of the southeastern United States, specifically the South Atlantic Bight (Cape Hatteras, North Carolina, to Cape Canaveral, Florida). Concentrations occurring during winter, when peak breeding activity is underway, are suggestive of breeding birds foraging along the Florida Current and Gulf Stream and moving to and from breeding colonies (Lee 1984, 1995).

It is clear that the Black-capped Petrel is well down the path to extinction. The combined effects of habitat loss, harvesting by humans and predation by introduced mammals have wiped out



Fig. 1. Black-capped Petrel *Pterodroma hasitata* photograph by G. Tepke (pbase.com/gtepeke) off Cape Hatteras, North Carolina, 1 September 2007.

most populations throughout the Caribbean Basin and are rapidly extinguishing the few remaining breeding colonies. Proposed energy development (Lee 1999) and *Sargassum* harvest (Moser & Lee 2012) off the Outer Banks of North Carolina may threaten important foraging habitats adjacent to the Gulf Stream. Conserving this species will require rapid delineation and protection of the remaining nesting habitats and foraging habitats along the Outer Continental Shelf of the southeastern United States.

This document compiles current knowledge about the distribution, abundance, biology and conservation needs of the Black-capped Petrel. Authors summarizing what was previously known about this species include Bent (1922), Bond (1936, et seq.), Palmer (1962), Collar *et al.* (1992), Lee (2000a), and Goetz *et al.* (2012). Warham (1990, 1996) has provided important information on the biology of the genus. We trust that what follows will stimulate additional research and conservation actions, and more importantly provide a foundation for the long-term protection and management of the species.

SYSTEMATICS AND TAXONOMY

The genus *Pterodroma* comprises approximately 30 widely distributed species (Bourne 1972, Jouanin & Mougin 1979, Imber 1985, Brooke 2004). Many species are of conservation concern, with populations that have been in decline for centuries (e.g. Bourne 1965). All are highly pelagic and nocturnal at their nesting sites. Many are winter breeders. After fledging, the birds typically spend at least 4–6 years at sea before returning to nesting islands. Imber (1985) provided a thorough recent review of the taxonomy of the gadfly petrels.

Nomenclatural history

Before the mid-1800s, gadfly petrels were placed in the genus *Procellaria*. In 1856 Bonaparte proposed the genus *Pterodroma* (Greek for “winged runner,” or “fast on the wing”) for the all dark species, and *Aestrelata* for some of the ventrally white forms such

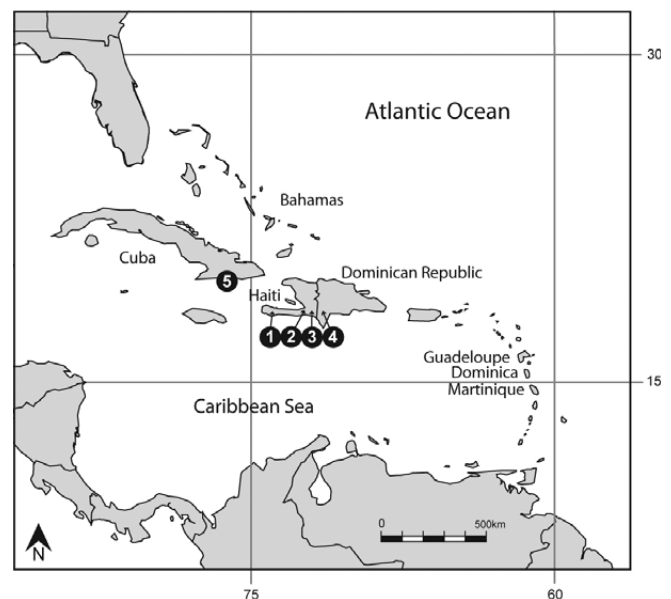


Fig. 2. Historic and current Black-capped Petrel nesting sites. The species has been extirpated from Guadeloupe, Dominica and Martinique. It is suspected to nest in the Sierra Maestra, Cuba (5), and is currently found on Pic Macaya (1), Pic Lavisite (2) and Morne Vincent (3), Haiti, and Sierra Bahoruco (4), Dominican Republic.

as *hasitata* (designated as the type for this genus by Coues 1866). *Pterodroma hasitata* (Kuhl) has been in general usage since Loomis (1918). The holotype, RMNH 87022, is the mounted skin of an adult labeled “Indian Ocean” on its leg tag and “Mer de l’Inde” on the stand on which it is mounted. This and another mount of the species (numbered 1 and 2 in the original collection numbers) were both considered as types, but the collection’s former curator, Gerlof Mees, concluded that the second bird arrived between 1820 and 1828 and was not available to Kuhl when he described the species. Kees Roselar of the Naturalis Biodiversity Center, Amsterdam, provided us with the following measurements of the type specimen: wing cord 303.0 mm, tail 131.0 mm, tarsus 40.5 mm, middle toe with claw 57.5 mm, culmen 35.1 mm.

In the original description of the Black-capped Petrel, Kuhl (1820) chose the specific name *hasitata*. The origin of this name is from the Latin *haesito*, which means to be perplexed and is the root of the English word *hesitate*, indicating the uncertainty Kuhl had concerning the validity of this species. This is a fitting name considering the lack of agreement on the taxonomic relationships of the Black-capped Petrel, uncertainty that continues to some extent to this day. The type locality of *P. hasitata* was never stated and has since been designated as Dominica. Lawrence (1853), for example, assigned *P. hasitata* to a specimen of *Procellaria cinereus* from the Nicolas Pike collection. For many years, this specimen was regarded as the only justification for the occurrence of the Grey Petrel in North America. Re-examination of the bird, as well as several other specimens from off Monterey, California, and their accompanying labels, indicates that the locality information was almost certainly in error. The correct identification of the California *P. cinereus* (AMNH 45967) was provided by Coues, but see Lawrence (1853) for an appreciation of the taxonomic confusion surrounding *hasitata* in the mid-1800s. Lee (1993) clarified the origin of a number of seabird specimens reported erroneously by Lawrence as originating from Monterey, California. Lee determined that the specimens collected from a variety of locations were shipped to east coast museums from Monterey, as ships from various ports traveled to California during the gold rush.

Local and regional nomenclature

The Black-capped Petrel is known by several names throughout the West Indies. In North America and in the English-speaking islands, it also goes by “Capped Petrel” and “West Indian Petrel.” The all-dark *caribbaea* has been called the “Jamaican Petrel,” and this bird was also known as the “dry land booby” and “Blue Mountain duck” on that island. In the creole-, French-, and Spanish-speaking islands, the petrel is usually referred to as “*diablotin*” or, more rarely, “*diablotine*.”

Translated into English, “*diablotin*” means little devil. Presumably a reference to the bird’s haunting nocturnal calls, the name is also used occasionally for Audubon’s Shearwater (*Puffinus lherminieri*). This name spread throughout the Greater and Lesser Antilles as agriculture expanded and slaves were traded throughout the region. In Haiti, and possibly other islands where French is spoken, “*chathuant*” is also used. This common name is frequently used for other nocturnal birds, including owls and caprimulgids. In Cuba, the bird is known as “*bruja*,” which means witch. They are also referred to as “Pampero de las Bruhas” and “Chanwan” in Cuba and “Chanwan Lasel Petrel” and “Canard de Montagne” in Haiti. In historical times, young birds savored for eating were referred to as “cottons,” a name obviously referring to their down feathers.

Zonfrillo (1987) makes a compelling argument regarding the common name of *Pterodroma hasitata*.

[T]he local name of the bird, Diablotin, appears to be as much in danger of dying out as the species itself. Where birds such as petrels feature in the economic or historical context of islands, or human populations on islands, it is surely not asking a lot to preserve the local name and incorporate it into modern usage? ‘Capped Petrel’, or ‘Black-capped Petrel’ as the bird is now referred to in the USA, are names which tell little about the bird or its history. There are several species of *Pterodroma* and shearwaters that have caps or a capped appearance. Along with the endangered Cahow *Pterodroma cahow* of Bermuda, the Gon-Gon *Pterodroma feae* of the Deserta & Cape Verde Islands, and the virtually extinct Frieria *Pterodroma madeira* of Madeira, the local names are more quaint and evocative than their rather bland English equivalents. The Diablotin, the ‘devil-bird’, should not be allowed to fade away.

We agree with Zonfrillo’s suggestion of resurrecting this petrel’s traditional name, and add that, because the future of this species depends to a large extent on conservation initiatives carried out on its Caribbean nesting islands, supporting the use of the historic regional name could prove important in winning local support for conservation efforts.

Relationships to other *Pterodroma*

Murphy (1936) considered the species *P. phaeopygia*, *P. externa*, *P. cahow* and *P. hasitata* to have a close affinity. Palmer (1962) considered many forms of *Pterodroma* to be subspecies of *P. hasitata*. These include not only *P. caribbaea* (see below) and *P. cahow* of the North Atlantic, but the four Pacific forms that get progressively larger and grayer, with a reduction in dark pigmentation, from north to south. These include *P. sandwichensis* of Hawaii, *P. phaeopygia* of the Galapagos, *P. cervicalis* from the Kermadec Islands, and the large *P. externa* breeding on the Juan Fernandez islands.

Phylogenetic analyses fail to support common ancestry among these dorsally dark, ventrally white *Pterodroma*, especially among species that occur in different ocean basins. Despite the superficial similarities, these petrels are not genetically related and indeed fall into different clades (e.g. Penhallurick & Wing 2004). Moreover, mitochondrial studies indicate that Black-capped Petrels are more closely related to the other North Atlantic *Pterodroma* than they are to the similar-appearing *Pterodroma* found in the Pacific (Penhallurick & Wing 2004, Jesus *et al.* 2009).

Imber (1985) placed *P. hasitata* in the *Pterodroma* subgenus *Pterodroma*, one of four subgenera. The 11 members of this subgenus include birds that are the largest in size, have the deepest, strongest bills, and have helicoidal intestines with a 93%–100% counterclockwise twist. Seven, including *P. hasitata*, are winter breeders. The intestinal structure of *P. hasitata* is virtually identical to that of *P. incerta*, which may be a sibling species of *P. lessonii* (Murphy & Pennoyer 1952).

Imber (1985) also notes that the North Atlantic may have been colonized twice by *Pterodroma*, once by summer breeding species,

and once by winter breeding ones (*P. hasitata*, *P. cahow*). Several early authors (e.g. Palmer 1962) stated that the Cahow *P. cahow* is a form of *P. hasitata*. However, helicoidal twist counts of intestines indicate that the Black-capped Petrel and the Cahow are clearly distinct (Imber 1985).

Timmermann (1965) noted that there were two very distinct species-groups of *Halipeurus* (Mallophaga) lice on gadfly petrels. Accordingly, he considered *Pterodroma* to be polyphyletic and proposed classifying gadfly petrels into two genera: *Pterodroma* for those hosting *procellariae*-group lice and *Aestrelata* for those hosting *marquesanus*-group lice.

We point out these studies primarily to illustrate that the systematics of gadfly petrels has not always been clear, even at the generic level (e.g. Bretagnolle *et al.* 1998). For the most part, however, the separate lines of evidence summarized above point to common ancestry between Black-capped Petrel and other Atlantic *Pterodroma*.

Relationships with other North Atlantic *Pterodroma*

In Table 1 we provide a summary of *Pterodroma* known to occur in the North Atlantic, their breeding sites and their reported population status. Recent trends in taxonomic status for North Atlantic *Pterodroma* suggest putative cryptic speciation, accompanied by the increasing tendency to recognize different forms and/or populations as full species (Zino *et al.* 2008, Jesus *et al.* 2009). Previously considered as one subspecies of the polytypic Soft-plumaged Petrel (Harrop 2004), Macaronesian petrels in the northeast Atlantic are now usually split, although these taxonomic revisions are not without controversy (Bretagnolle 1995, see also Rheindt & Austin 2005). Recent molecular research has shown that differentiation among these incipient forms is 10 times more recent than previously thought, with the Madeira rather than the Cape Verde taxon as the more ancestral form (Gangloff *et al.* 2013). Northeast Atlantic forms commonly recognized include Fea's Petrel *Pterodroma feae*, breeding on the Cape Verde Islands and Madeira Islands (Bugio Island); Deserta's Petrel *Pterodroma deserta*, considered a subspecies of *P. feae* (Brooke 2004), breeding on Bugio Island

in the Desertas islands off Madeira; and Zino's Petrel or Freira *Pterodroma madeira*, breeding endemically on Madeira. The Herald Petrel *Pterodroma arminjoniana* population nesting on South Trinidad Island in the tropical Atlantic is represented by two distinct color morphs that have different nesting behaviors, and it has been suggested that the Atlantic and Indian Ocean populations of this species may be distinct (Lee 2000b).

Variability within *Pterodroma hasitata*

Preliminary electrophoretic studies of *Pterodroma hasitata* collected off North Carolina (n = 7), conducted in the 1980s, did not show clear-cut dissimilarities, although one specimen exhibited slight frequency differences (J. Gerwin unpubl. data). Electrophoresis, however, is probably of little value below the generic level (Buth 1984), and we do not expect that additional electrophoretic data will contribute much information to our understanding of *P. hasitata*.

Black-capped Petrels exhibit a range of obvious morphological and plumage variability. This includes differences in overall size, size of the dark chest spur, and relative extent of black cap vis-à-vis white coloration on the head (Harrison 1983, Lee 1984, Howell & Patteson 2008, Howell 2012). Off North Carolina, light morph forms tend to be relatively more common in May and June, whereas dark morph petrels become more common in late summer and fall; molt occurs earlier in the light form as well (Howell & Patteson 2008). Birds off the Outer Banks and South Atlantic Bight may thus originate from geographically or seasonally distinguishable populations in the Caribbean. At the same time, the observation of intermediate forms confounds reaching such a conclusion based on current knowledge.

Manly *et al.* (in press), following approaches used successfully on other *Pterodroma* species (Lawrence *et al.* 2008, Nunn & Stanley 1998), amplified mitochondrial cytochrome oxidase 1 (CO1) sequences to look for genetic differences among plumage variants (Lee 1984, Howell & Patteson 2008) of Black-capped Petrels collected off North Carolina in the 1970s and 1980s. They analyzed 22 sequences and found a 1.2% fixed genetic difference between

TABLE 1
Species and populations of *Pterodroma* known to occur in the North Atlantic

Species ^a	Nesting areas	Estimated breeding population (pairs)	Authority
Black-capped Petrel <i>Pterodroma hasitata</i>	Greater and Lesser Antilles	500–1000	This study, Birdlife International 2011c
Jamaica Petrel <i>Pterodroma caribbaea</i>	Eastern Jamaica	Believed extinct	Imber 1991
Cahow (Bermuda Petrel) <i>Pterodroma cahow</i>	Bermuda	98	Birdlife International 2011a
Fea's Petrel <i>Pterodroma fea</i>	Cape Verde Island	500–1000 (minimum)	Hazevoet 1995, Ratcliffe <i>et al.</i> 2000
Zino's Petrel <i>Pterodroma madeira</i>	Madeira	65–80	Zino and Zino 1986, Birdlife International 2011b
Deserta's Petrel <i>Pterodroma deserta</i>	Bugio Island, off Madeira	150–200	Zino and Biscoito 1994
Soft-plumage Petrel <i>Pterodroma mollis</i>	Central South Atlantic and Sub-Antarctic	Tens of thousands	Jouventin <i>et al.</i> 1984
Herald Petrel <i>Pterodroma arminjoniana</i>	South Trinidad Island	Atlantic population: 600	Luigi <i>et al.</i> 2008

^a Species designations follow Sangster *et al.* (2002), Jesus *et al.* (2009), Zino *et al.* (2008) and Zonfrillo (1993).

the dark morph and the light morph of the Black-capped Petrel. Birds with intermediate plumage all grouped phylogenetically with the light morph. They concluded that, combined with significant differences in body size and phenology, their genetic results suggest seasonal or geographic breeding isolation of the two color morphs. They note that their findings do not rule out the possibility that the Black-capped Petrel may consist of two distinct species, but caution that better information on the genetic identity of birds from known nesting colonies is necessary to draw further conclusions. For example, recent studies of the closely related Hawaiian Petrel (Wiley *et al.* 2012) indicate substantial genetic and foraging divergence in populations on the islands of Kauai and Hawaii. This divergence occurs in spite of the relatively close proximity of the two breeding populations in Hawaii. Future genetic studies hold the promise of providing information on the likelihood of inbreeding effects, the possibility of cryptic populations beyond known breeding localities, the level of genetic isolation or gene flow among populations, and the phylogenetic relationships and time since divergence of extant populations and species.

Examination of museum skins reveals considerable variation in size and coloration, and historical accounts describe two types of petrels nesting on Guadeloupe (see below), suggesting that distinct breeding populations once existed in the West Indies. All of these sources of information indicate the need for detailed systematic review and related genetic studies. Unfortunately, limited museum material and the loss of key historic specimens held in European museums during World War II may make such an undertaking difficult and probably inconclusive, while import/export regulations complicate overseas loans (for a complete list of museum specimens extant, see Table 2). The type specimen is lacking complete documentation.

A dark form, *Pterodroma caribbaea* (now considered a separate species; Imber 1985), bred in the Blue Mountains of Jamaica, where at least 26 specimens were obtained between 1825 and 1879 (Benson 1972, Bourne 1965). The few measurements available show this form to be smaller than *P. hasitata*. Murphy (1936) assessed the relationship of these birds as follows:

The question has arisen many times as to the relationship of the Diablotin to the black petrel or 'Blue Mountain Duck' (*Pterodroma caribbaea*) of Jamaica. It has been pointed out by Loomis (1918) and others that *hasitata* and *caribbaea* may represent dichromatic phases of the same species, a condition familiar enough among petrels of this group. Dr. G. K. Noble has informed me that the two specimens of the Diablotin preserved in the museum at Guadeloupe are both light-colored, black-capped birds. Pere Labat's observations were, however, made at this island, and Bangs and Penard (1919) have called attention to the fact that Labat's plate and text both refer to a bird of uniformly dark plumage. But only a quarter of a century before Father Labat's visit to Guadeloupe, du Tertre (1667), who had visited that island and apparently had witnessed the hunting and tasted the delicate flesh of the petrels, states with all clearness that the plumage of the birds was "a mixed black and white." A still further taxonomic complication is introduced by information advanced by Lafresnaye (1844) and Noble (1916), namely, that two different sorts of closely related white-breasted petrels formerly bred at Guadeloupe, the respective birds coming to nest at different seasons, and choosing quite different

altitudes on the island for the sites of their colonies. Lafresnaye states that the inhabitants distinguished one as the 'high petrel,' the other as the 'low petrel,' and that the two kinds were of different sizes. Although such a distinction is not currently recognized, there seems to be a wide range in the dimensions of existing specimens of the Black-capped Petrel, and it is unlikely that the last word upon the subject has been said.

Returning to the question of identity of the dark Jamaican Petrel, Murphy (1936) went on to state: "I consider it highly probable that this bird and the Black-capped were color phases of the same species." Complete or prevailing segregation of two phases in distinct though adjacent breeding grounds is a phenomenon known among other procellariiforms, such as *Pterodroma neglecta* and *Puffinus pacificus*. It is possible that a dichromatic petrel was abundant and widespread in the West Indies, becoming exterminated in most places soon after large numbers of African slaves and domestic animals were imported to the region throughout the colonial period. Our only knowledge of the dark phase, aside from the figures and text of Labat, is based upon the Jamaican representative, *P. caribbaea*. M. J. Imber (pers. comm.) believes that *P. caribbaea* is a distinct species most closely related to *P. feae* of the North Atlantic. The second type of *diablotin* on Guadeloupe may have been nesting Audubon's Shearwaters, *Puffinus lherminieri*, as the name *diablotin* was also used for this species.

All specimens obtained in North America are of *P. hasitata* (i.e. the nominate form). No dark forms (*P. caribbaea*) were ever noted in the multi-year studies of Lee (1995, 2000a) or Haney (1987a, 1987b) conducted off the southeastern United States.

DESCRIPTION

The original description by Kuhl (1820) is quite vague. It is reprinted here in its entirety:

11. *Proc. hasitata* Forster.
Forster tab. 97. — tab. 98, sub nomine *Procellariae leucocephalae*.
c) Cauda cuneiformi.
2. Remige primo longissimo.
Unguibus falcatis, altitudine latitudinem superanti.
Halluce mediocri.
Alis caudam aequantibus, a flexura ad apicem usque 11 1/8 poll. longis. Cauda cuneiformi, acuta, 6 poll. longa; rostro robustiori, valde deflexo, ab angulo oris ad apicem 19 lin. longo. Pedibus humilibus, tarsis 17 lin., digito medio 25 lin. longis. — Longitudo corporis 16 1/3 poll. — Alba sunt: latus inferius, frons, facies, nucha caudaeque tectrices superiores et inferiores. Brunescen-tigra sunt: alae, cauda, dorsum, uropygium et vertex medius, interscapulium autem brunescen-tinereum. Rostro et membranae natatoriae parte antica nigris, pedum parte reliqua flava. In Museo Bullokiano, nuc in Temminkiano.

Harrison (1983) provides a modern and popular description:

Length 35–46 cm, wingspan 89–102 cm, Iris blackish-brown, bill black, legs-feet whitish-flesh, webs distally black. Sexes alike; no seasonal variation but much variation in extent of white on hindneck and rump.

TABLE 2
Museum specimens of Black-capped Petrels

Institution^a/catalogue no.	Sex/preparation/tissue	Year collected	Location
LSUMZ/131206	f/study skin/no	1987	NC, Dare Co. off Oregon Inlet
LSUMZ/131207	m/study skin/yes	1987	NC, Dare Co., off Oregon Inlet
LSUMZ/131208	m/study skin/yes	1986	NC, Dare Co., off Oregon Inlet
CU/5838	m/study skin/no	1933	NY, Tioga Co., Hiawatha Island
CU/36805	m/flat skin/no	1989	NY, Horseheads TWS
CU/36939	m/partial skeleton/no	1989	PA, Wyoming Co., Nicholson
CU/50218	f/study skin/yes	?	NY, Onondaga Co.
ANSP/182924	f/?/no	?	PA, Venango Co., Oil City
ANSP/182925	m/?/no	?	PA, Wyoming Co. Nicholson
ANSP/5089	?/?/?	?	?
MCZ/73219	?/study skin/no	No date	Guadeloupe
MCZ/73220	?/study skin/no	No date	Guadeloupe
MCZ/73221	?/study skin/no	No date	Guadeloupe
MCZ/73222	?/study skin/no	No date	Guadeloupe
MCZ/328581	?/study skin/no	1893	VA, near Winchester
MCZ/291232	?/study skin/no	1893	NH, Merrimack Co, Pittsfield
AMNH/DOT9015	f/?/yes	1987	NC, Dare Co. 45 m E Oregon Inlet
AMNH/749105	m/study skin/no	1898	OH, Cincinnati
AMNH/648893	?/study skin/no	1962	Haiti, Port-au-Prince
AMNH/818562	f/study skin/no	1987	NC, Dare Co. 45 m E Oregon Inlet
ZMUC/9/Pro/11/j/1	?/mount/no	No date	?
USNM/488735	m/skeleton/no	1936	Haiti, La Selle Ridge
USNM/596792	f/study skin/no	1989	VA, Augusta Co., Veronia
USNM/527749	m/study skin	1977	FL
USNM/556303	m/skeleton & skin/no	1980	NC, Dare Co., off Oregon Inlet
USNM/598521	f/skeleton & skin/no	1980	NC, Dare Co, off Oregon Inlet
USNM/598522	m/skeleton & skin/no	1980	NC, Dare Co, off Oregon Inlet
USNM/598523	f/skeleton & skin/no	1980	NC, Dare Co, off Oregon Inlet
USNM/598524	m/skeleton & skin/no	1980	NC, Dare Co, off Oregon Inlet
USNM/558357	?/?/?	?	?
USNM/560208	f/skeleton/no	1978	NC, Dare Co, off Oregon Inlet
USNM/358081	?/skeleton & skin/no	1939	Haiti, Lafond
USNM/152522	?/study skin/no	1893	VA, Fredrick Co., Winchester
USNM/80859	f/ study skin/no	1879	Jamaica, Cinchona Plantation
USNM/80860	f/study skin/no	1879	Jamaica, Cinchona Plantation
USNM/621363	f/skin in alcohol/no	1996	MD, Talbot Co., Miles River
USNM/228371	m/syrinx,wings,tail/no	?	NC, Dare Co. off Oregon Inlet
YPM/102698	?/partial skeleton/no	?	Bahamas, Gordon Hill Cave
ROM/34255	?/ study skin/no	1893	Canada, Ontario, Halton
ROM/34256	m/study skin/no	1893	Canada, Ontario, Toronto
ROM/33965	?/skeleton/no	?	Canada, Ontario, Toronto
ROM/76829	?/alcohol/yes	1955	Canada, Ontario, Niagara, Morgans Point
ROM/159637	m/skeleton/no	1996	Canada, Ontario, Niagara, Windmill Point Beach
ROM/159638	m/skeleton/no	1996	Canada, Ontario, Niagara, Thunder Bay
ROM/159639	f/skeleton/no	1966	?
ROM/159640	m/study skin/no	1996	Canada, Ontario, Hamilton, Van Wagners Beach
ROM/159641	?/skeleton/no	1996	Canada, Ontario, Niagara, Waverly Beach
ROM/159643	?/skeleton/no	1996	Canada, Ontario, Niagara, Lorraine
ROM/159644	?/skeleton/no	1996	Canada, Ontario, Niagara, Pleasant Beach
ROM/159646	?/skeleton/no	1996	Canada, Ontario, Niagara, Willow Bay
ROM/159647	?/skeleton/no	1996	Canada, Ontario, Niagara, Empire Beach
ROM/159824	?/skeleton/no	1996	Canada, Ontario, Hamilton
UF/22114	m/skeleton & skin/no	1988	NC, off Oregon Inlet
UM/228,315	m/study skin/no	1989	NC, off Oregon Inlet
CM/81920	m/study skin/no	1895	NY, New Pahtz
CM/168749	f/skeleton & skin/no	1989	PA, Buena Vista

^a Museum codes: LSUMZ, Louisiana State University; CU, Cornell University; ANSP, Academy of Natural Sciences, Philadelphia; MCZ, Museum of Comparative Zoology; AMNH, American Museum of Natural History; ZMUC, Zoologisk Museum Copenhagen; USNM, U.S National Museum; YPM, Yale Peabody Museum; ROM, Royal Ontario Museum; UF, University of Florida; UM, University of Michigan; CM, Carnegie Mellon University. Specimens in the North Carolina State Museum, NCSM, are summarized in Table 3.

TABLE 3
Measurements of Black-capped Petrels collected off North Carolina

NCSM ^a catalogue no.	Date	Sex/age/bursa ^b	Weight (g)	Wing cord/ total length (mm)	Culmen length/ depth (mm)	Primary molt
7551	8 May 1980	M/?/?	414.2	296/384	33.4/14.5	No
7745	10 Sept 1980	M/?/?	392.0	279/387	33.4/14.9	No
7919	21 Aug 1980	M/A/No	531.0	282/408	33.2/16.8	Yes
7993	3 June 1981	M/A/No	442.0	282/408	32.4/16.2	Yes
7995	11 June 1981	M/A/No	496.0	306/436	37.0/13.0	Yes
8050	11 Aug 1981	M/?/?	403.0	247/402	33.1/17.6	Yes
8388	19 May 1982	M/A/No	481.3	308/412	38.1/16.8	Yes
8389	19 May 1982	M/A/No	448.9	-/424	35.8/17.6	Yes
8391	19 May 1982	M/A/No	364.9	-/390	33.6/16.3	Yes
8393	19 May 1982	M/A/No	401.2	-/391	32.7/15.9	Yes
8774	19 May 1982	M/J/Yes	437.5	-/413	34.4/15.8	No
8403	19 May 1982	M/A/No	367.5	-/381	33.7/15.0	No
8407	19 May 1982	M/A/No	361.5	-/389	-/	Yes
8774	6 Oct 1982	M/?/?	437.5	-/	34.4/15.0	-
8958	28 Dec 1982	M/A/No	458.2	-/405	32.5/14.5	No
8559	28 Dec 1982	M/?/?	438.0	-/	32.9/14.3	-
8962	28 Dec 1982	M/A/No	479.6	-/402	-/	No
8963	28 Dec 1982	M/A/No	450.7	-/387	32.3/15.4	No
8964	28 Dec 1982	M/A/No	482.1	-/400	32.2/16.3	No
9353	28 Dec 1982	M/A/No	473.0	-/388	32.2/15.7	No
9398	28 Dec 1982	M/A/No	431.2	-/402	33.3/14.4	No
9399	28 Dec 1982	M/A/No	447.4	-/392	33.9/15.8	No
9401	28 Dec 1982	M/A/No	523.1	-/393	-/	No
9402	28 Dec 1982	M/A/No	432.9	-/403	-/	No
9403	28 Dec 1982	M/A/No	452.5	-/396	31.8/15.7	No
9404	28 Dec 1982	M/A/No	536.4	-/379	-/	No
9405	28 Dec 1982	M/J/Yes	329.3	-/395	31.8/15.7	No
9406	28 Dec 1982	M/A/No	401.1	-/396	32.8/15.7	No
9409	28 Dec 1982	M/A/No	502.4	-/395	31.4/16.0	No
9489	28 Dec 1982	M/A/No	407.2	-/402	33.0/15.0	No
9490	19 May 1982	M/A/No	382.0	-/382	32.5/16.0	No
9494	28 Dec 1982	M/A/No	534.3	-/429	38.6/16.6	No
9497	28 Dec 1982	M/A/No	549.7	-/435	33.3/16.6	No
9499	28 Dec 1982	M/A/No	523.0	-/437	34.6/16.5	No
9501	28 Dec 1982	M/A/No	423.6	-/395	33.9/15.5	No
9511	12 July 1983	M/A/No	383.4	-/390	-/	Yes
9522	26 July 1983	M/A/No	438.4	-/437	34.6/17.0	Yes
9525	5 July 1983	M/A/No	445.3	-/404	34.0/16.4	Yes
9526	19 July 1983	M/A/No	403.0	-/397	33.2/16.2	Yes
9529	12 July 1983	M/A/No	348.9	-/392	32.8/14.6	Yes
9539	28 Dec 1982	M/A/No	557.2	-/402	36.5/18.0	No
9540	9 Aug 1983	M/A/No	379.1	-/387	32.2/16.1	Yes
10417	7 Aug 1984	M/?/?	355.0	-/391	31.2/15.0	Yes
10418	10 Aug 1984	M/?/?	404.5	-/378	-/	Yes
11150	29 April 1980	M/?/?	-	-/	-/	-
11151	29 April 1980	M/?/?	-	-/	-/	-
17105	4 Aug 1989	M/?/?	-	-/	-/	-
17139	10 July 1989	M/?/?	-	-/	-/	-
6456	10 May 1978	F/J/?	373.5	370/275	31.7/17.0	No
7375	22 Oct 1979	F/A/?	421.6	285/375	31.4/14.5	No
7552	22 May 1980	F/?/?	367.8	290/385	31.4/14.6	No
7553	22 May 1980	F/?/?	347.0	284/380	29.2/14.1	No
8392	19 May 1982	F/A/No	459.0	-/432	34.0/15.5	Yes
8402	19 May 1902	F/A/No	400.2	280/403	33.4/15.5	Yes
8956	28 Dec 1982	F/A/No	463.8	-/391	31.8/15.7	No
8960	28 Dec 1982	F/A/No	467.5	-/409	34.8/14.8	No
8961	28 Dec 1982	F/A/No	511.2	-/410	-/	No
9352	28 Dec 1982	F/A/No	423.3	-/387	31.7/15.6	No
9488	28 Dec 1982	F/A/No	420.0	-/401	32.9/13.7	No
9491	19 May 1982	F/A/No	393.1	-/394	31.5/14.3	Yes
9498	28 Dec 1982	F/A/No	470.0	-/398	31.7/14.5	No
9507	28 Dec 1982	F/A/No	391.7	-/416	35.0/16.8	No
9508	20 Oct 1982	F/J/Yes	355.2	-/382	31.4/15.0	No
9510	12 July 1983	F/A/No	382.5	-/403	-/	Yes
9548	9 Aug 1983	F/A/No	394.8	-/404	33.4/14.0	Yes
10419	7 Aug 1984	F/?/?	381.3	305/379	31.9/14.8	No
10450	27 Mar 1985	F/A/?	545.4	305/415	34.6/15.8	No
11152	29 Apr 1980	F/?/?	-	-/	-/	-

^a North Carolina State Museum.

^b M = male, F = female, A = adult, J = juvenile.

Head Brownish-black cap extending to eye and nape, remainder including hindneck white. **Body** Upperparts mostly brownish, shading to blackish on lower back; rump and upper tail coverts white, forming conspicuous broad band over base of tail. Underparts mostly white except for narrow dark collar on sides of breast (extension from mantle) and blackish feather tips on thighs. **Wings** Upperwing brownish-black, primaries and secondaries slightly darker. Underwing mainly white, with irregular blackish margins, tip and short diagonal bar of variable width and length extending inwards across coverts. Tail blackish-brown.

Black-capped Petrels encountered off the southeastern US coast display considerable variation in size (Table 3) and markings (Fig. 3a and 3b). This variation is not related to age, sex or molt sequence. Based on these specimens, it is apparent that Black-capped Petrels are either extremely polymorphic or that the birds off the North Carolina coast are recruiting from distinct breeding populations. Black-capped Petrels range from large (≥ 550 g) birds with classic black caps, wide, distinctive collars, and conspicuous white “rump” patches to much smaller (≤ 300 g) birds with reduced areas of white. Thus, the smallest and darkest would approach a Cahow in both size and, from a distance, in appearance.

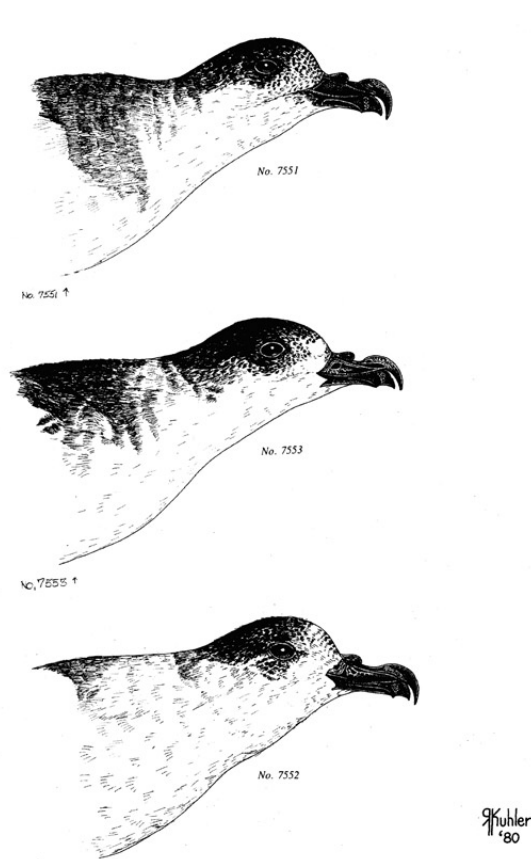


Fig. 3a. Variation in the extent of dark cap exhibited by some Black-capped Petrels at the North Carolina State Museum of Natural History (top NCSM 7551, center NCSM 7553, bottom NCSM 7552). See also Howell and Patteson (2008). Drawings by R. Kuhler in Lee (1984).

HISTORICAL AND RECENT DISTRIBUTIONS OF NESTING POPULATIONS

It is worthwhile to examine the current distribution of breeding Black-capped Petrels (Fig. 2) in view of Antillean geological and biogeographical interpretations. Like most *Pterodroma*, nesting populations of *P. hasitata* are found along the edges of oceanic fault plates. Not only is the species endemic to the Caribbean, but nesting colonies are confined to islands on the northern and eastern edge of the Caribbean plate, Jamaica being the exception.

We suggest that the distribution of the Black-capped Petrels is related to the geological history of the Antillean region. Winter-breeding, non-migrating *Pterodroma*, the *Aestrelata* of Bonaparte (1856) and the subgenus *Pterodroma* of Imber (1985) colonized one or more of the larger Caribbean Islands during the Pleistocene or earlier. The presence of an open tropical middle sea (Pan-Tethyan), which closed 65 million years ago, could have allowed the original colonization to come from Pacific stock. Such a scenario would explain the close affinity of *P. hasitata* to some of the Pacific members of the subgenus *Pterodroma* such as *P. incerta* (see above). However, the evidence strongly suggests that this colonization came from the South Atlantic after the closure of the Panama isthmus (Imber 1985). (Note: *P. incerta* is a South Atlantic species not to be confused with *P. externa*).

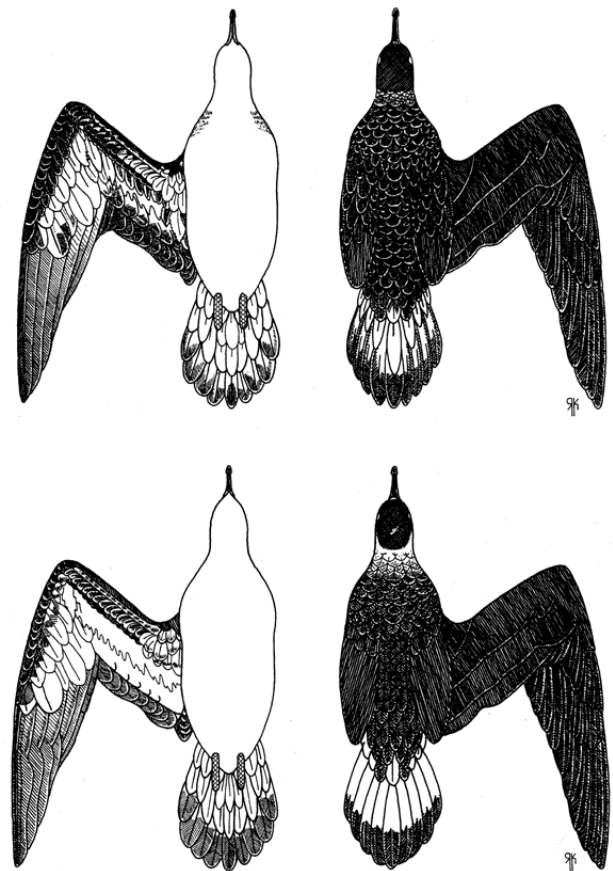


Fig. 3b. Dorsal and ventral color variation in the Black-capped Petrel. Bird at top (NCSM 7551) represents a dark extreme in pigmentation, bird at bottom (NCSM 7552) represents a light color phase. Drawings by R. Kuhler in Lee (1984).

Once established, the Caribbean stock colonized other Antillean islands. The apparent separate evolutionary history of Jamaica may in part explain the distinct appearance of the Jamaican Petrel, which may have arrived at a different time. Although marine birds are certainly not as limited in dispersal abilities as terrestrial animals intolerant of salt water, *Pterodroma* may not disperse easily or widely from ancestral breeding grounds to establish new colonies. This is a result of strong philopatry, not poor dispersal *per se*. Evidence of this pattern is provided by the complex taxonomic and geographic mosaic of the genus and by highly endemic forms such as *P. cahow*, which have been shown to exhibit extreme fidelity to specific nesting islets.

In the Greater Antilles today, breeding *Pterodroma* are distributed primarily along the suture zone of the North and South Island of Hispaniola; formerly, they also bred in mountains in Jamaica. These two sites are geologically younger than Cuba, Puerto Rico and northern Hispaniola. We suspect that *P. hasitata* or its ancestors also colonized the older islands but were largely extirpated from them, perhaps because their mountains did not provide sufficient refuge from humans, or as a result of ecological incompatibility with maturing biotas. The relationship of *P. caribbaea* to *P. hasitata* is problematic; based on both its smaller size and all-dark coloration, it may not be closely related to *P. hasitata* or other Atlantic *Pterodroma*.

The Lesser Antilles are younger than the Greater Antilles and have less diverse fauna. Hurricanes, earthquakes and volcanic eruptions could intermittently restrict available nesting habitat or enhance sites for colonization. We believe that *P. hasitata* colonized and re-colonized the Lesser Antilles initially from stocks in Greater Antilles, and then later from within and across the Lesser Antilles.

Natural disasters commonly influence populations of plants and animals on islands. Hurricanes can destroy forests over vast areas. Location (including origin), frequency, strength and track length of Caribbean hurricanes are all cyclical and exhibit considerable variability through time (Goldenberg *et al.* 2001, Emanuel 2005, Webster *et al.* 2005). At time of writing, after two decades of low activity, Caribbean hurricanes are expected to increase in frequency and strength (Emanuel 2005). Vegetative changes associated with periods of increased hurricane activity could have periodically affected the suitability of highland forest sites used by breeding populations of Black-capped Petrels. Because hurricanes typically occur in summer and fall (May–November), breeding activity by petrels would not be affected directly. In fact, it has been suggested that Black-capped Petrels and other seabirds nesting in the West Indies have adjusted their breeding cycles to allow fledging of chicks before the hurricane season. In the case of the Black-capped Petrel, protracted incubation and fledging periods may have resulted in the birds initiating their breeding in early winter (Lee 1996). Hurricanes could affect the accessibility or suitability of nesting sites by opening the canopy or by eroding soil needed for burrow construction. On Dominica, much of the interior forests have remained undisturbed by man, yet Hurricane David in 1979 caused the most severe damage ever reported to forests on that island. Montane rainforest on Dominica is expected to require 50 years or more to regain climax conditions (Lugo *et al.* 1983). Even forests on the leeward slopes of Morne Diablotin (so named because it was at least formerly a petrel nesting site), probably the most sheltered region of the island, were extensively damaged (Evans 1986).

Heavy rains often create mud-slides, which can deforest many acres. We believe these and similar natural openings in high-elevation areas and subsequent successional stages of regenerating forests may benefit nesting petrels. The 1847 earthquake on Guadeloupe is blamed for the disappearance of *P. hasitata* from that island. Although earthquakes during the nesting season might be initially detrimental to breeding populations, in the longer term they may help create forest openings and disturbed soils suitable for nesting sites. To some extent, storms may also affect the size of predator populations (e.g. Allen 1942). While the situation Allen described has little direct bearing on nesting situations of Caribbean *Pterodroma*, the principle of tropical storms influencing terrestrial predator populations is important. Catastrophic events in the past could have played a major role in the colonization of *P. hasitata*. The unstable mosaic of available nesting habitats may have forced colonies to move or reduced them to relict populations; this process may have favored the polymorphism presently exhibited by the species. Stable forest systems seem critical to the survival of Pacific petrels. Many *Pterodroma* habitually climb trees to exit colonies (Warham 1996). However, because current populations of Black-capped Petrels represent relicts of their former distribution, it is not clear how closely historic populations were tied to forested habits. An island-by-island summary of breeding localities follows:

Lesser Antilles

Martinique. Most authors (e.g. Pinchon 1967, van Halewyn & Norton 1984) concur that the Black-capped Petrel was extirpated on Martinique in pre-Columbian times by the Carib Indians, who used the bird as a source of food. However, Wetmore (1952), in his report of a humerus of this petrel from Martinique (USNM 428289), points out another record from the early 1800s when L’Herminier (1879, cited in Wetmore 1952) included it in a list of species without data other than the name (observed between 1827 and 1844). Wetmore concluded that the bone specimen is verification of L’Herminier’s report (see also Olson & Hilgartner 1982). The eruption in 1902 of Mount Pelée is of speculative interest in that it may relate to the disappearance of *Pterodroma* on this island. However, *Pterodroma* were reported as “not uncommon” in the Martinique and Guadeloupe channels in the early 20th century (Verrill 1905). Today, Martinique is largely deforested, with most of the available land converted to agriculture.

Guadeloupe. Former nesting of the species in the 1800s on Soufrière Mountain is well documented. In the 1890s the species was reported as nesting “even as low” as Camp Jacob (~500 m) (Lawrence 1891). Bent (1922) and Pinchon (1967) reported rapid declines in the population as a result of an earthquake in 1847, the use of the adult birds for food and exploitation of the greasy young birds for fuel. Nesting birds disappeared around 1850. Murphy (1936) states:

Labat’s (1724) account is accompanied by an illustration of the ‘Montagne des Diables,’ showing negroes at work with their bird-poles in the treeless Soufriere of Guadeloupe. He states that in spite of the fatigues of the hunt, his curiosity led him to take part in one which lasted for more than 24 hours. The party followed the bed of a running stream inland as far as was possible, then climbed the steep slopes of the mountain and camped for the night. Next morning the burrows were searched out,

the occupied homes being determined through the aid of dogs with well-trained noses. The birds, for the most part, were dragged out by being teased into seizing with their bills the end of a pole thrust into the burrows. Before noon of the second day, the party of six men had captured 213 petrels, with which they returned to the coast. 'One has to admit,' writes Pere Labat, 'that a Diable right from the spit is a delicacy. I had thought that one bird would well satisfy my appetite but, whether it was due to the cold mountain air, the strenuous trip, or to the fact that the Diables of this island are more tempting and digestible than those of other regions, I felt constrained to do as my companions did and to eat a second.'

Pere Labat evidently had the instinct of a conservationist, for he wrote in his notes for the year 1696 that the reprehensible habits of the French settlers had nearly wiped out the Diablotins in the accessible regions of Guadeloupe. This, however, did not prevent him from recording that the birds are a sort of manna which God had sent the inhabitants of the island for an annual period of gourmandising. The "cottons" he describes as particularly tasty, and he gives detailed recipes for cooking both these and adult birds in several different ways. (Murphy 1936, Bent 1922 cites Labat's entire account of this species)

The most recent information for the island was presented by Noble (1916), who provided the following information (also recorded in Bent 1922):

One of the chief reasons of my visit to Guadeloupe was to obtain information about the black-capped petrels... Finally we made a trip together high up into the hills of Matouba to visit an old Negro called Pere Lownisky living on the slopes of the Soufrier. This old man in his early youth had often hunted Diablotins and had joined several of the large parties which had camped on the Nez Casse to dig out the diablotins from their burrows. Since Pere Lownisky had spent his entire life in Matouba he knew all the old breeding grounds of the black-capped petrels. He told us that the diablotins formerly bred on the north and northeast slope of the Nez Casse. The birds arrived in late September and the period of incubation for the colony as a whole extended through November and December. The young birds remained in the nest until March. He asserted positively, however, that no diablotins had been heard or seen since the great earthquake of 1847. The old Negro remembered that earthquake for during it the whole side of Nez Casse, on which the petrels bred, had collapsed and fallen into the valley. Pere Lownisky ended his exposition by dramatically raising his withered hand, exclaiming again in his 'creole' French that the diablotins had not been heard of for nearly seventy years, 'Jamais! Jamais!' (Murphy 1936).

Guadeloupe, too, has suffered heavy deforestation.

Dominica. The species was numerous on Dominica (the designate type locality) in the early 1800s, and, although its numbers certainly have been decimated, a portion of the population may still be extant. It appears that historically the largest portion of the population nested here. French colonists on Dominica formerly exported "great

quantities" of petrels to Martinique and other French possessions in the Antilles (Porter 1930). Murphy (1936) states:

During the West Indian work of the Brewster-Sanford Expedition, Beck hunted for the breeding grounds of the Black-capped Petrel in late April, 1917. They are known to have been abundant at Dominica as late as the year 1858, coming from sea each year in October (Lawrence 1878). A native guide, whose parent had dug the birds out of their holes in the forest a half century before, accompanied Beck, and together they combed over the ground on the steep ridge below the crest of Morne Diablotin. They also spent the whole of one night and parts of others in the woodland, listening for calls of the birds, but without result. The only warm-blooded animal found in burrows of the forest floor, or in undermined recesses among the roots of trees on steep slopes, was an unidentified, rat-like mammal, which may possibly represent the species of opossum which, according to Nicoll (1904), was introduced from Grenada or Tobago into Dominica some time since the latter part of the seventeenth century. Nicoll infers that this animal may well have wiped out most of the petrels at their nesting sites. Ober (1881) also scaled the precipitous sides of Morne Diablotin in vain, investigating traces of the petrels' burrows at a date when many natives asserted that they well remembered the bird. Other unproductive searches on Dominica are referred to by Godman (1907–1910).

Murphy (1936) further notes:

That the Black-capped Petrel was not collected during the course of the Brewster-Sanford Expedition is due to no lack of effort on the part of Mr. Beck. The species is still in existence and has been identified in the field by competent observers many times during the last twenty years. Not long since, Bond (1928) warned against placing too much credence in the commonly accepted story of the complete extirpation of this petrel at Dominica. He called attention to the facts that large areas of the mountain known as Morne Diablotin were still unexplored, and that the mongoose, charged with the wiping out of certain West Indian birds, had, fortunately, never been introduced into the island. Proof that the Black-capped Petrel is, indeed, not extinct in the Lesser Antillean region, and that it almost certainly still breeds at Dominica, has since been forthcoming through the capture of an exhausted adult female in the streets of Roseau on May 2, 1932, as recorded by Hobley (1932), who has published three excellent photographs of the living bird.

Petrels collected on Dominica in 1932 and heard as recently as 1977 (van Halewyn & Norton 1984) provide an indication that the species may still nest on the island. Although the last confirmed date of nesting is 1862 (Smith 1959), a recent specimen record from the island (A. Christian, Forestry Division, pers. comm. 1990) provides further promise that a few birds continue to breed on Dominica. Another specimen, an adult female with a brood patch, was found grounded in May 2007 by Vincent Theophile at Padu at the entrance to Trafalgar village, below Morne Micotrin. It died and was prepared as a specimen for the Forestry and Wildlife Division by David Wingate in February 2010. Nevertheless, lacking further evidence, the species is presumed extirpated from the island.

Wingate (1964) visited Dominica between 16 October and 10 November 1961. Conditions for field work were extremely difficult. In addition to the steep terrain and impenetrable nature of the rain forests, it was also the rainy season. Nights were spent on or near the summits of the two highest peaks, Trois Pitons and Diablotin, where as much as four inches (10.6 cm) of rain fell each night, and progress was possible only by climbing through the top of a matted dwarf forest. Western slopes of Morne Diablotin were watched on several clear and moonlit nights in early November, all with negative results. It was possible only to check a small proportion of potential breeding sites by night watches. Many parts of the island, including all climatic zones and some offshore rocks, were, however, visited in daylight hours.

Examination of the terrain suggested that the original breeding population occupied only a narrow zone at about 1 200 m elevation on leeward and 1 000 m on windward slopes of one or more of the higher peaks. Excessive rainfall and ground saturation might be a limiting factor for burrow construction at higher altitudes, and continuity of tall forest cover might be a limiting factor at lower altitudes. Many potential sites within these limits are probably above the reach of the introduced opossum (*Didelphis marsupialis*) that, according to plantation owners, does not occur much above 800 m. These sites are probably also too steep to be reached by pigs, which may have roamed wild in the interior for more than three centuries. Wingate (1964) found tracks of pigs on more level areas up to 1 200 m, but never on the near-vertical slopes. The black rat (*Rattus rattus*) probably occurs throughout the island.

During his excursions, Wingate questioned many local inhabitants about the petrel. Although some of the older people knew the tradition of the *diablotin*, as it was locally called, they unanimously agreed that it had disappeared before their time. It should be pointed out, however, that more than 388 km² of the interior of Dominica still remains uninhabited and is rarely, if ever, visited at night. Investigations, including those of Wingate (1964), indicate that the mid-October to mid-November period during which the island was surveyed may not be an appropriate time to hear or see these birds. A single night of listening surveys with audio playback and the inspection of several dozen potential sites conducted in January 2001 found no evidence of nesting Black-capped Petrels (Collier *et al.* 2002). Several recent surveys documented by Lowrie *et al.* (2012) have failed to confirm nesting on the island.

While numerous searches to document nesting of this species on Dominica during the second half of the 20th century have been unsuccessful, the petrel itself has been legally protected on the island since 1932 (Hobley 1932).

Greater Antilles

Hispaniola — Haiti. Prehistoric: There are at least 15 known fossil sites on the Plateau of the Massif de la Selle that contain *P. hasitata* material. The specimens, collected in 1983–84, are housed in the Florida State Museum. The collections were made in caves and sink-holes (some as deep as 45 m) in the Plateau, at elevations ranging from 1760 m to 2060 m. There is a large amount of material, and both adults and young petrels are represented. Associated fossils include parakeets, small crows, flightless rails (two different-sizes), various rodents, and small ground sloths (D. Steadman, pers. comm.). While these fossil series have not been carbon-dated, they appear to be recent. Many of the bones were charred, suggesting that they had been cooked by pre-Columbian humans.

Historic: Lost to science for decades, an account of a fledgling bird captured in Port-au-Prince on 30 June 1938 suggests Black-capped Petrels were breeding in the mountains of Haiti at that time (Wetmore 1939, Wetmore 1940). Intrigued by these observations and accounts by Bond of Haitians describing a duck-like nocturnal bird that visited the Pic la Selle region in the winter, Wingate (1964) launched an expedition to the region in 1961. He discovered an estimated population of at least 2 000 breeding pairs in the Massif de la Selle, where the species survived along cliff faces of the inland mountains that were inaccessible to both humans and mongoose. Wingate identified consumption by humans, forest fires and introduced mammals as the primary threats to the remaining populations.

Subsequent surveys by Woods (1987) discovered a previously unreported nesting colony in the Massif de la Hotte but indicated that the overall population in Haiti had declined by 40% since Wingate's surveys owing to the combined effects of habitat destruction, predation by introduced mammals and harvesting by humans. More recent estimates suggest further declines (Gochfield *et al.* 1994).

A team from the Vermont Institute of Natural Sciences (Rimmer *et al.* 2010) conducted Black-capped Petrel surveys in the La Visite and Macaya regions of Haiti in late January 2005 and early February 2006. They reported severe habitat loss in the vicinity of Pic La Visite, including extensive evidence of recent cutting and burning of the pine forest and terraced crop production on the steeper slopes at the base of the cliffs. They detected several calling birds along the ridge line during early evening surveys in late January and concluded that populations had experienced sharp declines since Wingate's (1964) surveys 45 years earlier (Fig. 4). Subsequent surveys of Pic Formon on 7 February documented evidence of a few calling birds, but no birds were recorded at Pic Macaya on 10 February 2005. J. Goetz returned to La Visite in November 2008 and February 2009 and reported as many as 24 birds vocalizing at some of the more active sites along the escarpment. He concluded that clearing of the La Visite broadleaf forest for charcoal production, lumber and conversion to agricultural and grazing land had destroyed a large portion of the confirmed breeding refuge for the species, noting that the largest remnant patch of intact broadleaf forest was <230 ha. Judd (1987) provides a detailed floristic analysis of the ridgetop habitats in Haiti where these petrels nest. Nine of the 11 colonies first reported by Wingate (1964) are within the present boundaries of La Visite National Park.

Hispaniola — Dominican Republic. Wetmore and Swales (1931) summarize early reports of this species from the Dominican Republic. The information is sketchy, but, based on what is now known, these reports represent the first documentation of the species from the country. While there were a number of reports, the authors did not suspect the species to be nesting. However, later in the century, the presence of a small nesting population of Black-capped Petrels near Loma del Toro in the Sierra de Bahoruco was suspected in 1979 (Ottenwalder & Vargas 1979) and confirmed in 1981 (van Halewyn & Norton 1984). This site is immediately adjacent to the location of the Haitian population. The newly discovered population was surveyed by Woods & Ottenwalder (1983) in 1981; by the authors in January and August 1989 and 1990, November 2000 and January 2002; by Williams in April 1996 (Williams *et al.* 1996); and by D. Schock of The Nature Conservancy (pers. comm.) in November 2006. Small numbers of nocturnally calling birds were noted on each occasion. The colony is apparently less than 200 breeding

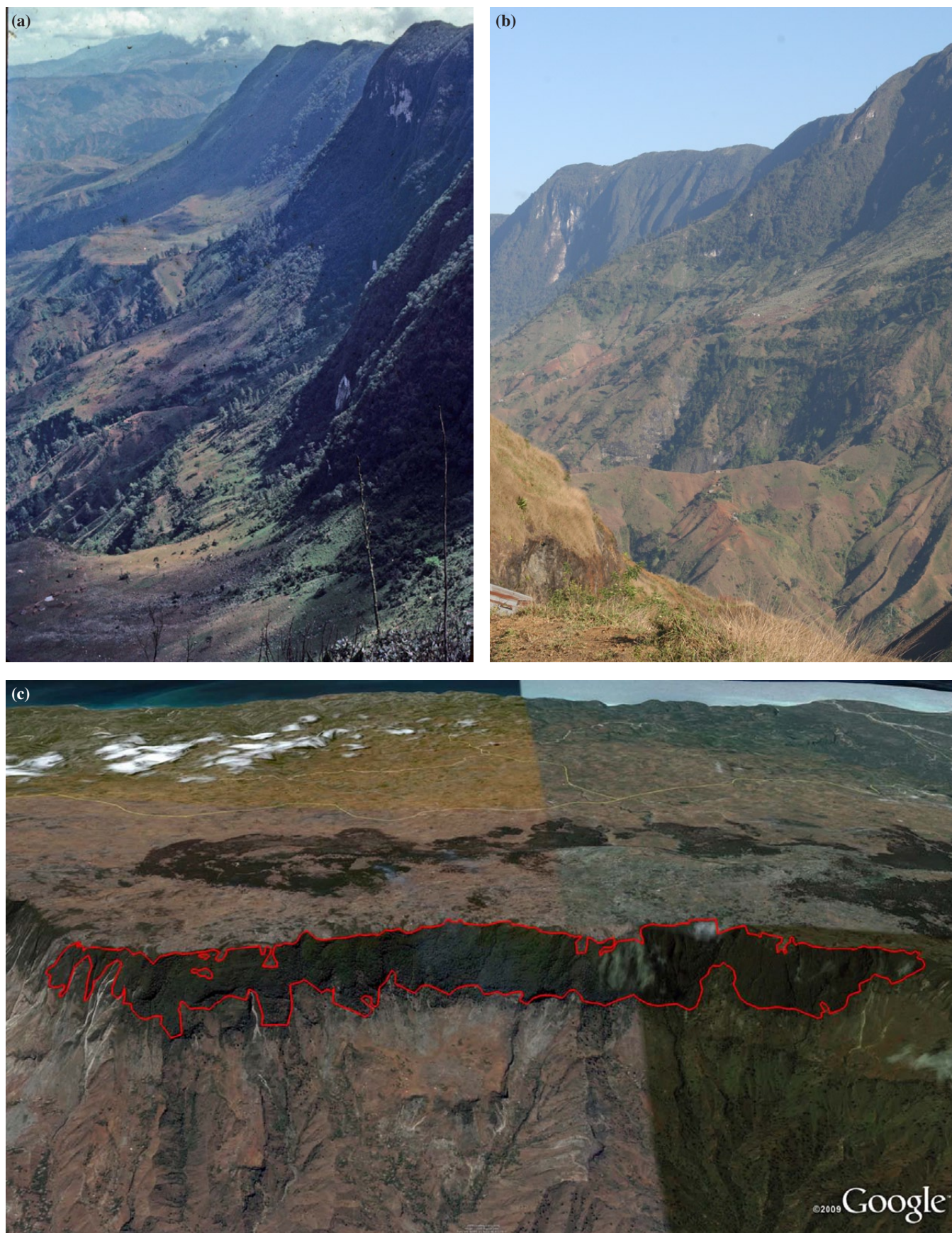


Fig. 4. Black-capped Petrel nesting habitat along the La Visite escarpment illustrating habitat changes over the past 50 years. (a) Photo by D. Wingate (1961), (b) Photo by J. Goetz (2010), (c) Google Earth image by J. Goetz (2010) illustrating the approximately 230 ha of forested habitat remaining along the escarpment.

pairs (Simons *et al.* 2002), and extensive searches indicate that the birds are limited to a single, 120 m cliff that extends approximately 8 km southeast from Loma del Toro at an elevation of 2200 m. This is the only confirmed nesting area in the Dominican Republic.

The high ridgetops, where Black-capped Petrels are believed to currently confine their nesting activities, are dominated by the pine *Pinus occidentalis*. This pine, the only species in Hispaniola (Mirov 1967), occupies a large area in north-central Dominican Republic, but is also found in the southwestern part of this country and in Haiti where *Pterodroma* have been heard calling. The forest in the Sierra de Bahoruco of the Dominican Republic was logged regularly through the early 1960s, but since then the area has remained a national park, with its forests generally protected from human disturbance (Fig. 5). In Haiti, the cutting of these pines is so extensive that some mountains in Morne la Selle range support only isolated trees (pers. obs. 1989, 1990) (Fig. 6).

Holdridge (1942) describes the distribution of the *Pinus occidentalis* forest in the portion of Hispaniola where *Pterodroma* breed as follows:

Of the five species of pines in the Caribbean region *P. occidentalis* is the only high elevation species. Generally the species grows at elevations from about 900 to over 2700 m. In Haiti, the range of the species includes most of the country, although in most sections it occurs only as scattered specimens. In the southern ranges of mountains, good stands of pine are found in large blocks. At the eastern end of the Morne la Selle range, in the section called Mornes des Commissaires is located a stand estimated to cover approximately 10,000 acres [a little over 4000 ha]. This is contiguous with the pine forest across the border in the Bahoruco Mountains of the Dominican Republic. The Haitian tract is located on a plateau at an elevation of about 5000 feet [1500 m] above sea-level, although scattered patches of pine to the north and south grow down to 2000 feet [about 610 m]. This is the only forest in Haiti which is traversed by a public road



Fig. 5. Dominican Republic–Haiti border. View from the Sierra de Bahoruco toward the Massif de la Selle, Haiti. The treeline in the foreground represents the boundary between protected forests in the Dominican Republic and unprotected lands in Haiti.

and when “le forêt de pins” is mentioned in the capital, it is almost invariably with reference to this unit.

Only a few miles to the west of this area La Selle Peak, the highest point of land in Haiti, attains an elevation of over 9000 feet [over 2700 m]. It is covered to the very peak with a pine forest which has an area probably greater than 25,000 acres [about 10 000 ha]. West of La Selle on the main plateau and on the various ridges extending there from scattered individuals and patches are encountered to slightly beyond Furcy and Kenscoff.

As well, a breeding colony may occur on cliffs on Beata Island off the southwestern Dominican Republic. Wiley and Ottenwalder (1990) reported seeing birds at sea in the vicinity of this island and also near Alto Velo Island. They also reported sightings by fishermen, who stated petrels nested on cliffs on the Peninsula de Barahona. On 28 January 1990, Lee flew over the Beata Island, which measures about 8 km by 8 km. Steep cliffs with caves meet the sea on the south side, and the same cliff face rises to a central plateau on the west side of the island. These inland cliffs rise out of a low coastal forest. The cliff faces are sparsely vegetated and are similar to those on the main island that support colonies of *P. hasitata*. The island has limited access because it is controlled by the Dominican Republic Navy, and therefore it is essentially protected. Other species of seabirds known from the island include *Puffinus lherminieri*, *Phaethon lepturus*, *Sula leucogaster*, *Pelecanus occidentalis*, *Sterna fuscata* (Wetmore & Lincoln 1933) and *Sterna antillarum* (J. Ottenwalder pers. comm.), but it has not been extensively surveyed. The island is only 8 km from the coast of the Dominican Republic, but its long isolation from mainland Hispaniola is indicated by a large number of endemic reptiles (Cochran 1931, Noble 1923).

Cuba. Historical: There are no references to the occurrence of petrels on or around Cuba before the mid-1970s. **Recent:** In the last several decades there has been a considerable amount of interest in the possibility that Black-capped Petrels nest in the mountains of southeast Cuba. The first published reference was by Bond (1978) in his 22nd supplement to the checklist of the birds of the West Indies.



Fig. 6. Typical Black-capped Petrel nesting habitat in the Sierra de Bahoruco, Dominican Republic.

***Pterodroma hasitata*:** I am grateful to Orlando H. Garrido for sending me an article with clear photographs of *P. h. hasitata* that evidently breeds on a coastal mountain called “La Bruja” between Uvero and Ocuja in the Sierra Maestra (Bohemia, 1977, pp. 88-89). Dr. Nicasio Viña Bayes, accompanied by two companions, collected a male and three females on January 29, 1977, when these petrels were highly vociferous.

Subsequently, several seabird biologists reading this account concluded that it was firm evidence that Black-capped Petrels nested in the mountains of Cuba, as *Pterodroma* are not regularly encountered close to land except near breeding sites. By 1984 authors were making definitive statements such as “Small additional colonies have been discovered in the Sierra Maestra of eastern Cuba” (van Halewyn & Norton 1984). Garrido (1985) discusses the possibility of a nesting site in Sancti Spiritus, near Playa Yaguanabo, Trinidad. A number of other publications likewise reported that the species nested in Cuba (e.g. American Ornithologists’ Union 1983, Haney 1983).

The original observations were never formally reported and found their way into the current literature through a popular magazine article sent to Bond by Garrido. A more detailed newspaper account appeared in the *Sierra Maestra* (27 February 1977, Vol. 19, No. 48). In January 1992 Lee and Dickerman visited Viña, and together they made an excursion of several days to the area to see what more could be learned about the petrels. The following year Lee and Viña (1993) published a short report in an attempt to clarify the situation. They noted that, contrary to previously published reports, Viña’s six specimens were collected at night from small boats several kilometers off the coast, not while coming ashore. They concluded that there was no direct evidence of nesting of Black-capped Petrels in Cuba. The breeding locality reported by Bond (1978) is Monte La Bruja, with “*bruga*” being the local name for this petrel and several other vocal nocturnal birds. However, Monte La Bruja and a town of the same name are inland sites named after an adjacent point of land called La Bruja, a popular fishing spot near where the petrels feed at night.

The sea immediately adjacent to La Bruja has an upwelling area so intense that the swell of the upwelling can be seen from shore with binoculars. This upwelling area extends approximately 1.5 km to the east and 2 km to the west of La Bruja. This is the only area along the entire southeast Cuban coast where the petrels can be seen or heard. One kilometer from shore the sea floor drops to 500 m, and beyond that is the Cayman Trench that drops to 7241 m below sea level. From an oceanographic point of view, this is similar to the deep-water areas of the outer continental shelf off the southeastern United States where these petrels also occur. Local residents we interviewed said that the “spirits” were heard only on the coast, although one person said that occasionally they were heard inland. From this experience, Lee and Viña (1993) concluded that the petrels were coming to the upwelling area to feed; the occasional inland reports of vocalizing birds, if true, were perhaps individuals riding updrafts off the mountains.

While many seabird biologists associate vocalizing birds with nesting behavior, petrels also commonly vocalize at sea (both day and night, D.S. Lee pers. obs.) although most people are unaware of this because the birds’ calls are drowned out by ship-engine noise. The upwelling site is only about 500 km northwest of known breeding colonies in Haiti, and this is the presumed source of the

birds feeding off the coast of Cuba. In addition, despite considerable interest in Pleistocene to recent fossils in Cuba, there is no fossil evidence of *Pterodroma* from the island. Farnsworth *et al.* (2005) conducted a one-night survey at La Bruja on 24 February 2004. Up to 46 petrels were observed offshore from the adjacent cliffs, and vocalizations indicated that at least some of the petrels came ashore and flew up the steep mountain. While this behavior is consistent with nesting, it does not rule out the likelihood that the birds were simply enjoying free rides on updrafts coming off the slopes. The relict pine forests of *P. occidentalis*, with which *Pterodroma* is associated in Hispaniola, also grow in the mountains of eastern Cuba, where they are found at elevations of 300 to 1500 m (Smith 1954). Here they are represented by a closely related species of pine, *P. cubensis*, which some authors (e.g. Shaw 1914) consider a synonym of *P. occidentalis*. These pines are found on the eastern portion of the island (Oriente), in the mountains of Sierra de Nipe, Sierra de Moa and Cuchillas de Toa. The altitudinal range of the pines in Oriente is much lower, however, extending from sea level to about 820 m (Smith 1954).

On 24 February 2004, the Cornell Laboratory of Ornithology conducted a Rapid Biological Inventory at Parque Nacional La Bayamesa, Cuba, including a survey for Black-capped Petrels. Viña led the biologists to a remote site along the coast directly below the Sierra Maestra where the petrels had previously been seen (Lee & Viña 1993, Farnsworth *et al.* 2005). Up to 46 Black-capped Petrels were observed from the bluffs forming several tight flocks on the water just offshore at dusk. After dark, continued vocalizations from the birds indicated that at least some of the petrels flew ashore near a narrow stream valley up the steep mountainside towards the Sierra Maestra peaks. An additional 25 birds were sighted at the same location on 9 February 2004. More recently, Norton *et al.* (2008) reported others’ sightings on the south coast of Cuba of dozens of Black-capped Petrels offshore at dusk, then “seen and heard flying inland up a small valley” after dark.

Thus, proof of a breeding population in Cuba awaits definitive evidence of nesting sites. It is informative that, in a recent publication on West Indian seabirds, three well-known Cuban seabird researchers did not consider the Black-capped Petrel as known to currently or historically breed in Cuba (Jimenez *et al.* 2009). Lee took photographs and measurements of most of the original specimens collected by Viña, and there is no apparent difference in size or plumage between the Cuban specimens and those from Hispaniola or those collected off the Carolina coast. However, all of the Cuban specimens collected by Viña are light morph birds. Further investigation is clearly warranted.

Jamaica. An endemic petrel, *P. (h.) caribbaea*, considered by most authors a distinct species, was known from the John Crow and Blue Mountains of Jamaica (Bond 1967), but is now thought to be extinct. Jamaica is the westernmost West Indian island upon which *Pterodroma* have nested, and the one deepest in the interior of the Caribbean. A good review of the species is available in Collar *et al.* (1992). Specimens obtained in the mid-1800s are darker and smaller than *P. hasitata*. This form may have survived in the John Crow Mountains in northeast Jamaica until recent times (Scott 1891, van Halewyn & Norton 1984), but this has not been confirmed. Nevertheless, its continued survival cannot be completely ruled out (see discussion in van Halewyn & Norton 1984). The demise of this population appears to be a direct result of the mongoose *Herpestes auripunctatus* which was first brought to the island in 1872. This

represents the earliest introduction of this carnivore in the West Indies. Murphy (1936) summarized Scott's (1891) report:

...in February, 1891, a black man named William King made a trip into the hills of Jamaica in search of a bird which he knew as the "dry land booby" or Blue Mountain Duck. This bird dwelt in holes in the cliffs, and had formerly been extensively hunted by the mountain people. King, himself, had eaten a pair not long before, and had been impressed by the sounds made by the birds in their holes at night. After a six days' search, on the trip referred to, King reported that he had found the old breeding places, had dug out not less than 25 of the burrows, and had found a mongoose in some and nothing in the others. We need go no further in seeking an explanation of the disappearance of the petrel from Jamaica.

Murphy (1936) noted that the American Museum's single Black-capped Petrel specimen was obtained by Governor Newton of Jamaica during either April or November 1879. Bond (1936) recorded a sighting of the black phase of *P. hasitata* at sea, west of the Bimini group of the Bahama Islands. Recent records of the dark phase of *P. arminjoniana* from the North Atlantic (Lee 1979, 1984, Gochfield *et al.* 1988) suggest that the bird in question may have been that species or some other dark procellariiform species rather than *P. caribbaea*.

Although there is little additional information, we believe it is informative to outline subsequent field efforts to locate populations. This information is primarily from a series of articles that appeared in a newsletter of the Gosse Bird Club (Jamaica).

It may be of interest, too, to see that on the visit we made to the summit of Blue Mountain Peak, we were unable to find any evidence or information that the "Blue Mountain Duck" resorts regularly to this locality, though such is said to be the case (Field 1894).

In 'Broadsheet No. 2' of the Gosse Bird Club appeared the first account of the recent discovery by David Wingate of Bermuda of the breeding grounds of the Black-capped Petrel in Haiti under the title 'Does the Blue Mountain Duck of Jamaica survive?' Here is a project that should be undertaken in January or February. Probably the best locality for a search would be high in the John Crow Mountain, for these seabirds nest in burrows where they can take off against the wind. I must say that I do not believe any petrels nest in the Blue Mountains. I certainly never heard any of these highly vociferous birds when I spent a week or so near Portland Gap during the month of December (Bond 1965).

BLACK-CAPPED PETREL. (*Pterodroma hasitata*). Unfortunately we cannot report the finding of the extinct(?) species in Jamaica. We made a preliminary look for petrels on a high cliff (Judgement Cliff in the Yallaks Valley), the top of which is some 1,400 feet above sea level. We reached the top of the cliff before dusk and remained until about 8 p.m., walking and listening for signs of birds. All was silent on the return journey, however, we met an old farmer who lives in the area, and, during a conversation about birds in general ...the old gentleman volunteered

without prompting on our part, the information that the Blue Mountain Duck regularly flies in from the ocean to the south, and over the top of the Blue Mountain at night. The birds, he said were large, and could be seen against the pale night sky, and flew very fast with a loud rushing noise. Perhaps the old man has hallucinations, or on the other hand the Blue Mountain Duck may indeed be still extant. A night spent on the ridge of Blue Mountain may well be profitable. Why not try? (Smith & Gochfield 1965).

JAMAICAN BLACK-CAPPED PETREL

...Our main purpose in coming was to begin a search for the Jamaica Petrel, believed by many to be extinct for 50 years. Operating on the optimistic assumption that a small population exists which has escaped the notice of man and introduced predators alike, we hoped to hear them calling at night in the Blue Mountains, which was their custom in the past. Although we spent one night each on Blue Mountain Peak and East Peak, we heard no calls. We plan to return next winter to renew the search, this time further to the east near Sugarloaf or Stoddart's Peaks.

Our observations began on 22nd March...After passing the night on Blue Mountain Peak, we set off for East Peak in the fog on a foot trail...Our goal was Sugarloaf several miles to the east and invisible to us in the fog. After clearing our own trail for 6 hours on a compass course we came upon the old trail to Sugarloaf which was somewhat overgrown but not difficult to follow if one took pains to look for old blazes on trees on the way. Since we had to retrieve our packs which we had carried only part way down our trail we were unable to continue on to the summit of Sugarloaf Peak, so we returned to East Peak for the night. From the summit we watched a Barn Owl hunting along the summit ridge in the light of the full moon (King & Fern 1976).

It was while lunching off a delicious roast duck in a charming house on a banana property in St. Mary, gazing at the misty outlines of the Blue Mountains...that the following story was told me. One of the luncheon guests was a lady, Mrs. K., who before the war lived in the Blue Mountains where she farmed a small property and also took in paying guests. One of the "regulars" was an American ornithologist who collected birds for the Smithsonian Institute. Sometime around 1930, a few days before the ornithologist was due to arrive for his winter holiday, the headman brought in a strange duck-like bird that he had shot. Mrs. K. decided to add a little variety to the menu and have it for lunch. "It must have been very old because after trying to roast it, we had to stew it before it was tender enough to eat..." When the ornithologist arrived and she described this bird to him he became very over-excited and told her that the Smithsonian would have gladly given here two thousand dollars for a specimen of this bird, and proportionate sums for any eggs that could be found. (The headman told her that this kind of bird laid its eggs in a hole in the ground). I too became excited as she continued to describe the bird to me..."a little, dark, duck-like bird with webbed feet - dark brown with light colored underparts...a funny beak - (Hart 1965)."

The dark phase (or sub-species?) *P. h. caribbeae* was known only from Jamaica, and it was last reported breeding in the Blue Mountains in 1890 (Scott 1891). The last specimens were collected at Newcastle and Cinchona during the decade 1880-90, and one of these is now a mounted specimen in the Natural History Museum at the Institute of Jamaica. Following Wingate's discovery of the Haitian birds, several attempts have been made to determine whether the Blue Mountain duck still survives here, but so far these have proved fruitless. The attempts include those of Trimble, Gochfield, and King.

Because of the introduction of the mongoose into Jamaica, any surviving breeding colonies must be located on very steep cliffs, safe from this animal. The birds breed in shallow burrows which they excavate, and therefore colonies must be in areas where some soil clings to the cliff faces, and is held in position by the roots of trees.

These conditions do occur in Jamaica, principally on the north side of the Blue Mountain ridge, and in particular on the north side of Sugarloaf and Stoddart's peaks, and the narrow ridge which links the two. Cliffs also occur on the west side of Abraham's ridge, a long buttress stretching north from Stoddart's Peak, and the east side of a similar buttress stretching north from Sugarloaf peak to Two Claw Peak. Between these buttresses the Stoney River rises, its tributaries falling down steep cliffs forming waterfalls up to 200 feet high, leading down to Nanny Town, and on to the confluence with the Back Rio Grande, and so to the Rio Grande itself. Few people know these mountain ridges and mountain rivers: this is truly the wildest and most beautiful part of Jamaica. Access into the area is, furthermore, becoming increasingly difficult, for in the past trails were kept open by wild-hog hunters, and these days only the older men, mainly maroons from Seaman's Valley and Windsor, still hunt hogs: the life is too hard for the young of today.

The well-organized search for the site of Nanny Town, planned and successfully executed by one of our previous members, Alan Teulon, and reported in the Daily Gleaner, provided an excellent opportunity for flights in a helicopter of the Jamaica Defense Force over the north side of the Blue mountains. Very good photographs by David Lee (now at the Scientific Research Council) clearly showed the cliffs to the N of Sugarloaf and Stoddart's peaks, and expeditions by foot from Windsor to Nanny Town, provided first hand views of the cliffs from the upper reaches of the Stoney River, but access to the top of the cliffs from this north coast route would obviously be very difficult if not impossible.

In May, 1968, therefore, Mike Ashcroft and I decided to attempt to reach the summit of Stoddart's Peak from the south side, following the route of the long lost and overgrown Trelawny's Path, from Island Head in St. Thomas. Early on Saturday morning, at first light we set out from Island Head, and found the route to Stoddarts surprisingly easy, though a little steep at times. There was no marked path once we left the cultivated lands and entered the wet mountain forest. The first land-mark is

the hill called Half-a-bottle: and shortly after reaching it the mist descended, and the rain fell. On Stoddart's peak it was very cold, so cold we couldn't stop our teeth chattering, and had to keep moving, stamping our feet to keep warm, whilst we hurriedly ate some bun and cheese, half a chocolate bar and drank some condensed milk. It was 11:00 a.m.

On Stoddart's peak the forest floor is free of undergrowth, the tall trees with sodden moss covered trunks stand among moss covered rocks. The earth is wet, muddy, and on the very summit there were two muddy, rain-filled holes where wild pigs had recently been wallowing.

We had to keep moving, and had set out prepared to spend the night at Stoddart's. No point in going back so soon, so we went on, taking the ridge to the north, out towards Abraham's Peak... The ridge to Abraham was difficult, the top getting narrower and narrower, forming a knife edge falling away on both sides down steep hills to the rivers below. From Abraham's Peak, away to our left we caught a view of the great fall, a strip of silver marking a 200 foot vertical line down the steep cliff face, and we saw the inaccessible cliffs, wooded and ideal for the breeding colonies of the Blue Mountain Ducks. Last spring, and all the springs before, had the petrels come speeding in from the ocean and laid their eggs on these cliffs, or, long ago had the mongoose, or some other undetermined ecological factor caused the birds to depart from these hillsides? Perhaps next spring we would find out. After detours around rock faces, we eventually dropped down the west side of the ridge, reaching the top of the steep gully through which the upper stoney river was flowing, but night fell, and forced us to camp on a 45° slope, to wait for morning light before we dare risk finding a way into the river valley.

Our camp site was close by Nanny Town, we were in fact further upstream than the actual site of the town discovered by Teulon, and on the opposite side of the river...

To cut a long story short, dawn came at last the following morning... We scrambled down to the river, and spent the hardest day of our lives making our way along the river, now swimming the deep, clear pools, now clambering over the rapids or jumping down the waterfalls, but always wet, mostly warm in the water, but cold when the clouds obscured the sun, and the showers passed. By dusk, we arrived at Durham, stiff and cold, and very tired, but with a great sense of achievement in having crossed the Blue Mountains, followed Trelawny's path, and in two days achieved what many had failed to do in more than a week. We had seen the cliffs, and were optimistic that if the petrels still survived, then we had seen the most likely place. Next spring would tell.

Next spring is now this spring: and Operation "Mountain Duck" took place on the weekend of January 25th. This time, Mike Ashcroft, Dave Romney and I would go again to Stoddart's Peak, but turn west at the top, and try to reach the top of Sugar Loaf peak, where we would camp the night listening for the sound of the birds. This we did, a

beautiful day, no rain this time, and we reached the mossy Stoddart's peak again around 11:00 a.m. Lunch break, and on to Sugar Loaf. Soon after leaving Stoddart's, on a trail partly marked, often obscure, we reached the water-hole and filled our bottles: knowing that we would not see water again till we reached the west peak of Blue Mountain. A long day, checking compass, reading maps, we eventually reached the foot of the last climb up to Sugar Loaf, and at 5:00 p.m. we were within 10 minutes of the peak, and made camp under a gnarled and leaning tree, just to the south of the ridge, out of the wind.

The night was still: not a breath of wind, but the air was cool. Our fire tried to burn, the tree fern fronds, dry yet wet provided a kindling, but the wood merely sizzled as the rain soaked fibers would not dry. What was that? Tree frogs whistling? Yes, but no petrels. Can we hear the faint noise as a swarm of bees or the rushing of wings? Our imagination taunted us: Again a noise - this time far below at Palisades a jet taxied along the runway, and in seconds was higher than we, on its way to Miami, or South America. But still no petrels.

Intermittently we slept, and woke, during the night: the cold wind from the north livened, rustling through the trees over the narrow ridge, and creeping through our blankets and clothes. We waited, and listened: but still only tree frogs and airplanes. Waited until the sky became light in the east, and the sun rose over St. Thomas.

Our failure to hear Petrels does not mean that they are extinct, our hearing range, both in distance and time, was limited. The Blue Mountain Duck may yet survive in the mountains, or on the steep West side of the John Crows. We will try again (Smith 1969).

In 17 November and 1 December 2009, multi-day searches at sea were conducted for both Jamaican and Black-capped Petrel off the eastern and northeastern coasts of Jamaica. A total of at least 46 Black-capped Petrels (no Jamaican Petrels) were recorded after deploying large and persistent chum slicks (Shirihai *et al.* 2010). Before this study, apparently only a single Black-capped Petrel had been detected in Jamaican waters, an individual seen at sea between the main island and the Morant Cays (Zonfrillo & Douglas 2000). Although Shirihai *et al.* (2010) describe shoreward flight directions for some of these petrels, inferences of breeding on Jamaica are unsubstantiated.

Ann Sutton (Jamaica WI) kindly provided the following place names in Jamaica which appear to be named for the Jamaican Petrel and are believed to represent former nesting colonies: Devil's River, near Above Rocks, St. Catherine; Devil's River, near Spring Bank, Bath, St. Thomas; Egg Hill, near Washington, Portland; and Mount Diablo, St. Ann.

Incomplete descriptions, early taxonomic confusion and the lack of existing specimens make statements regarding the possible former occurrence of breeding Jamaican Petrels on Guadeloupe questionable. However, this is a reasonable explanation for the occurrence of the mystery black-plumaged petrels reported there in the 1600s (Labat in Murphy 1936). Likewise, Verrill's (1905) reported occurrence of both Black-capped and Jamaican Petrels on Jamaica cannot be substantiated. As small islands in the Indian

Ocean and in the southern and western North Atlantic support more than one breeding species of *Pterodroma*, it is reasonable to think that this was also the case in the West Indies. Nevertheless, lacking further evidence, the Jamaican Petrel is best regarded as an endemic allopatric and probably extinct species.

BIOLOGY OF NESTING POPULATIONS

Most of the early information on the life history of the Black-capped Petrel is from the single report of Pere Labat (1724). This is quoted in entirety by Bent (1922), although at the time Bent had some misgivings about the identity of the bird. Murphy (1936), quoting Labat, states:

We learn from him that the Diablotins nested high on the mountains, perhaps altogether on volcanic ridges above the zone of dense forests. There the birds burrowed in the earth like rabbits, and remained concealed throughout the hours of daylight in the customary petrel manner. Labat says that the Diablotins are goggle-eyed birds which can neither stand the light nor discern objects in it. They are, therefore, clumsy and helpless when pulled forth from the burrows. Yet such observations take no account of the obvious ability of these birds to fly about over the sea during the day; it is probably the sudden change from darkness to light which discommodates their eyes. At night in the mountains they could be heard crying continuously, as though calling and answering one another with mournful voices while in flight. The annual mating season began after the end of September, and eggs were probably laid during January, for the young were hatched by March. These were covered with thick yellow down, and were known to the blacks of the islands as 'cottons.' By the end of May the fledglings made their way to sea, and thereafter no Diablotins were seen in the neighborhood of the nesting grounds until the following September.

Subsequent reports are second-hand, or from people who located nesting colonies, but usually not the nest themselves. The eggs of this species have never been described, and the only mention of them at all is of a single egg, one-third incubated, taken on Dominica on 1 February 1862 (Smith 1959). L. Kiff (Western Foundation of Vertebrate Zoology, pers. comm.) is not aware of any eggs of this species in any collection.

Most of the current information on the breeding habitat of this species is from Wingate's (1964) discovery of this species in Haiti. He states:

At present the breeding habitat is confined to areas so steep as to be virtually inaccessible. This is in contrast to the historic accounts, which imply clearly that burrows occurred on slopes negotiable by men and dogs. The 11 colonies located were in forested cliffs 500 m or more in height and above 1,300 m altitude. Most were located between 1,500 m and 2,000 m above sea level. Proximity to the sea did not appear to be necessary. All but one of the colonies were on the north or inland side of La Selle Ridge, presumably because the most suitable habitat occurred there. One of these, near Pic la Selle, was 20 km from the sea. The mountains of the Massif de la Selle are composed primarily of dolomitic limestone.

Where this rock is exposed as bare cliffs, mainly on east-facing slopes, there are no caves or crevices to provide a foothold for petrels. Colonies occurred only where a sufficient soil cover existed for burrowing—hence the association with forested cliffs where the vegetation held in place a steep talus of boulders, soil, and humus at a high level of stability. I reached such an area, where petrels had been burrowing, on one occasion and found loose feathers and soil kicked out from under boulders, but no occupied burrows. There were sufficient gaps in the horizontally growing forest cover here to give the petrels direct access to the ground.

In the Greater Antilles, current Black-capped Petrel nesting colonies are associated with open park-like pine savannas, and all known nesting cliffs are in such habitats. Lower elevations are dominated by dense tropical cloud forest through which it may be difficult for the birds to maneuver. The habitat of the Jamaican petrel has never been described, but natural pines are totally lacking there, as well as throughout the Lesser Antilles. *Pinus caribaea* occurs in the Bahama and Caicos Islands, both to the north and south of Crooked Island, which fossil evidence suggests was once a petrel breeding site.

The apparently limited altitudinal zone of former breeding sites on Dominica may have been due to the petrel's requiring areas of open or short vegetation to maneuver. The high peaks of Morne Trois Piton and Diablotin are covered with elfin woods, shrubs and protruding rocks and banks. As previously discussed, other natural open areas may have been available to nesting birds as a result of fire, hurricanes, mud slides, earthquakes and/or volcanoes. A pine sub-climax savannah provides suitable open areas on two of the three islands in the Greater Antilles on which *Pterodroma* nest or are suspected to nest (Hispaniola and Cuba), and early-aged successional communities are suspected to be of major significance to birds nesting in the Lesser Antilles. Such a pattern would tend to

concentrate birds into temporarily formed open communities, and this in turn may have allowed early settlers to collect large numbers of birds and decimate populations in a relatively short period. However, this association with open habitats may simply be a result of the restriction of available, or predator-free, nesting sites during the historic period. Nesting habitats and distributions before human settlement are speculative. For example, Dark-rumped Petrels in Hawaii nest in heavy vegetation on the islands of Lanai and Kauai (Simons & Hodges 1998).

Although it is well-established that Black-capped Petrels nesting localities are currently restricted to steep cliff faces, it is unclear whether this is their preferred habitat or the result of predation by man and by introduced predators in more accessible locations. It is also possible that on land this *Pterodroma* needs to launch itself from high cliffs in order to become airborne.

Black-capped Petrel vocalizations are strongly reminiscent of those of closely related *Pterodroma* species such as Cahow and Hawaiian Petrel (Reynard & Wingate 1980). Flight calls are characterized by a penetrating resonant growl punctuated by high frequency squeaks (Reynard 1980) (Fig. 7). Although other *Pterodroma* occasionally call from their burrows, Black-capped Petrel vocalizations have been reported only from birds at sea or flying over colony sites at night. Typically birds fly in pairs or small groups calling back and forth, and it is likely that the primary function of this calling behavior is related to pair formation and maintenance. As in other *Pterodroma* seasonal calling, rates reflect these functions, showing peaks early in the nesting season and steady declines over the course of the nesting season.

The first active nest of the Black-capped Petrel was described in 2002 (Simons *et al.* 2002). On 20 January 2002 evidence of an active burrow was located halfway down the uppermost cliff in Loma del Toro in the Sierra de Bahoruco (grid cell 24-14, UTM 2024479E, 0213055N). Freshly excavated dirt containing egg shell fragments below a large boulder, and evidence that pine needles and sticks were being dragged into the burrow, suggested that birds were in the process of preparing their nest. No bird or nest was visible from the burrow entrance. A toothpick barrier was placed across the burrow entrance to monitor the departure or arrival of birds (Fig. 8).

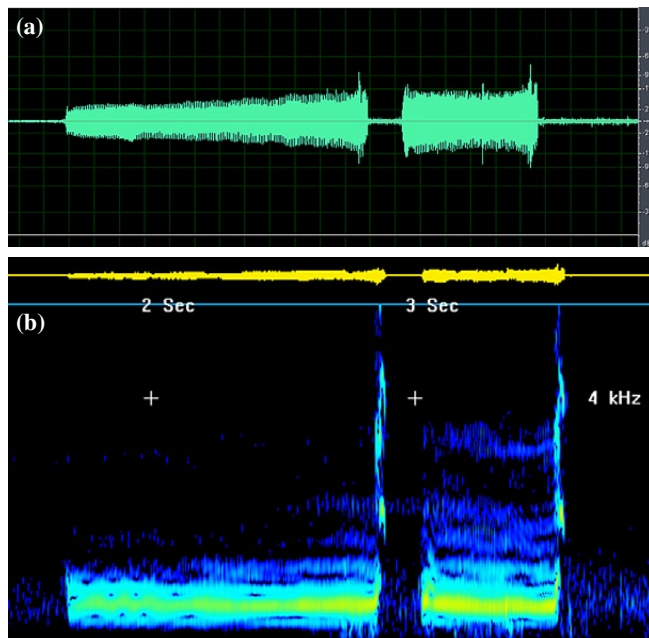


Fig. 7. Waveform (a) and spectral (b) characteristics of Black-capped Petrel vocalization (Macaulay Library, audio 139296). Recorded 9 February 1980 at La Visite, Haiti, by George Reynard.



Fig. 8. Black-capped Petrel nesting burrow in the Sierra de Bahoruco, Dominican Republic. The burrow was located approximately 100 m below the ridge top in a jumble of limestone boulders interspersed with a thin layer of soil. The nest cup, smoothed out of the soil and lined with pine needles and grass, was located 1 m beyond the burrow entrance.

On a return visit to the burrow on 22 January the intact toothpick barrier indicated that no birds had arrived or departed in the preceding 48 h. Partial excavation of the loose dirt at the burrow entrance revealed egg shell and bone fragments in the soil, evidence that the burrow had been in use for many years. With the entrance enlarged, it was possible to see the entire cavity beneath the boulder. An adult Black-capped Petrel resting on a well-constructed nest was clearly visible approximately 1 m from the burrow entrance. The bird was facing away from the entrance and the white rump and upper tail coverts, black tail, white under tail coverts, and black wing tips were clearly visible. A well-defined 30 cm diameter nest cup lined with pine needles was visible around the bird. The bird appeared to be incubating, but it was not possible to reach the bird or the nest. To our knowledge, this is the first description of an active Black-capped Petrel nest.

The next day the toothpick barriers were flattened, indicating that the bird had departed the burrow. Further examination revealed a newly constructed nest lined with dry, brown, pine needles. There was no egg in the nest. These observations indicate that the bird observed was probably a male waiting in the burrow for the return of its mate. Male Cahows (*D. Wingate* pers. comm.) and Dark-rumped Petrels (Simons 1985) frequently visit their burrows before egg laying in expectation of their mate's return. Females generally engage in an extended pre-laying absence from the colony, apparently acquiring the nutritional reserves necessary for egg production. Males generally visit the burrow several times during this period, and if they are in the burrow when the female returns to lay, they begin the first incubation shift. If the male is absent when the female returns, she begins incubation but exchanges duties with the male as soon as he returns. It is possible that the bird observed was a pre-breeding adult prospecting for a nest site, but the well-constructed nest and evidence of previous breeding attempts suggest the bird was a breeding adult male.

Subsequent to this discovery, Rupp *et al.* (2011) discovered three active Black-capped Petrel nests on Morne Vincent, Massif de la Selle, Haiti in March 2011. The location is approximately 50 km east of the colonies described at La Visite by Wingate (1964) and 3 km from the Bahoruco site in the Dominican Republic. One nest



Fig. 9. Approximately 80-day-old Black-capped Petrel chick and adult in nesting burrow, Morne Vincent, Haiti, 2 July 2012. The nest was located in a side chamber at the end of a 6 m deep limestone cave. Photograph by E. Rupp.

containing an incubating adult was located in a small limestone cave on 3 March; the other two nests were discovered in crevices in an adjacent ravine on 13 March. The crevice nests failed during incubation, but the cave nest contained a small chick on 2 April, and a nearly full grown chick on 24 June. These observations are consistent with those at Bahoruco and La Visite, suggesting that birds are laying eggs in mid- to late January, chicks are hatching in mid- to late March and fledglings are departing the colony sites in Hispaniola from mid-June to early July. Returning to the area the next year, Rupp *et al.* (2012) monitored a total of 30 active nests; 15 on Morne Vincent, Haiti, and 15 directly adjacent to the Morne Vincent site on Loma del Toro, Dominican Republic (Fig. 9). Nesting success in 2012 was 76.67%, with 23 of 30 active nests fledging chicks. This level of fecundity is near the maximum reported in similar species (Simons 1984, Madeiros 2009) and well above the level needed to sustain an equilibrium population.

Although the breeding biology of *P. hasitata* is poorly understood, it is better known for *P. cahow*. These two petrels are not believed to be closely related, but their winter breeding phenology and behavior at sea appear to be similar as a result of the proximity of their nesting grounds and foraging areas along the Gulf Stream and Outer Continental Shelf of the southeastern United States. With this in mind, we provide the following synopsis of the breeding biology of *P. cahow* based on over half a century of observations by D. Wingate (pers. comm.).

Established Cahow pairs return to their nesting sites to breed between mid-October and early November. At this time courtship and mating occur in the burrows, burrows are cleaned as necessary, and the nest chambers are lined with vegetation collected from around the burrow entrance and with feathers molted from the brood patch. A pre-laying exodus from the colony, averaging 40 days, begins between mid-November through early December. Females return from early to late January to lay a single white egg. Adults vocalize within burrows during courtship and later when they are exchanging incubation duties and feeding their young. The male typically returns shortly after egg-laying and takes the first long incubation shift. The pair then alternates continuous incubation shifts of 8 to 12 days. Occasionally one member of the pair will depart before their mate returns, but eggs can remain viable for several days without incubation. The incubation period ranges from 50 to 53 days, with hatching occurring between 20 February and mid-March.

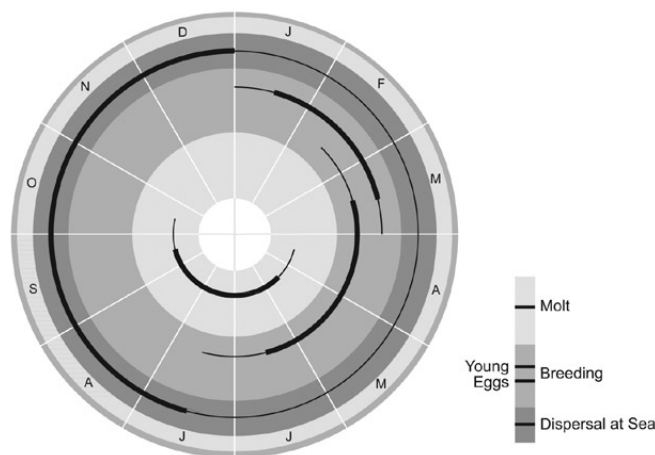


Fig. 10. Annual cycle of the Black-capped Petrel. Dates estimated from activity at nesting colonies, specimens collected at sea and known chronologies of closely related species.

Both parents help feed the chick, and their visitation patterns are quite variable, averaging every four days. The downy plumage of the chick is retained until near fledging and then is shed rapidly in the burrow. Wing and dorsal down is molted first, and some down still remains on the flanks when the chicks depart. Chicks are usually abandoned by their parents a week or more before fledging. At ages of 80–85 days the grown chicks begin coming out of their burrows to exercise their wings between 22h00 and 02h00. The nightly exercise periods continue for about a week, ranging from 4 to 15 days. Departure occurs between late May and mid-June with extreme dates of 18 May and 30 June. The breeding sites remain vacant from July through mid-October. An estimated annual cycle for the Black-capped Petrel, based on current data and extrapolation from closely related species of *Pterodroma* is summarized in Fig. 10.

Age of first return to Cahow nesting areas varies, but could be as little as four years. Typically, these birds first return between late January and early March. In subsequent years pre-breeders return before the pre-laying exodus to secure burrows and find a mate. Aerial courtship that consists of chasing flights and vocalizations appear to be restricted to pre-breeding birds. Vocal exchanges between the adults are sexually dimorphic. Age at first breeding ranges from five to eight years, and established pairs persist for 10–20 years. Burrows are occasionally abandoned when one member of the pair dies, but typically the surviving adult obtains a new mate within a year or two. The majority of Cahow nesting burrows remain in continuous occupancy. Annual mortality is estimated at 5%.

POPULATION ESTIMATES

Actual population size of the Black-capped Petrel is unknown, but it is believed to be quite small. Based on the 1961 survey of La Selle in Haiti, Wingate estimated a minimum of 2000 pairs. Van Halewyn and Norton (1984), apparently based mainly on Wingate's calculations, stated that the population size ranged between 2000 and 25000 pairs. This estimate was based on an assumption of as many as 40 colonies in Haiti, although only 14 colonies have been documented to date. Lee (2000a) believed the total West Indian population to be less than 2000 pairs. The colony in the Sierra de Bahoruco, Dominican Republic, was estimated to be 65 pairs in 1981 (Woods & Ottenwalder 1983). By 1990, Haney and Lee (Lee 2000a) believed that perhaps as few as five pairs remained present at this site. All current population estimates are based on detections of calling birds at night. These observations are extremely difficult to translate to reliable estimates of breeding pairs because of temporal variations in calling behavior related to the sex, age and breeding status of calling birds (Simons 1985).

In January 2002 a team of biologists and climbers from North Carolina State University (Simons *et al.* 2002) spent seven days surveying potential nesting areas in the Sierra de Bahoruco. Surveys covered approximately 20 km² extending along the main ridge running southeast from the rangers' station above Loma Los Aguacates. Most cliffs could be traversed only using climbing gear, and conditions proved to be quite dangerous due to the crumbling nature of the fossilized coral bedrock. Access to some cliffs east of camp was hampered by extremely dense vegetation. In many areas it was necessary to cut trails to reach the cliff face.

Birds at Bahoruco generally began calling about an hour after sunset and continued to call for several hours. We estimated a maximum

of seven to 10 birds calling simultaneously on any evening, but it is very difficult to infer much about the size of the breeding population from these estimates. Lee and Haney (Lee 2000a) recorded a similar number of calling birds at the site a decade earlier. Listening conditions varied dramatically from night to night due to wind, rain and fog. The relationship between the number of calling birds, breeding chronology and breeding population size is unknown. Surveys of closely related Dark-rumped Petrels (Simons & Hodges 1998) suggest that this level of activity represents a breeding population of 10s to low 100s of breeding pairs.

For Haiti, Wingate (1964) noted:

It was exceedingly difficult to estimate the population when the nest sites were inaccessible and visited by petrels only at night. Flying birds could not be seen to be counted and individual calls could not be discriminated from the total chorus. The volume of chorus was, however, arbitrarily measured and some advantage was derived from the fact that the ratio of chorus volume to total breeding population is known for the Cahow (Wingate, unpubl. data). On this basis I judged that each colony of *P. hasitata* contained at least 50 pairs and probably many more.

Estimating the number of colonies on Hispaniola was somewhat easier. This was done by calculating the ratio of occupied to unoccupied potential sites as determined on La Selle Ridge and relating this to the approximate number of potential sites on the island, as deduced from maps. Assuming, on authority of Wetmore (1932), that mountain ranges in the Dominican Republic are occupied, something in the order of 40 colonies may exist. Correlating these estimates gives a minimum breeding population of 4000 birds. The actual population is probably much higher.

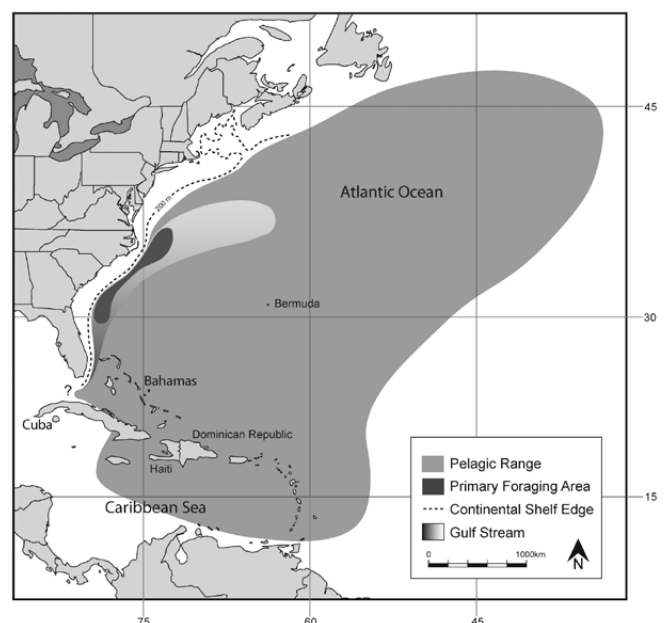


Fig. 11. Marine range of the Black-capped Petrel in the western Atlantic Ocean.

It is clear from historical accounts that the species was once quite common, at least on Guadeloupe and Dominica. The abundance of sub-fossil bones in caves in Haiti suggests it was also common in portions of Hispaniola. Despite ample montane habitat on the east side of Hispaniola, there is no evidence that the species was ever common or widespread in the Dominican Republic. In any event, the petrel has been extirpated from a large portion of its former breeding range, and former population sizes are unknown. A population model of the closely related Hawaiian Dark-rumped Petrel (*P. phaeopygia sandwichensis*) projected that pre-breeding birds comprised approximately 50% of the total population (Simons 1984). Extrapolating from Wingate's minimum estimate of 2000 breeding pairs in 1964 suggests a minimum total population estimate of 8000 birds at that time. Recent evidence suggests that populations remaining in Haiti have declined substantially in recent decades. Unless substantial new breeding colonies are discovered, it appears unlikely that the extant population is comprised of more than 1000 breeding pairs, perhaps as few as 500, and a total population of 2000–4000 birds.

Black-capped Petrels can be seen off the Outer Banks of North Carolina, the Georgia Embayment, and other portions of the South Atlantic Bight (Cape Hatteras, North Carolina, to Cape Canaveral, Florida). This is the only marine zone where consistent or regular concentrations are known to occur. If the most conservative estimates of breeding population size are correct, the majority of the world's population forages off the coast of the southeastern US. If the higher estimates are correct, a significant portion of the population occurs off this region in all seasons. In either case, these offshore waters appear vital to the survival of the species. Because of their mobility, high flight speeds and regular occurrence during the breeding season, birds nesting in the Caribbean likely commute to these waters to feed. The concept of such long-range foraging is not far-fetched. Adams and Flora (2010) report a single Hawaiian Petrel that covered over 10000 km on a single 19-day foraging trip in August 2006.

MARINE DISTRIBUTION

In contrast with most seabirds, far more is known about the Black-capped Petrel's marine ecology than about its terrestrial breeding biology. Among gadfly petrels, a group notorious for their high mobility and capacity for long-distance dispersal, Black-capped Petrels are distinctive for having a marine range situated within a relatively confined portion of the Atlantic Ocean basin. They are primarily limited to tropical and subtropical water masses in the western North Atlantic Ocean between about 10°N to 40°N latitude, and about 80°W to 60°W longitude (Fig. 11). At sea, almost all Black-capped Petrels have been observed close to Caribbean islands and along the western edge of the Gulf Stream in the South Atlantic Bight off the coast of the southeastern United States (Lee 1977, 1984; Clapp *et al.* 1982; Haney 1983).

In the Caribbean Sea, Black-capped Petrels can occur within the inter-island regions, straits and offshore zones of both the Greater and Lesser Antilles but still primarily east of 80°W. At least during winter and spring, petrels occur north and south of Hispaniola, offshore of southeastern Cuba (Garrido 1985, Farnsworth *et al.* 2005), off eastern and northeastern Jamaica (Shirihai *et al.* 2010), and near Puerto Rico and the Virgin Islands (Mörzner Bruijns 1967a; Norton 1983, 1984). Except for the latter region, all of these at-sea locations are close to known breeding colonies in southwest Hispaniola.

Black-capped Petrels have been recorded from the central-eastern Caribbean, including both Leeward and Windward groups of the Lesser Antilles (Levesque & Yésou 2005), near the leeward Netherlands Antilles, and off the north-central (especially Venezuelan) coastline of South America (Mörzner Bruijns 1967a). However, Black-capped Petrels seem to be scarce if not absent from the western Caribbean, i.e. areas around the Cayman Islands, western Cuba, Belize and northeast Mexico, including the Yucatan Peninsula, and eastern Central America. On 23 April 2011 a single bird was observed from a research ship flying north within sight of the southern tip of Cozumel Island, Mexico, at 20.2174°N, 87.1297°W (Keiper *vide* Haney).

Between 1913 and 2002, at least 13 reports totaling 20 birds were made from the Bahama islands, evenly divided between winter (January, February) and spring (April, May), with one August report (see below) (White 2003). D. Wingate (pers. comm., June 1990) reported sightings of Black-capped Petrel over deep channels off the southern Bahamas in the winter of 1988. All appeared to be migrating and were not observed feeding. Petrels at sea have been reported from waters near the Bahamas: one off Savannah Sound, Eleuthera, at 31°48'N, 75°58'W in January 1913 (Nichols 1913), and five off the coast of Great Abaco at 26°02'N, 76°03'W on 19 August 1988 (Collar *et al.* 1992).

Black-capped Petrel occurrence within the Gulf of Mexico basin is poorly known. Aside from storm-driven strays, Black-capped Petrels were once thought absent from the gulf, and there is no evidence that Black-capped Petrels occur in concentrations there. A synthesis of pelagic observations from this region indicated no records (Clapp *et al.* 1982), and several field studies failed to encounter any despite extensive or systematic surveys in this region (e.g. Fritts & Reynolds 1981, Davis *et al.* 2000). Except for two inland occurrences, most reports of this species in Florida are from the Atlantic Ocean, including the Florida Straits (Scales 2002). Nevertheless, in the western Gulf of Mexico there are two well-documented (photographed) records of single Black-capped Petrels observed 60 or more miles offshore of Port O'Conner, Texas: one on 28 May 1994, and another on 26 July 1997 (Texas Birds Records Committee 1997). However, during the past 10 years no Black-capped Petrels have been recorded during more than 24 one-day seabird excursions conducted off Texas in the far western Gulf of Mexico (Texas Pelagics.com 2011).

Based on proximity to breeding location, primary at-sea foraging range, and suitability of marine habitat, Black-capped Petrels are more likely in the eastern Gulf of Mexico, particularly the Loop Current system off far western Florida. The Loop Current system consists of a complex eddy field with oceanographic attributes similar to those of the Florida Current and Gulf Stream, but this region has not been extensively studied for seabirds. Duncan and Havard (1980) reported a possible Black-capped Petrel in July 1976 in deep water near Desoto Canyon, 60 km off Orange Beach, Alabama, the only published record for the eastern gulf. An emaciated bird was recovered on the beach in Destin, Florida, on 6 September 2011 following the passage of Tropical Storm Lee.

Putative records of Black-capped Petrels from the western North Atlantic Ocean far east of the West Indies (Voous 1983; R. van Halewyn, pers. comm.) and far south, off eastern South America, lack strong documentation; for example, an old record of the Black-capped Petrel off Brazil (American Ornithologist's Union 1983) is apparently not substantiated with sufficient details (R. van Halewyn,

pers. comm.). Similarly, a single bird reported by multiple observers from Point Vicente, Los Angeles, California on 20 September 2001 (the only instance of putative occurrence outside the Atlantic Ocean) was rejected as both implausible and insufficiently distinguished from the similar and more likely Juan Fernandez Petrel (*P. externa*) or White-necked Petrel (*P. cervicalis*) (San Miguel & McGrath 2005).

Black-capped Petrels can occur, although rarely, east of the Gulf Stream in the western Sargasso Sea (Nieboer 1966, Mörzer Bruijns 1967b). However, Haney saw none during two weeks of daily observations in the western Sargasso Sea during August 1984, and D. Wingate (pers. comm.) did not detect any Black-capped Petrels more than 50 km from the western edge of the Gulf Stream during his crossings from Bermuda to continental North America.

Off North America, Black-capped Petrels occur at least occasionally just south, north or east of their primary foraging range in the South Atlantic Bight. The species is rarely recorded (and never observed in large numbers) within the Florida Straits and Florida Current regions of southern Florida, suggesting that most petrels commute instead between the West Indies and the South Atlantic Bight along routes north of and around the east side of the Bahamas (e.g. Bracey 2001). Single petrels and small groups have been seen off the Mid-Atlantic States, including Virginia and Maryland (Rowlett 1977, Lee & Rowlett 1979, Harrison 1983). There is one record of an apparently non-storm-driven individual at the Hudson Canyon off New Jersey on 16 September 1991; a total of eight Black-capped Petrels were seen off Cape May during an afternoon seawatch after passage of Hurricane Bertha on 13 July 1996 (Hanson 2006). Other petrels have been recorded north to about 40°–45° in the northwest Atlantic off New England and southern Canada (e.g. Brown 1973, Lambert 1977, Howell 2002), some of which were storm-assisted (Lambert 1977, Sutton 1940). This region is still heavily influenced by the Gulf Stream, however, because the current here exhibits larger meanders (some of which separate as warm-core rings; Haney 1987b) and the current becomes much wider once the Gulf Stream bends eastward at about 36°N, losing the tight, steering influence of the continental shelf and slope.

The species is an exceedingly rare vagrant to the northeast Atlantic in marine waters off western Europe and northwest Africa. Two specimen records exist for England: one from Norfolk (1852) and a tide-line corpse found in East Yorkshire (1984). Sight reports are available from the Bay of Biscay (30 April 2002; Howell 2002), and an older observation from Rockall Bank, the latter by far the most northerly latitude record for this species (Cramp & Simmons 1977, Bourne 1983). There are also two photographic records of Black-capped Petrels from the Azores: a single individual 16 km southeast of Graciosa, Graciosa Island, on 26 May 2007, and another single individual 11–14 km south of Queimada, Pico Island, on 22 May 2009. A Black-capped Petrel was also reported from a cruise ship at about 35°50'N, 14°46'W, approximately 200 nautical miles (370.4 km) northeast of Madeira (Birding on the Net 2010).

Some of the earliest records of the Black-capped Petrel at sea were given by Wetmore (1927), who observed a number of the birds along the steamship course between New York and Rio de Janeiro, at a point southeast of Bermuda, during early June 1920. Unlike the smaller storm-petrels, he states:

The Black-caps paid no attention to the wake of the vessel, although at times they approached within a

distance of 10 m before veering far out to one side. Their gliding flight was near the water, with frequent changes of course. Those seen at close range showed the dark crown, with a white line behind it, the more or less grayish cast to the back, the white rump, and a dusky tinge along the sides. The lower surface of the wings was white, outlined in black, with the dark margin heavier in front. It was in approximately these same latitudes that Nichols (1913) observed a Black-capped Petrel at the opposite season of the year, namely on January 25. He states that the flight and appearance of the bird reminded him of the Greater Shearwater (*Puffinus gravis*), from which the Black-capped Petrel can readily be distinguished by the large patch of white above the tail.

Long-distance vagrancy is well known in petrels, particularly in the genus *Pterodroma* (Bourne 1967). In addition to reports discussed above there are many records of apparent vagrants in the North Atlantic that do not appear to represent birds displaced by storms (e.g. Dannenberg 1983). We have made no attempt to include or summarize all these records as there is seemingly no pattern to vagrant dispersal. Likewise, there are many records of storm-displaced individuals, many of which died and found their way into museum collections (Allen 1904). Other records are of coastal and inland sightings that have been reported in *American Birds* or in regional and state ornithological journals. Because of the soaring behavior of *Pterodroma* species, especially soaring high above the ocean in strong winds, these birds appear to be displaced at a high rate, out of proportion to their actual numbers, by hurricanes and other storm events.

The first report of Black-capped Petrels in North Carolina's waters, and the first indication that the species occurred regularly off the North American coast, was not until 1972 (Lee 1977). Since then, the species has been regarded as regular and relatively common off the coast of the southeast in general, and off North Carolina in particular. Counts of 30 to 100 birds in a single day are not unusual in offshore waters, and one tally of over 300 birds is available. Much of the information that follows comes from over 3000 sightings of Black-capped Petrels recorded by Lee off North Carolina during 325 days at sea as well as from observations of 500 individuals by Haney during 143 days of surveys off South Carolina and Georgia.

Black-capped Petrels are generally restricted to relatively deep water (200–2000 m [100–1000 fathoms]), and they are most common in waters more than 1000 m (500 fathoms) in depth. Haney (1987a) suggests that, south of Cape Hatteras, the distribution of Black-capped Petrels is most influenced by the position of the Gulf Stream, a major current system that is highly dynamic in its position. Petrels generally are not common over the outer continental shelf and are absent from the inner shelf. In 20 days of monitoring shallow shelf waters (30–40 m) off the Virginia Capes during the summer, Lee did not record a single *Pterodroma*. In Lee's major study area off Cape Hatteras, North Carolina, the shelf break, continental shelf-slope and the inner edge of the Gulf Stream are all in close proximity, making it difficult to determine which factors affected the local petrel distribution. Subsequent research, however, indicates that petrels track the Gulf Stream's inner (western) edge in this region as well (Hass 1997).

Haney (1987a) further noted that petrels occurred almost exclusively within a cross-shelf interval that corresponded to the maximum and

minimum extent of Gulf Stream frontal meandering in the South Atlantic Bight. Although petrel locations remained relatively fixed with respect to the Gulf Stream boundary, they varied by depth and distance offshore. Off Florida, Black-capped Petrels occurred over shallower depths and closer to land than farther north off Georgia and South Carolina. Haney (1987a) also detected broader cross-shelf distributions of Black-capped Petrels at higher latitudes, where amplitude of the cross-shelf range of frontal meandering was greater. East of the western Gulf Stream frontal boundary, Black-capped Petrels were observed only over seamounts, submarine ridges and mesas on the Blake Plateau. He also observed small numbers of petrels feeding over and downstream of the Stetson Mesa (30°30'N, 79°30'W) and Hoyt Hills (32°00'N, 78°30'W). Petrels there were primarily observed in or near internal wave crests (Haney 1987a, 1987b, 1987c).

Off the southeastern United States, Black-capped Petrels vary in abundance by latitude. South of Cape Hatteras, they are more abundant off northern Georgia and southern South Carolina, where upwelling is most frequent, persistent and extensive (e.g. Bane 1983, Haney 1986a). Another peak in abundance occurs in the Hatteras region of North Carolina, also an area of strong upwelling.

At finer geographic scales, petrels are more abundant in the immediate frontal region at eddies (e.g. at the 28°C and 29°C isotherms) and in Gulf Stream waters rather than in continental shelf waters (Haney 1986b). The Black-capped Petrel is one of few species of seabird regularly present in the Gulf Stream throughout the year, as productivity in the surface waters of the Gulf Stream is very low (Yoder *et al.* 1983). However, behavioral and structural adaptations of gadfly petrels facilitate exploiting ocean niches with scarce prey (Imber 1985). Their low wing loadings allow efficient gliding (Warham 1996) but not sustained flapping flight. As a result, the Black-capped Petrel depends on wind for long-distance foraging in this oligotrophic environment.

Sea surface temperature and depth do not consistently characterize Black-capped Petrel marine habitat throughout its range. Nevertheless, during any given season, they tend to be found in waters warmer than average (D.S. Lee pers. obs.). For example, in the South Atlantic Bight, petrels were observed in waters that ranged between 20.5°C and 29.0°C, in part because of seasonal and latitudinal changes in the Gulf Stream itself (Atkinson *et al.* 1983). Thus, we do not believe that these birds respond to water temperatures *per se* but restrict their activity to areas that are most influenced by the Gulf Stream. For example, Black-capped Petrels did not occur during summer in shelf waters although sea surface temperature there may equal or exceed temperatures found in the Gulf Stream (Atkinson *et al.* 1983, D.S. Lee pers. obs.).

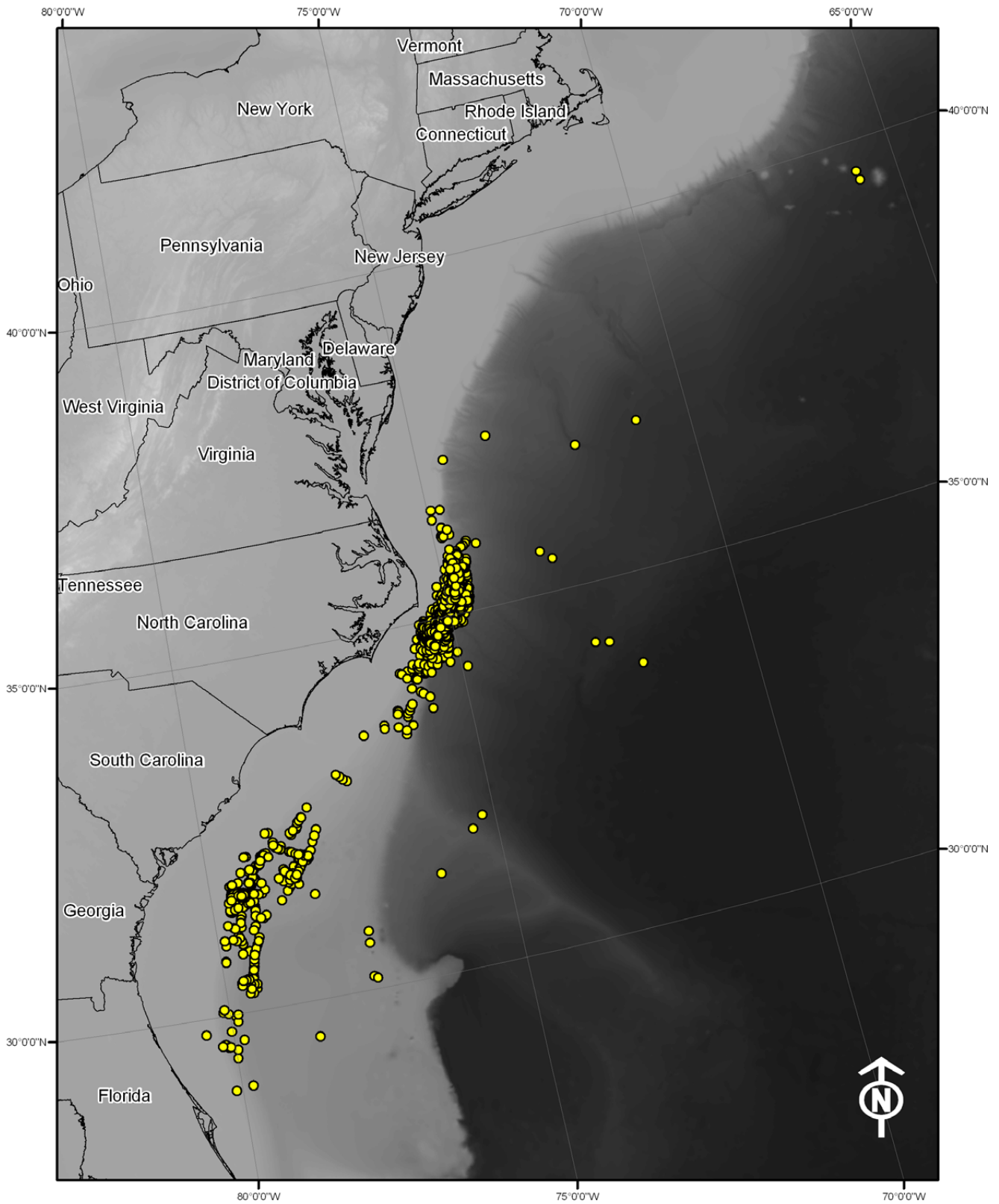
The Black-capped Petrel is the only locally occurring seabird found during all seasons off North Carolina (Lee 1986, 1987) but is most common in May, August and late December through early January. Petrels were commonly seen off of Cape Hatteras in December, with a minimum count of 115 on 28 December 1982; during this month, they were quite vocal and less likely to be solitary than in other seasons. "Pairs" were regularly seen in flight following one another at this time of year. D. Wingate (pers. comm.) suggests that the large numbers of Black-capped Petrels seen off the coast of North Carolina in December may represent pre-nesting dispersal from breeding islands after burrow sites have been chosen (Lee 1987). Individuals collected in December were mostly adult males, and all

specimens collected had brood patches, further indicating that these were breeding individuals. The scarcity of females in December could indicate that they were foraging closer to their nesting areas. The possibility that Black-capped Petrels commute between nesting areas in Haiti and waters off the southeastern United States during the breeding season is strengthened by observations made by D. Wingate (pers. comm.) in the Bahamas. In mid-February 1988, Wingate observed six individual petrels flying both north and south over the deep channels that separate the various southern Bahamas Banks. This would represent an almost direct route between Haiti and the Gulf Stream off the east coast of Florida.

Haney (1987a) also noted year-round presence with a maximum occurrence of Black-capped Petrels south of Cape Hatteras in April and November, which indicates that major segments of the population of these birds may be foraging in different areas during different seasons (Haney *et al.* 1992).

Based on photographs and museum specimens obtained off North Carolina, Howell and Patterson (2008) reported the light color morphs to be more common in spring, while the dark morphs were most common from late summer through fall.

Researchers at the Patuxent Wildlife Research Center have recently compiled a spatially referenced Microsoft Access database of marine bird survey data for species occurring along the South Atlantic Bight (O'Connell *et al.* 2009). Their goal is to make better predictions of seabird distributions that can be used by regulatory agencies such as the US Fish and Wildlife Service and Bureau of Ocean Energy Management for evaluating proposed offshore development projects. Metrics of seabird occurrence include measures of relative abundance or occupancy, rather than density or absolute abundance. To date, the researchers have catalogued 65 datasets on seabird occurrence for the western Atlantic, representing more than 400,000 observation records. They have also developed color-coded maps of survey effort that present a standardized representation of survey effort by species. Survey effort is portrayed as the number of five-minute equivalent transects for a vessel cruising individual grid cells at 20 knots (37 km/h). The Patuxent team is also developing species habitat models for Black-capped Petrels and nine other species proposed by the USFWS for threatened or endangered status. Models will relate biophysical data (chlorophyll, bathymetry, surface temperature, etc.) to spatial/temporal patterns of relative abundance and occurrence. The database contains approximately 5,000 individual sightings of Black-capped Petrels collected between 1979 and 2006 (Fig. 12). Survey effort across time and space is quite patchy. Over 85% of documented sightings were collected within 100 km of Cape Hatteras, North Carolina. Sightings include approximately 90 records collect by the Manomet Bird Observatory between 1979 and 1987, 500 records collected by Haney between 1983 and 1985, 650 records collected by Lee between 1980 and 1991, 50 records collected by the Hatteras Eddy Project in 2004, and 3,750 records collected by Pattenon between 1992 and 2006. The distribution of sightings reinforces Haney's (1987a) conclusion that birds appear to associate with the western edge of the Gulf Stream (Fig. 12). Considerable seasonal variation in survey effort and coverage is apparent in the available data (Fig. 13). This variability in survey effort and unaccounted-for variations in detection probability among observers, locations and seasons limits our ability to extrapolate from these data to more accurate estimates of distribution and abundance. Existing survey data suffer from significant spatial, temporal and detection bias



Projection: Albers Equal Area Conic CONUS
Datum: North American Datum 1983
Background: ETOPO1 1 Arc-minute global relief model (Amante and Eakins 2008)
U.S. state outlines from ESRI, Inc., Redlands, CA, 2005

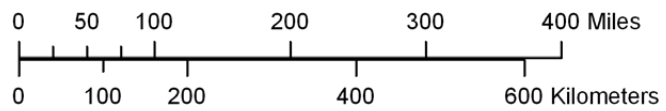


Fig. 12. Locations of Black-capped Petrel reports at sea off the eastern United States in relation to bathymetry of the continental shelf and slope. These data were compiled by O’Connell *et al.* (2009) and supplied by numerous contributors.

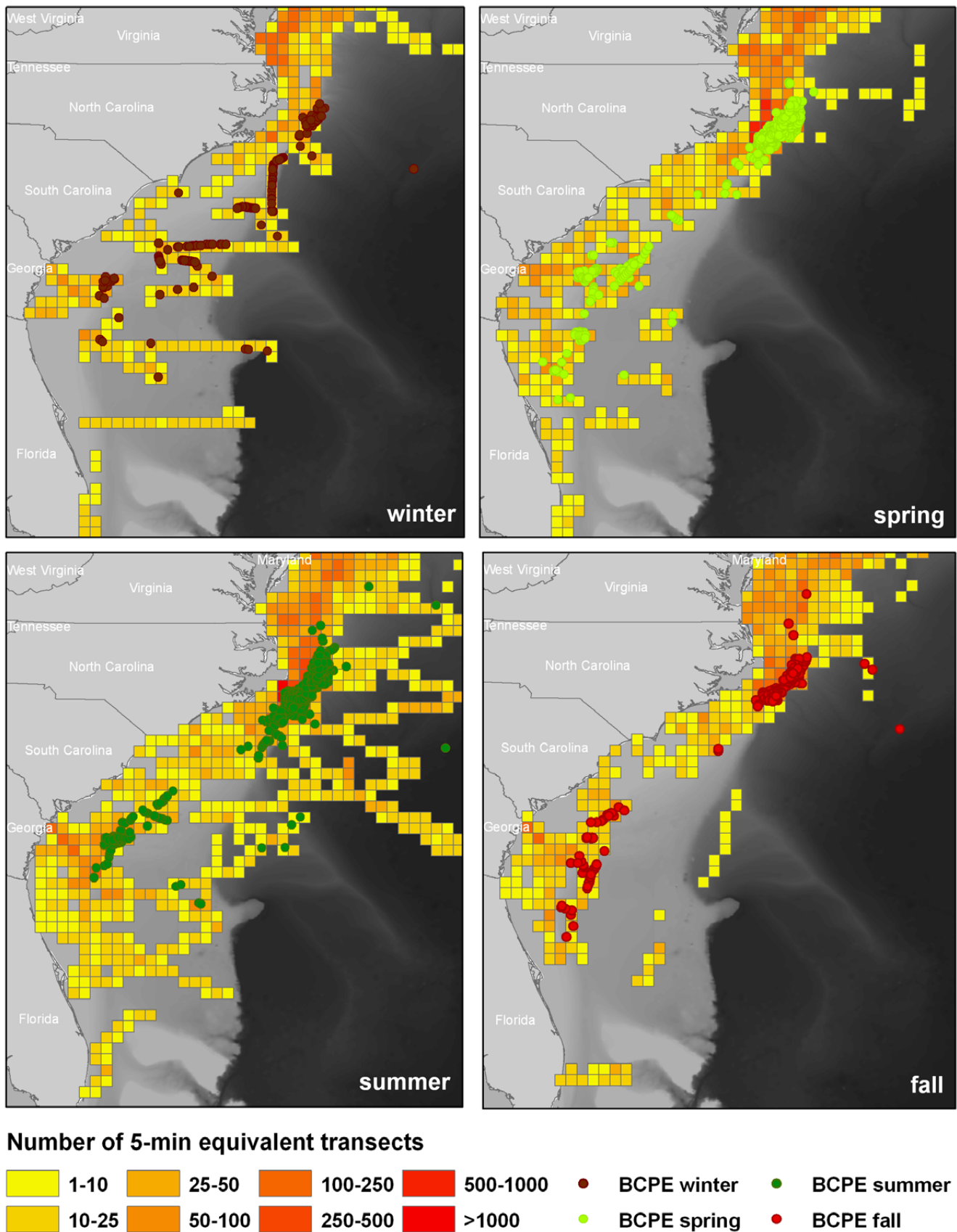


Fig. 13. Seasonal distribution of Black-capped Petrel off the southeastern United States in relation to survey coverage and effort. These data were compiled by O’Connell *et al.* (2009) and supplied by numerous contributors. The background grid shows a standardized metric for survey effort. Five-minute equivalent transects were computed as the distance traveled by a vessel traveling at 10 knots (18.5 km/h) for 5 minutes (0.8333 nautical miles or 1.54 km). Dots represent the detection of one or more Black-capped petrels within the grid cell.

associated with variations in survey design as well as unaccounted-for variations in sea and weather conditions, observer skill and the use of chum to attract birds.

BEHAVIOR AT SEA

Haney (1987a) reported on the marine habitat and behavior of Black-capped Petrels off Georgia. Petrels usually flew in rapid “roller coaster” flight on bowed and angled wings that produced a distinctive bounding or rising-and-falling progression (Harrison 1983). Occasionally, they rose to 20–25 m above the sea at the peaks of the arcs. The extent of wing-flapping in this flight mode was inversely related to wind speed. At wind speeds less than or equal to about six knots (11.11 km/h), petrels used a very slow and labored flight with many deep, rapid wing-beats, particularly when taking off from the ocean surface. Gull-like soaring on horizontal wings from 50 m to 100 m above the ocean surface was observed very rarely during moderate wind conditions (6–15 knots or 11.11–17.77 km/h). In higher winds, Black-capped Petrels may spring directly into the air from the water surface (Harrison 1983). In low winds (<6 knots, 11.11 km/h), they run along the ocean surface for 2–4 m before taking flight (Haney 1983).

Relative petrel abundances increased from Beaufort force 2 to a peak at force 5 (17–21 knots, 29–38 km/h). Individuals were not observed by Haney in winds <4 knots (7.41 km/h), except when sitting birds were flushed from the ocean surface by passing ships. The majority (72%; $n = 19$) of all sitting birds observed during transit, as well as all ($n = 13$) non-feeding sitting petrels, were recorded at wind velocities <4 knots (7.41 km/h). Unless petrels are more difficult to detect when sitting on the ocean surface under conditions of low wind velocity, this information suggests that petrels depend on higher wind velocities for foraging and dispersal (Jouventin & Weimerskirch 1990).

Individual Black-capped Petrels are often seen flying just ahead of storms and small isolated squalls; it is not clear whether this is simply storm avoidance behavior or whether the petrels obtain additional lift for their dynamic soaring under these conditions (D.S. Lee, pers. obs.). This behavior was not observed regularly in other seabirds, but the observations may be biased due to the petrel’s habit of soaring considerably higher than other marine birds, making them easier to detect. Haney found that Black-capped Petrels were active during all daylight hours, with an apparent peak in activity from 07h00–09h00 and a less pronounced peak from 17h00–19h00. Lee’s offshore surveys seldom reached areas where Black-capped Petrels occurred earlier than 09h00. A marked decline in activity often occurred after 11h00, but by mid-afternoon survey boats were again out of areas where the species occurred. Petrels were seen flying in the ship’s high-beam searchlights at night, although no feeding was observed during these limited observations. All eight natural feeding aggregations reported by Haney (1987a) occurred before 09h00 or after 15h00. All aggregations that resulted from artificial, chum-feeding experiments ($n = 6$) occurred after 15h00. Lee found that petrels exploit mostly diel, vertically migrating, mesopelagic nekton (Imber 1985), prey types that strongly suggest an adaptation for crepuscular or nocturnal feeding.

Although petrels were generally silent, individuals at chum slicks occasionally uttered single bleating or croaking notes, “waaahh” or “aaa-aw,” when feeding (Wingate 1964, Imber 1985, D.S. Lee pers. obs.). On one occasion in December 1982 Lee noted a large flock

of vocalizing petrels at sea. Most (22/29) birds collected from this flock were adult males, and all but two of the males were adults.

The majority (96%) of petrel feeding bouts reported by Haney ($n = 25$) occurred in flocks, 88% of which included other species. Petrels were observed feeding at “baitfish” or invertebrate swarms with 12 other species, and averaged 4.3 species per feeding flock (range 2–8 species/flock). The most frequent associates were Cory’s Shearwaters *Calonectris diomedea*, Greater Shearwaters *Puffinus gravis*, Audubon’s Shearwaters *P. lherminieri* and Pomarine Jaegers *Stercorarius pomarinus* in summer, and Herring Gulls *Larus argentatus* and Black-legged Kittiwakes *Rissa tridactyla* during the winter. Petrels fed with 10 seabird species (mean 3.8 species/flock; range 3–6) at chum slicks, including Greater Shearwaters, Wilson’s Storm-Petrels *Oceanites oceanicus*, and Pomarine Jaegers in summer and Herring and Laughing Gulls *L. atricilla* in winter. Less common feeding associates observed by Lee included South Polar Skua *Catharacta maccormicki* and Common *Sterna hirundo*, Bridled *S. anaethetus*, and Sooty terns *S. fuscata*. Both Parasitic *Stercorarius parasiticus* and Pomarine Jaegers attempted to parasitize feeding petrels as they rested on the surface (Haney 1987a). Lee (*in Haney et al.* 1999) watched a Bridled Tern repeatedly attack a Black-capped Petrel that was trying to feed on the wing. The pursuit continued for some period with the Black-capped Petrel eventually leaving the area. This was the only such incidence observed during 15 years of study. Brinkley (1994) reported evasive maneuvers by Black-capped Petrels pursued by South Polar Skuas and Pomarine Jaegers and provided a photograph of a South Polar Skua feeding on the carcass of a Black-capped Petrel.

With one exception, Black-capped Petrels were not seen in association with marine mammals, despite ample opportunity to make such observations during Lee’s long study period. On 1 April 1987 a single petrel was seen foraging around a fin whale *Balaenoptera physalus*, his only record of this petrel in shallow (<30 m) shelf waters.

Haney’s (1987a) observations of Black-capped Petrels feeding at chum were among the first such reports for this species. During his study, petrels frequently flew in to inspect fresh waste fish as well as fish and chicken entrails near fishing boats. Petrels settled on the water and consumed the chum, occasionally flying off with large pieces, or attempting to steal the food items from other petrels. On 13 April 1984, 65 petrels fed on fish entrails, with five to 10 individuals on the ocean surface continuously. Solid chum seems to attract petrels best during windy conditions, when the bait floats for

TABLE 4
Measurements of Black-capped Petrels collected off North Carolina^a

Measurement	Mean ± SEM (n)	
	Males	Females
Weight (g)	439.8 ± 8.8 (44)	419.4 ± 12.0 (19)
Wing cord (mm)	285.7 ± 7.3 (7)	289.1 ± 4.1 (7)
Wing length (mm)	400.6 ± 2.5 (42)	396.5 ± 4.5 (19)
Culmen length (mm)	33.6 ± 0.3 (37)	32.5 ± 0.4 (17)
Culmen depth (mm)	15.8 ± 0.2 (34)	15.1 ± 0.2 (17)

^a $n = 68$, 48 males and 20 females

long periods, and when solid bait is clearly visible and accompanied by odor additives such as fish oil (Shirihai *et al.* 2010).

Like several other procellariiforms (Guzman & Myres 1983), Black-capped Petrels may scavenge discarded waste only when natural foods are not abundant or reliable, such as when large numbers of migrating individuals are concentrated locally in unproductive waters. Black-capped Petrels do not appear to rely exclusively on olfaction for locating food sources like some procellariiforms that are attracted to food-related odors from downwind (Hutchinson *et al.* 1984). We have observed petrels flying in from upwind to inspect other feeding seabirds. Haney *et al.* (1992) used geometry to calculate the theoretical upper (20–30 km) and lower (0.7–6.2 km) limits of the distances from which seabirds could use visual cues to locate foraging flocks in pelagic environments. The arrival times and flight times of birds responding to chumming experiments were closer to the lower theoretical limits. Of the 15 species recorded in 17 recruitment experiments, Black-capped Petrels were the most commonly encountered seabird. Visual recruitment distance in this species is almost certainly enhanced by their high, arching flight pattern.

Petrels used at least four foraging postures when feeding: (1) sitting on the ocean surface with wings outstretched and sharply angled backward; (2) aerial dipping, pattering and hydroplaning (Ashmole 1971), with their feet extended and touching the ocean surface but still remaining airborne; (3) aerial maneuvering; and, (4) less commonly, sitting on the ocean surface with folded wings and the head and neck submerged underwater. The last behavioral pattern is similar to the foraging behavior of the Audubon's Shearwater (Haney 1986c). Birds resting on the surface elevate and fan their tails, displaying the white areas of their tail feathers, when other petrels approach the flock. When resting in rafts, these petrels appear to sit higher on the water than shearwaters (D.S. Lee pers. obs.).

On 5 May 1983, P. W. Stangel (pers. comm.) observed aerial “flushing” and chasing of flying fish by two Black-capped Petrels but did not observe a successful capture. On one occasion, a petrel was seen diving 3–4 m from the air to, but not beneath, the ocean surface at an angle of 45°–60°. This behavior resembled “belly flop” diving or surface plunging by gulls (Ashmole 1971). Petrels were never seen to submerge beneath the ocean surface.

BIRDS COLLECTED AT SEA

No detailed comparisons of recent specimens obtained at sea with birds collected from nesting colonies have yet been made. Nearly all birds (housed primarily in the North Carolina State Museum collection) collected by Lee from the mid-1970s through the 1980s off North Carolina ($n = 68$, 48 males and 20 females) were adults (Table 3). Only three of them had bursas and were considered to be young birds. Biases in the distribution of the petrels by sex and age are consistent with similar biases in the seasonal age and gender distributions of other seabirds (Lee 1988). Male petrels were also generally larger than females (Table 4). Weights of males ranged from 329 g to 557 g and of females, from 347 g to 545 g (Table 3). The only available information on molt previous to this study was provided by Palmer (1962), who noted two birds taken in August in wing and body molt. Black-capped Petrels collected between 10 September and 29 April by Lee showed no sign of molt. Most adult May specimens exhibited no molt of flight feathers, but four of six collected on 19 May 1982 were molting their innermost primaries (one new, two to three in sheaths and growing, four to 11 old).

A single bird, age unknown, from 22 May had no sign of molt. All birds collected between 3 June and 21 August were molting primaries with the outermost primaries molting in those collected from 11 to 21 August. Body molt is most advanced toward the end of this period, and tail molt occurs from May to July. The extended primary molt period for males may simply reflect the larger sample size for males (Table 3). Molt of flight feathers at this time of year suggest that breeding activities are complete by early May and that birds may remain in residence off the Outer Continental Shelf of the southeastern United States throughout the summer. The larger light morph birds undergo wing molt earlier than the darker birds, suggesting differences in breeding phenology between the two forms. The molt sequence of other feathers and of immature birds is available from field data sheets that accompany the specimens at the North Carolina State Museum. Adults of both sexes collected in December had brood patches and white filoplumes on their crowns, napes and hind-necks, with males having more filoplumes than females. Imber (1971) reported similar patterns for plumages of 16 other species of *Pterodroma*. While the presence of brood patches and filoplumes probably corresponds with the onset of the nesting cycle, Imber questioned the usefulness of filoplumes on nocturnal burrow-nesting Petrels. However, many of the birds observed and collected off North Carolina in December appeared to be engaged in courtship flights. Sexually dimorphic plumage may be important for such diurnal social interactions.

Parasites

External parasites of Black-capped Petrels ($n = 20$) obtained off North Carolina include several lice (Phthiraptera). Taxonomic affinities of these lice include the family Philopteridae (*Halipeurus* [*Halipeurus*] *theresae*, *Trabeculus fuscoclypeatus*, *Saemundssonina jamaicensis*), and the family Menoponidae *Austromenopon popellus* (R. L. Palma pers. comm.). *Austromenopon popellus* is widespread on the petrel genera *Procellaria*, *Pseudobulweria*, *Lugensa* and *Pterodroma* (Pilgrim & Palma 1982, R. L. Palma, pers. comm.), including most of subgenus *Pterodroma* (*sensu* Imber 1985): *P. macroptera*, *P. lessonii*, *P. incerta*, *P. mollis* and *P. magentae*. However, this is the first record from the North Atlantic (R. L. Palma pers. comm.). *Saemundssonina* (*Puffinoecus*) spp. live on shearwaters and other petrels, but on gadfly petrels have so far been found only on several species of subgenus *Pterodroma*, including *P. lessonii* and *P. caribbaea* (Pilgrim & Palma 1982). *Halipeurus theresae* belongs to the *H. (H.) procellariae* group of this genus, thus refuting Timmermann's (1965) suggestion that, if *P. hasitata* hosted a *H. (H.) marquesanuo* group louse, like *P. phaeopygia*, *P. cervicalis*, *P. alba* and *P. heraldica*, it would be the type of the resurrected genus *Aestrelata*. *H. theresae* is found on other subgenus *Pterodroma* species in the North Atlantic and South Pacific Oceans (R. L. Palma, pers. comm.), as well as on two small Pacific species: *P. hypoleuca* and *P. axillaris* (Pilgrim & Palma 1982, R. L. Palma, pers. comm.).

Thus, three of the four louse species found on *P. hasitata* are consistent with evidence from intestinal structure (Imber 1985) and from vocalizations (Wingate 1964, pers. obs.) that the Black-capped Petrel belongs to subgenus *Pterodroma* and is therefore closely related to the other extant North Atlantic *Pterodroma* species. However, *T. fuscoclypeatus* is not found on other subgenus *Pterodroma* species but rather is hosted by numerous medium-sized tropical and subtropical gadfly petrels, mainly of the *Hallstroma* subgenus of Imber (1985) (R. L. Palma, pers. comm.). Therefore, this louse is probably a secondary infestation from one of those

species. Although carried by the surface-breeding Trindade Petrel *P. arminjoniana* of the South Atlantic, *T. fuscoclypeatus* is a surface-breeder, and contact between *P. arminjoniana* and *P. hasitata* on breeding grounds seems unlikely. Rather, it is possible that the group of *Pterodroma* that radiated westward from *P. cervicalis* in the southwest Atlantic Ocean at St. Helena Island (now extinct, but represented among subfossil bones of gadfly petrels, e.g. Olson 1975, Meredith 1985), and possibly the Lesser Antilles, is the source of this ectoparasite. This could explain statements by Lafresnaye and Noble (in Murphy 1936) that two closely related white-breasted petrels bred on Guadeloupe at different seasons. White-breasted *P. hasitata* is a winter-breeder, but the *P. cervicalis-baraui* group petrels are summer-breeders. Thus, up to three species should be sought among sub-fossil bones from the Antillean chain of islands: *P. hasitata*, *P. caribbaea*, and a lost species akin to one represented by sub-fossil bones on St. Helena Island.

Diet

Little information is available on the diet of Black-capped Petrels (Clapp *et al.* 1982). Haney (1987a) examined stomachs of three individuals collected off Georgia and found squid, fish (one a *Monocanthus hispidus*, 40 mm), and *Sargassum* algal blades. Examination of 57 stomachs and crops of Black-capped Petrels collected off North Carolina revealed the following (by frequency of occurrence): squid (93.0%), fish (49.1%), crustaceans (3.6%), pieces of *Sargassum* (14.0%), plastic (1.8%), unidentified items (17.5%) and empty (4%) (Moser & Lee 1992). The time of collection and degree of digestion indicate that most individuals feed at night or early in the morning. Squid were certainly the most frequently encountered food item, but beak fragments accumulate in crops and may create the false impression of a preference for squid. Unlike other seabirds examined, these Black-capped Petrels harbored few plastics or other unnatural items in their digestive tracts (Moser & Lee 1992). Haney (1987a) recorded small pieces of petroleum residue and paper in one stomach. Weights of total stomach contents were as high as 35 g for individuals collected off North Carolina.

North of the Hatteras area of North Carolina, *Sargassum* is typically transported northward along the inner edge of the Gulf Stream and by oceanic fronts within the Gulf Stream. Unlike some of the other tropical pelagic seabirds (notably Audubon's Shearwaters and Bridled Terns), Black-capped Petrels have rarely been observed foraging in or near *Sargassum* lines. Presence of *Sargassum*, mostly floats, in the stomachs nevertheless indicate that at least some foraging of the petrel probably takes place around *Sargassum* mats, perhaps at night. The file fish *Monocanthus hispidus*, present in one stomach, is clearly a *Sargassum* associate. Birds collected off North Carolina (Moser & Lee 1992, 2012) showed evidence of feeding in *Sargassum* in only 14.0 % of stomachs (pieces of *Sargassum* or prey items associated with the pelagic alga), suggesting the association was incidental. Platania *et al.* (1986) measured body temperatures of nine Black-capped Petrels and found a mean of 39.1 °C (range 38.0 °C–40.0 °C). These temperatures were within the range of other mid-sized procellariiforms and most other pelagic western North Atlantic seabirds.

THREATS TO REMAINING POPULATIONS

There is little doubt that the breeding population on Hispaniola has decreased since European colonization, but the extent to which this trend continues remains uncertain. Some factors that obviously

limit the breeding population now, and that may reduce it further in the future, include human predation, forest fires, deforestation, introduced mammals, wind farms, communication towers, offshore oil and gas development, mercury and plastic pollution, climate change and marine fisheries.

Human predation

Before the arrival of Europeans and Africans, seabirds were apparently eaten by Native Americans. In addition to the *Pterodroma* remains from pre-Columbian middens on Crooked Island, Bahamas, and caves in Haiti, Wing (1989) reports the remains of numerous Audubon's Shearwaters from a prehistoric site on Antigua. The West Indies were populated rather recently, however. Casimiroid people arrived on Cuba and Hispaniola about 5000 BP and did not migrate to central Cuba and the Bahamas until 1210 and 810 BP. Ortoroid people from South America arrived in the Lesser Antilles and Puerto Rico about 3000 BP (Rouse 1989).

In colonial times, the French islands and Jamaica probably supported larger human populations than these islands' natural resources could physically sustain. Human populations were protein-deficient; thus, birds were considered a great delicacy. Consequently, petrels were hunted constantly during the breeding season. Often, dogs were used to locate burrows (Labat 1724). Even the difficult and dangerous cliffs were scaled in pursuit of the birds. The young in down, called "cottons" on the French Islands of Guadeloupe, were thought to be particularly succulent.

Based on fragmentary written observations from the 17th and 18th centuries, these birds must have been consumed in considerable numbers. Du Tertre (1654) noted:

Its flesh is so delicate that no hunter ever returns from the mountain who does not ardently desire to have a dozen of these "devils" hanging from his neck.

The presence of the Catholic Church in the early post-European contact period is likely to have contributed to the demise of the species. As an approved food during Lent, the petrels were commonly hunted at their Lesser Antillean nesting sites. Labat (1724) writes:

It may be said that these birds are a manna which sends every year for the Negroes and for the lowly inhabitants, who do not live on anything else during the season. After two or three hours of hunting I returned with my Negro to rest to cook some birds for dinner. I began finally to hunt alone. We reassembled at midday. The four Negroes had 138 diabolins. Albert had 43, and I 17. Each of us ate two, and we left carrying the rest of our game. Those who read these memoirs will doubtless be surprised that we should eat birds in Lent; but the missionaries who are in these islands, and who in many matters exercise the power of bishops, after serious deliberation and a consultation of medical men, have declared that lizards and diabolins are vegetable food, and that consequently they may be eaten at all times.

A practice of exploitation called "sen sel" continues on moonless foggy and rainy nights. "Sen sel" is a method for capturing petrels at breeding colonies (January through March) by lighting a

moderate fire on a cliff top above a colony. Birds flying near the fire become disoriented and crash either directly into the fire or into nearby vegetation. Wingate (1964) notes that about 15 were caught using this method in February by employees of a logging camp at Casse Dent near Sequin, Haiti. Wingate (1964) tried to capture birds by “sen sel” on 12 nights but was successful only once when he captured four birds.

Wingate noted that the “sen sel” practice would seem to take an insignificant toll, but considering the small size of the colonies and the low reproductive yield of the species, it could be argued that any disturbance at the nesting area would be detrimental to the species’ survival. Unfortunately, the already dense human population on Haiti continues to increase, bringing more people in close proximity to breeding colonies. Although cliffs where most Black-capped Petrels nest will continue to be inaccessible, agricultural clearings now extend close above and below these colonies. The standard practice of burning the cleared vegetation on these clearings was reported to have the same effect as “sen sel.”

Human predation continues today, but it is more limited in nature than in the past. Due to the rarity of the species and the restriction of the remaining relict colonies to steep cliff face nesting sites, human predation seems to be sporadic and opportunistic.

Forest fires

Wingate (1964) noted that a direct result of increased human population is the higher frequency of intentional and accidental forest fires. The pine forest areas above colonies, with their even ground cover of bracken (*Pteris longifolia*), are highly combustible. In recent years, ground fires have raged over vast areas of the pine forest, particularly in the Forêt de Pins near La Selle in Haiti. Natural fires occur primarily in the summer and have little effect on nesting petrels, while human-induced fires occur in the winter dry season. A 1994 fire at the Sierra de Bahoruco breeding site in the Dominican Republic created a pine savannah with an open overstory (T. Varga pers. comm.). Open habitats may be more accessible to flying petrels, although D. Shoch (pers. comm.), a forester with The Nature Conservancy, Arlington, VA, visited the site in 2006 and reported extensive and rapid pine regeneration. It is not known how the closing canopy and understory may affect the suitability of the habitat for nesting petrels. Other gadfly petrels appear well adapted to forested nesting habitats, where they adeptly climb trees and rocks before flying. Although the forested cliffs generally escape burning because of the completely different nature of the vegetation, Wingate (1964) recorded one instance in which a patch of cliff face vegetation had recently been burned off adjacent to a petrel colony. Depending on the location and season, such fires could have disastrous effects on chicks in petrel colonies. For example, fires burning through the nesting habitat of endangered Zino’s Petrel *Pterodroma madeira* destroyed 65% of the chick production on Madeira in 2010 (Birdlife International 2010). Mudslides following the forest fires on Madeira further damaged critical nesting habitat. We suspect that recent erosion of forested cliff habitats used by Black-capped Petrels on the Massif de la Selle in Haiti may have resulted from forest fires set intentionally to clear land in the area. Conversely, natural fire may also be important in maintaining the open park-like savannah habitat at high elevation, similar to the role of earthquakes, hurricanes and volcanoes in the pineless Lesser Antilles. The long-term importance these disturbance events might have on petrel nesting sites is unknown.

Deforestation

Since colonization by Europeans and Africans, West Indian islands where Black-capped Petrels bred or breed have lost a considerable amount of their original forest habitats. Direct effects of deforestation on petrels are unknown and may not always be detrimental, but the fact that deforestation has occurred most rapidly and completely in Haiti certainly bodes ill for the future long-term survival of these petrels. The increased presence of protein-deficient human populations so near the principal breeding population greatly increases the risk of direct exploitation. The remaining suitable nesting sites are few and fragmented, primarily due to rampant deforestation on Hispaniola, especially in Haiti (Lewis and Coffy 1985). According to the United States Library of Congress, by 1988 Haiti had lost approximately 98% of its original forests (Haggerty 1989).

On Guadeloupe, where petrels have been extirpated for decades or centuries, little forest remains on the eastern island of Grande Terre, and only 14600 ha remains on the western island of Basse Terre (Johnson 1988). All forest habitats on Martinique have been affected by human activities, although remaining forest tracts on this island are among the largest remaining in the Caribbean (700–9000 ha). However, the species was thought to have become extirpated from Martinique in the pre-Columbian era (van Halewyn and Norton 1984). Forests on Jamaica are being lost at a rate of 20 km² per year, and all remaining areas of forest are severely threatened (Johnson 1988), largely because of government-sponsored silviculture, the development of coffee plantations, illegal cultivation and charcoal burning.

Introduced mammals

Allen (1911) reviewed the land mammals of the West Indies. The majority of the species present in the recent period are bats and introduced species. Native terrestrial mammals were represented in the historic period primarily by a few species of rodents, and these were not wide ranging in the region.

The small Indian mongoose *Herpestes auropunctatus* has often been blamed for the decimation of *P. hasitata* and other native fauna of the West Indies. The mongoose may or may not have been responsible for the extirpation of this seabird on the French Lesser Antilles. In any case, the process of extinction was well on its way by the time the mongoose was imported. The date of the first importation to the West Indies was 1872, when four males and five females were released in Jamaica (Espeut 1882). The population expanded quickly, and animals from Jamaica were introduced to 29 other Caribbean Islands. Introductions to other islands on which *Pterodroma* may have nested occurred by the end of the 1800s: Hispaniola (1895), Cuba (1882), Guadeloupe (1880–1885), and Martinique (1889) (Hoagland *et al.* 1989). Certainly, if birds were still nesting at lower elevations then they would have been greatly reduced in number and in great danger from the rapidly expanding mongoose population. Wingate (1964) received reliable reports of the mongoose above 2000 m on the Massif de la Selle, but it is apparently not common there. He saw none during 25 days at that altitude, and recent investigators have not reported them. It is likely that some of the remaining breeding sites are inaccessible to mongooses.

Rats and mice were introduced to most of the West Indian Islands early in the colonial period. By 1654 du Tertre noted the abundance and voracity of rats among the French Islands (in Allen 1911). In addition to the black rat *R. rattus*, the Norway rat *R. norvegicus* was

also common. Gundlach (1866–1867) considered Norway rats to be more abundant than the black rat in Cuba. House mice *Mus musculus* were also introduced throughout the Caribbean. They were widespread but not abundant in the French Islands by the mid-1600s.

Wingate (1964) set standard snap traps for rats above and below colonies near Morne Cabaio in Haiti in late February. These caught *R. norvegicus* and two distinct and sympatric races of *R. rattus*. The former were caught only near dwellings and farmland and thus probably do not commonly come into contact with the petrel. The latter were widespread and common even on steep cliffs, but Wingate (1964) doubted they were significant predators of the petrel. *R. rattus* probably occurs throughout Dominica, but it is unclear whether it is a major predator on that island. Rupp *et al.* (2011) recently photographed *R. rattus* at an active Black-capped Petrel nest in Bahoruco, where a chick successfully fledged. Wingate (1964), unlike Murphy and Mowbray (1951), concluded that *R. rattus* do not interfere much with the Cahow on Bermuda. However, *R. rattus* are important nest predators on other burrowing petrels (Bourne 1981, Grant *et al.* 1981, Moors & Atkinson 1984) as well as other cavity-nesting tropical seabirds.

The rat-like animal referred to by Nicoll (1904) and the introduced opossum on Dominica mentioned by Wingate (1964) are certainly the same animal. They may have been important predators of Black-capped Petrels in earlier times, when the birds may not have been restricted to mountain cliffs. The animal in question is *Didelphis marsupialis insularis*, a race described from material collected in Trinidad (Allen 1902). In addition, this same race is established (presumably but not certainly through human intervention) on St. Vincent, Grenada, and Martinique (Miller 1924). Although the role this mammal may have had in the extirpation or reduction of populations of Black-capped Petrels on Dominica and Martinique is unclear, the likelihood should be considered, as Nicoll (1904) found these animals in petrel burrows on Guadeloupe. Furthermore, its local introduction to these islands appears to be nearly two centuries earlier than the widespread introduction of the mongoose to Caribbean islands.

J.C. Haney and D.S. Lee (pers. obs.) noted the presence of feral house cats *Felis domesticus* at 2 100 m in the Sierra de Bahoruco in the Dominican Republic. The highest elevation at which they were observed was at the base of the petrel's nesting cliff. It is not known what potential problems, if any, these animals present to burrow-nesting petrels. Lesel and Derenne (1975) noted cats eating the eggs of *Pterodroma macroptera* on Kerguelen Island. Moors and Atkinson (1984) summarize records of cat predation on seabirds and cite a number of references to cats entering burrows and feeding on petrel-sized birds. Feral cats are significant predators of Hawaiian Petrels (Simons 1985) and other endangered seabirds around the world (Le Corre 2008).

Domestic free-ranging dogs *Canis familiaris* may also present a problem. D.S. Lee and J.C. Haney (pers. obs.) witnessed that Haitians coming across the border into the Dominican Republic at night near the Sierra de Bahoruco colony often had dogs with them. The staff at the communication tower adjacent to the colony also keep free-ranging dogs. While there is no published information directly stating that feral or domestic dogs prey on petrels, Lee and Mackin (2004) identified predation by dogs as causing the demise of another similar sized burrow/cavity-nesting tropical seabird in the Bahamas. A White-tailed Tropicbird colony of approximately 70 pairs in the Exumas decreased to less than 10 pairs (an 80%

decline) in just four years as a result of predation from three free-ranging dogs on one island. D. Wingate (pers. comm.) also reports numerous examples of dogs killing Tropicbirds in Bermuda. Rupp *et al.* (2011) documented dogs at the *P. hasitata* nest they identified in the Sierra de Bahoruco.

Lee and Clark (pers. obs.) found evidence that pre-Columbians living on Hispaniola had imported the coati *Naysa naysa* to the eastern part of that island. These were semi-domesticated and kept much like dogs. One specimen shot in the 1950s suggests that some survived as a feral population. It is unknown what impact, if any, these introduced rodents and carnivores currently have on nesting *Pterodroma* and other tropical seabirds, but their effects around the world are well-documented (Jones *et al.* 2008). Petrels are particularly vulnerable to terrestrial predators when pre-fledging birds leave their burrows at night to exercise their wings.

Wind farms

Wind farms placed at coastal sites or on mountain ridges on West Indian islands are a potential threat to these globally endangered petrels (Barrios & Rodriguez 2004, Desholm & Kahlert 2005, NRC 2007). The problem is not simply birds flying into fan blades. Lights are known to attract petrels and other birds. Local areas of upwelling are produced downwind from wind farms in marine environments that may stimulate productivity in the nutrient-deficient waters of the West Indies. These in turn may concentrate predatory fishes, squid and other surface-foraging marine organisms as well as seabirds. We too are concerned about potential effects of wind farms on petrels at sea, but because of the highly pelagic nature of these birds and their near absence from continental shelf waters in the major foraging grounds off the southeastern United States, it seems unlikely that wind farms will be detrimental to this species there. The closest proposed wind farm to documented Black-capped Petrel and Cahow foraging areas along the mainland US is the in the vicinity of the Virginia Capes, a distance of nearly 100 km from the edge of the outer continental shelf where these petrels forage (Kunz *et al.* 2007, Lee 2009).

Communication towers

Communication towers are typically placed along the top of mountain ridges, where they can pose a threat to birds (Longcore *et al.* 2008). This is of particular concern for species such as the Black-capped Petrel that engage in dynamic soaring along mountain ridges during courtship (Simons 1985). As communication needs expand on islands in the Lesser and Greater Antilles, pressure to locate towers along mountain ridges will likely increase. Towers, especially those that are lighted and supported with guy wires, are particularly hazardous on foggy nights during the nesting season. One such tower already exists in the Dominican Republic in the immediate vicinity of the petrel colony on the Sierra de Bahoruco and another near La Visite, Haiti. J. Goetz and A. Brown (pers. comm.) visited the La Visite tower in February 2013, where they documented several birds that had been injured after collisions with tower guy wires.

Offshore oil and gas development

There is a high probability that an exploratory test well will be put into operation along the edge of the continental shelf off the Outer Banks of North Carolina in the near future. Discovery of gas or oil at this site would almost certainly lead to development of an area where major concentrations of Black-capped Petrels are known

to occur (Fig. 12). Because most of the birds using this area are adults, human activities would have a more detrimental effect on the population than if it was composed mostly of younger birds. The vulnerability of long-lived seabirds to adult mortality has been discussed by Simons (1984), Saether and Bakke (2000) and others, who have pointed out that small decreases in adult survival greatly increased the amount of time required for these K-selected species to recover from population declines. Lee and Socci (1989) discussed the susceptibility of the Black-capped Petrel to oil pollution at sea, but also noted that little information is available because data on the effects of oil spills on tropical seabirds are lacking. A Black-capped Petrel found on a Connecticut beach in 1938 was coated with oil (Holman 1952). Haney (1987a) reported small pieces of petroleum residue in one stomach he examined. Clapp *et al.* (1982) stated that, in general, *Pterodroma* seem relatively invulnerable to spilled oil. However, few data are available to prove or disprove this assertion.

Petrels are attracted to lights, especially on foggy nights. They fly at high speeds, so lighted oil rigs could pose a serious hazard to foraging birds (Lee & Socci 1989). Le Corre *et al.* (2002) review light-induced mortality of several petrels nesting on Reunion Island, and Telfer *et al.* (1987) reviewed and reported on the attraction of three species of Hawaiian procellariiforms to lights. One of these species, the endangered Hawaiian Dark-rumped Petrel *Pterodroma phaeopygia sandwichensis* is quite vulnerable to mortality resulting from collisions with lights in the vicinity of nesting colonies.

Mercury and plastic pollution

Lee (1980) reported that Black-capped Petrels had some of the highest concentrations of natural mercury in their tissues of any species of seabird he had examined. The birds had mercury loads in liver, kidney and feather tissue seven to nine times higher than in most of the 27 pelagic species studied (Whaling *et al.* 1980). Mean mercury concentrations in 22 Black-capped Petrels examined were 0.98 mg/kg in muscle, 60.0 mg/kg in liver, 26.0 mg/kg in kidneys and 18.0 mg/kg in feathers. Levels measured in Black-capped Petrel kidney have been associated with neurologic effects in many species of birds and reduced hatching success in Common Loons (Wolfe *et al.* 1998). Offshore drilling along the outer continental shelf would release mercury and other heavy metals into the water column (Lee 1999, Wilhelm 2001). The potential for these heavy metals to accumulate in the tissue of petrel prey items would further increase already elevated mercury loads in the birds.

In a 14-year study of plastic ingestion in 38 species of seabirds collected off North Carolina, 21 contained plastic in their digestive tracts (Moser & Lee 1992). The larger procellariiforms consumed plastic most frequently. Black-capped Petrels, however, had very low frequency of occurrence (1.8% of 57 birds examined) compared with Northern Fulmars (86.4%) and locally collected shearwaters (63.6%). Only one petrel had single piece of plastic in its digestive track and, based on its small size (0.14 g), it was likely to have been secondarily ingested. The fact that Black-capped Petrels, unlike many of the other seabirds collected during this study, do not focus their foraging directly along current edges where the plastics tend to concentrate may account for their low frequency of plastic ingestion.

Marine fisheries

Despite observer programs for seabird bycatch in commercial pelagic longline fisheries that include the Atlantic, Gulf of Mexico and

Caribbean Sea, there are no reports of any *Pterodroma* mortalities from bycatch in the Atlantic (Hata 2006, Palka & Warden 2006). The surface feeding behavior of Black-capped Petrels (Haney 1987a) make them unlikely (but possible) candidates for bycatch in longline and pelagic gill net fisheries. Their marine distribution limits their vulnerability to inshore fisheries over the inner continental shelf, but these birds are given little consideration in regional conservation planning. However, information from the international fishing fleets is generally lacking. Chuksin (2006) provides a history of the pelagic Soviet fishery off the Atlantic continental shelf of the United States. For more than 20 years, major Russian drift net and other pelagic fisheries occurred in the western North Atlantic but marine bird bycatch was not reported (Chuksin 2006). Local offshore fisheries in the West Indies are also not monitored.

Climate change

Given future climate scenarios, both the marine foraging environment(s) and the terrestrial breeding site(s) of Black-capped Petrels are likely to be affected, with the two life-history periods experiencing different changes, creating different vulnerabilities and conservation risks to the petrel.

The Black-capped Petrel's very strong, if not obligatory, affinity for the Gulf Stream and its associated water masses in the western North Atlantic begs consideration of whether abrupt changes, including a projected "shutdown" of the North Atlantic Ocean Circulation System (Vellinga & Wood 2002, Lund *et al.* 2006), would alter the at-sea foraging environment for this seabird in negative ways. However, there are no specific projections that the Florida Current or the Gulf Stream proper, i.e. the current system situated between Florida and North Carolina, where most petrels appear to forage, is going to stop or reverse under projected climate change models. Unless the Gulf Stream changes course in fundamentally different ways from those observed today, we judge the overall conservation risk to the petrel from marine climate change to be low.

Risks from the threat posed by terrestrial climate change on the breeding grounds is probably greater. Types of climate change impacts expected for the wider Caribbean region may include: 1) sea level rise, manifesting as a) saline intrusion into freshwater aquifers and b) coastal flooding and erosion; 2) increased temperatures, manifesting as a) heat stress, b) coral bleaching, c) biodiversity loss and d) increased emergence of vector-borne disease; 3) changes in rainfall patterns, creating droughts or floods and reducing fresh water availability; 4) increased intensity of storm activity, causing damage to infra-structure and habitat and disrupting human and/or wildlife populations (NAO 2000). Furthermore, indirect effects of climate change could alter future human land use patterns on Caribbean islands and affect nesting populations in unforeseen ways.

Changes in rainfall could negatively impact breeding of the petrel in two ways. First, more intense rainfall could adversely affect high-altitude breeding sites through burrow flooding or washouts. In such cases, the provision of safe artificial burrows that also exclude predators may be an effective mitigation strategy (Carlisle *et al.* 2003). Second, hurricane intensity is predicted to increase under climate change. Reports of Black-capped Petrel strandings increased when Category 3 to 5 storms came ashore along the eastern seaboard of the United States, suggesting that higher hurricane frequencies will increase extinction risks for these birds (Hass 2012). Finally, recent evidence suggests very rapid transmission and low (or no) immunity

in birds that are subjected to new invasive diseases linked to altered climate (e.g. Naugle *et al.* 2004). Exposure to new vector-borne diseases arising from climate change may also pose a conservation risk to the Black-capped Petrel.

CURRENT PROTECTION

The Black-capped Petrel is internationally recognized as a species of high conservation concern. Yet, despite the documented decline of the species, its small populations, current threats, cultural and historical interest, endemic status, and wide agreement that this species is critically endangered, there is essentially no effective protection of these petrels at their nesting grounds or at sea. There are a number of designations that address the issue but these provide little legal protection, and enforcement is lacking. At this time there are no proposed regulations or plans for direct protection at known nesting sites.

The 1914 Wild Birds Protection Ordinance makes provisions for the protection of certain species of wild birds on Dominica; this includes the Black-capped Petrel. The *Declaración de Santo Domingo: Corredor Biológico en el Caribe* signed by the Dominican Republic, Haiti and Cuba in July 2010 provides a framework for international collaboration and includes an action plan that specifically targets Black-capped Petrel conservation issues. Currently the only other formal protection for the Black-capped Petrel is the Migratory Bird Treaty Act of 1918.

Black-capped Petrels are included in the 1988 ICPB list of threatened birds of the world (Collar & Andrew 1988). Vermeer and Rankin (1984) list *P. hasitata* as one of the seven threatened and endangered taxa of gadfly petrels. Collar *et al.* (1992) recognize the species as threatened. The IUCN (2011) currently designates the species as Endangered due to small, fragmented and declining breeding range and population, and likely continued losses due to habitat loss, hunting and invasive predators. It is ranked as Critically Endangered by the Society of Caribbean Ornithology (Schreiber 2000, Schreiber & Lee 2000), designated as Highly Imperiled in the Western Hemisphere in the North American Waterbird Conservation Plan (Kushlan *et al.* 2002), and considered a Caribbean At-Risk Species (Bradley & Norton 2009). These designations provide no legal protection. Of the four critically endangered Atlantic species of *Pterodroma* that regularly forage in waters off the southeastern United States, only the Cahow (listed in 1970) is formally recognized as endangered by the US Fish and Wildlife Service. Discussions with USFWS about listing this species as endangered have been continuing since the mid-1990s. A formal petition to list the Black-capped Petrel under the US Endangered Species Act was submitted to the US Fish and Wildlife Service by Wild Earth Guardians, Denver, Colorado, on 1 September 2011 (DeNovellis 2011). On 21 June 2012 the US Fish and Wildlife Service issued a 90-day finding on the petition and initiated a status review. Based on the status review, the USFWS will issue a 12-month finding on the petition, which will address whether listing under the Endangered Species Act is warranted.

The three known nesting localities on Hispaniola, Macaya and La Visite in Haiti and Loma del Toro in the Dominican Republic are each designated as national parks, but at this time the parks lack management plans that address the conservation needs of the petrel. Management capacity is low, and the parks themselves are not secure from poaching, illegal timber harvest, fires and

activities that threaten the remaining populations. In Haiti, the Parc National La Visite escarpment in the 1980 ha Aux Diablotins Important Bird Area (IBA), and the 1669 km² Massif de la Selle are recognized as Key Biodiversity Areas (CEPF 2010). Within these sites approximately 230 ha of forested cliffs along the Pic La Visite escarpment support an estimated 90% of the known breeding population of the petrels.

The Macaya nesting colony in the Massif de la Hotte has been designated as a priority for conservation action. The massif is largely encompassed by the 2000 ha Parc National Macaya. The area is recognized as a Key Biodiversity Area (CEPF 2010), and it is part of a UNESCO Biosphere Reserve. The forested areas of Macaya are much larger and in better condition than at Massif de la Selle, but protection is limited because of open access and limited management/enforcement capacity. These areas are currently thought to support less than 5% of the remaining petrel population. In the Dominican Republic, the Loma del Toro Sierra de Bahoruco National Park, created in 1983 and encompassing 112488 ha, includes approximately 2000 ha of forested ridges adjacent to the Haitian border, where it is estimated that less than 5% of the remaining petrel population nests. Protection and management are limited, and a recently constructed cellular telephone tower above the nesting cliffs poses a threat to nesting birds.

CONSERVATION AND RESEARCH NEEDS

The documented historical decline of Black-capped Petrels, small current population size and increasing threats to known breeding colonies and foraging areas off the coast of North Carolina place the Black-capped Petrel in imminent danger of extinction. Effective management poses numerous conservation challenges because individual governments often view pelagic seabirds, which may nest in several countries and disperse widely at sea, as an international resource without clear jurisdictional responsibilities. Black-capped Petrels, despite their rarity, are not officially considered Endangered by the US Fish and Wildlife Service, by any of the countries in which they breed or by any of the southeastern Atlantic states where these birds spend the majority of their time foraging in offshore waters. As Duffy (1994) points out, the long-term conservation of seabirds requires the identification and protection of both significant nesting and foraging sites and recognition of areas of use that distinguishes among national, regional and international importance.

Conservation actions to date are focused primarily on identifying “new” nesting populations, but little has been done to provide effective protection for known nesting areas. Although the discovery of new colonies would be a welcome contribution to conservation efforts, these relict populations are unlikely to significantly change the dynamics of the total Caribbean population. Key foraging habitat off North Carolina’s Outer Banks has been recognized as a Globally Significant Bird Area by the Important Bird Area program sponsored by Birdlife International and the Audubon Society, but this designation provides no legal protection.

In August 1997, an International Seabird Workshop was held at the Society of Caribbean Ornithology’s annual meeting in Aruba. Participants prioritized marine bird conservation needs in the region and laid the groundwork for the establishment of the West Indian Seabird Working Group, which produced several publications updating the status and conservation concerns of key species (Schreiber & Lee 2000, Bradley & Norton 2009), and

an online atlas of West Indian seabirds (West Indian Breeding Seabird Atlas 2012). Subsequent working group meetings were held at Cape Hatteras, North Carolina, and Antigua in 2009; Santo Domingo, Dominican Republic, in 2010; and Freeport, Bahamas, in 2011. The working group, now the International Black-capped Petrel Conservation Group, has recently completed a Conservation Action Plan (Goetz *et al.* 2012) summarizing key conservation and management objectives for terrestrial and marine habitats (Goetz *et al.* 2012). Our findings are in accord with these objectives and the recent decision by the USFWS to evaluate the need for additional protection of the species and the primary foraging habitat off the southeastern United States under the Endangered Species Act (USFWS 2012). Additional conservation measures and strategies that warrant further consideration include (1) protection, monitoring and management of known breeding populations and nesting habitat in the Dominican Republic and Haiti through predator control, the installation of artificial nest burrows in appropriate sites and hiring local wardens at breeding sites during the nesting season; (2) local and regional training, education and public awareness (e.g. Blanchard & Nettleship 1992); and (3) restoration of the original name “*Diablotin*” for standard usage to promote the historical and cultural importance of this species.

The use of artificial nest structures for burrowing petrels dates back centuries. The Portuguese, for example, constructed stone houses to accommodate Cory’s Shearwaters *Calonectris diomedea* and encourage them to nest in places where they were easily harvested for food (Baring & Ogilvie Grant 1885). In modern times, artificial nests have been used for research, photography and conservation of various species of shearwaters, petrels and storm petrels (Allen 1962, Byrd 1979, Warham 1982, Wingate 1977). Currently a number of seabird conservation programs use artificial nest boxes to protect and expand populations of rare seabirds. In the western North Atlantic the success of Bermuda’s conservation program for the Cahow is largely due to the construction of artificial nesting sites. An effort to mass-produce and deploy plastic nesting chambers for western North Atlantic seabirds is currently in development. These nest boxes can be fitted with different sized openings to encourage or exclude target species including Cahows, Black-capped Petrels, Audubon’s Shearwaters, and Tropicbirds.

Environmental Protection in the Caribbean (EPIC 2012) has initiated a formal public awareness program directed at conserving the Black-capped Petrel. It is asking volunteers to report observations of birds at sea. This educational effort will raise awareness among recreational boaters in the Caribbean, and it could lead to new discoveries of important foraging areas. The program was announced late in 2011 through a magazine that targets recreational boaters in the greater West Indies region (Lee 2011).

Future research objectives that are directly applicable to ongoing conservation and management programs include (1) conducting studies to further define the genetic variability within remaining populations, (2) assessing the status of the remaining Caribbean mountain nesting habitats and (3) documenting the distribution and abundance of birds at sea through satellite telemetry and light level geolocator studies and systematic pelagic surveys.

Continuously updated information on the biology and conservation of Black-capped Petrels can be found at websites maintained by the West Indian Seabird Atlas program (<http://www.wicbirds.net/>), the International Black-capped Petrel Conservation Group

(<http://www.fws.gov/birds/waterbirds/petrel/>), and Environmental Protection in the Caribbean (EPIC 2012). Recent reports include surveys conducted by EPIC of possible new breeding sites in the Cordillera Central and eastern Bahoruco, Dominican Republic, using portable marine radar and thermal imaging equipment (A. Brown pers. comm., EPIC 2012, American Bird Conservancy 2012), and the discovery of active Black-capped Petrel nests at Morne Vincent, Haiti (Hardesty & Rupp 2012, Rupp *et al.* 2011, Rupp *et al.* 2012).

CONCLUSIONS

P. hasitata, a Caribbean endemic, currently survives only in small relict populations on Hispaniola and perhaps Dominica and Cuba. No certain evidence exists that it ever bred on Cuba, despite published references that attribute breeding to that island. Historically, petrels nested on Guadeloupe, Dominica, Martinique and Jamaica (*P. caribbaea*). Presence of *Pterodroma* in pre-Columbian middens on St. Croix and Crooked Island suggests an even wider range for this seabird taxon in earlier times. All known breeding islands originally lacked large, native, predatory land mammals.

On the one island currently used for nesting, the bird is now confined to high, inaccessible cliff faces. We assume that before the arrival of pre-Columbian man, the birds occurred over much larger areas of the islands. Historical information indicates that petrels were not restricted to cliff faces before the colonial period, when Europeans and Africans greatly overpopulated many islands. A similar situation has occurred with the Cahow and with island-nesting gadfly petrels in the eastern North Atlantic. Fea’s Petrel *P. feae* in the Cape Verde Islands and Zino’s Petrel *P. madeira* on Madeira once bred in mountain woods, but deforestation has now largely confined these *Pterodroma* to a few inaccessible mountain ledges (Bourne 1955). Such marginal habitats are not conducive to long-term survival. Introduction of predatory mammals combined with well-developed hunting techniques apparently led to the early reduction of Black-capped Petrels on all Caribbean islands, and their complete disappearance from most.

Despite extensive searches over the last three decades, little new information about the nesting biology of this species has surfaced. Only a small number of active or recently active nests have been found. At present, the largest known population occurs in Haiti, where massive deforestation and continued hunting of the birds for food threatens their existence. Although it is not possible to directly compare population estimates conducted by surveys under different field conditions times of year, available data suggest a decline at all sites monitored since the initial rediscovery of the primary breeding ground in the early 1960s. At least one colony in Haiti has disappeared; in all cases field workers are estimating declining populations.

Unlike the case for most species of marine birds, more is known about the marine habits of Black-capped Petrels than is known about their nesting biology. Marine waters off the southeastern United States are a critical habitat for foraging Black-capped Petrels. The major nonbreeding concentrations and apparently the primary foraging areas for breeding Black-capped Petrels are centered in the South Atlantic Bight between North Carolina and Florida. Petrel records off Florida are based on sightings from the Cape Canaveral region northward. It thus seems likely that the majority of Black-capped Petrels disperse from West Indies breeding colonies north and east of the Bahamas via the Antilles Current rather than through

the Straits of Florida. Patterns of seasonal abundance suggest that the species is distributed in and near the Florida Current and Gulf Stream to 36°N, and perhaps farther north to 40°–45°N throughout the year. Pelagic surveys in the northwest Atlantic (Brown *et al.* 1975, Rowlett 1980, Powers 1983) have not been extensive on the continental slope or some of the more oceanic habitats of this region. Thus, while Black-capped Petrels may occur regularly farther north than present records suggest, especially where the Gulf Stream meanders and warm core rings occur near the shelf edge, current data are insufficient to evaluate the importance of these areas.

Black-capped Petrels found off the southeastern United States during the winter breeding season are mostly reproductively mature birds that apparently commute back and forth to nesting areas in the Caribbean. Breeding *Pterodroma* are known to range up to several thousand kilometers from nesting sites (Warham *et al.* 1977), so Black-capped Petrels could easily disperse to the southeastern United States between incubation shifts.

The Black-capped Petrel and the Cahow are the two most highly endangered species of marine birds nesting in the western North Atlantic. Their conservation trajectories are headed in opposite directions. The Cahow is a model of how focused conservation action, habitat protection and management can bring a species back from the brink of extinction. In contrast, the Black-capped Petrel has become increasingly rare since its rediscovery in 1964, and many conservation issues remain unresolved. An array of factors including habitat loss, predation, coastal energy development and climate change pose potential threats to remaining populations. Novel international conservation strategies that encompass all aspects of the complex life history of these birds are required to prevent the extinction of this unique Caribbean endemic.

CONTRIBUTORS

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